Deliverable Phase 2 – Climate risk assessment

ATLAS project

HAUTS-DE-FRANCE REGION

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HORIZON-MISS-2021-CLIMA-02-01 - Development of climate change risk assessments in European regions and communities based on a transparent and harmonised Climate Risk Assessment approach

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5. Abbreviations and acronyms

Abbreviation / Acronym	Description
AMEVA	Syndicat mixte AMEVA – Etablissement Public Territorial du Bassin de la Somme
BRGM	Geological and Mining Research Office
CAB	Agglomeration community of Boulonnais
CATNAT	Natural disasters in France recorded in a database
CCR	Central Reinsurance Fund
CCRA	Community of communes of the region of Audruicq
CUD	Dunkirk Urban Community
DGPR	Directorate-General for Risk Prevention (Ministry of Ecological Transition)
DDTM	Departmental Directorate for Territories and the Sea
DREAL	Regional Directorate for Environment, Planning and Housing
ECRIN	Environment Climate – Research and Innovation
EPCI	Public establishment of intermunicipal ccoperation
GREC	Regional group of experts on climate
PAPI	Flood prevention action program
PCAET	Territorial climate-air-energy plan
FRMP	Flood risk management plan
PMCO	Metropolitan Pole of the Côte d'Opale
PNACC	National Climate Change Adaptation Plan
PPR	Risk prevention plan
PPRI	Flood risk prevention plan
GIS	Geographic Information Service (Région Hauts-de-France)
SRADDET	Regional Plan for Planning, Sustainable Development and Equality of Territories
SMAGEAA	Joint Association for the Scheme for the Development and Management of Aa's Waters

SYMSAGEB	Syndicat Mixte for the Water Development and Management Scheme of Boulonnais
SYMSAGEL	Syndicat Mixte for the Water Development and Management Scheme of Lys
ROL	Normandy / Hauts-de-France Coast Observation Network
TRACC	Baseline trajectory of climate change adaptation
TRI	Territories at risk of flooding
USAN	Hydraulic installation union of Nord

Executive summary

This deliverable presents the results of Phase 2 of the ATLAS project, led by the Hauts-de-France Region in partnership with the University of Lille, the AERIS/ICARE data centre, the Hauts-de-France Regional Climate Expert Group, and the POLENERGIE association, within the framework of the Horizon Europe CLIMAAX programme.

The objectives of Phase 2 of the project are to specify sub-regional hazard data and fine-scale risk analysis. The hazard and risk assessment assessed on the following workflows: Heavy rainfall and river and coastal floods in the continuity of Phase 1 work.

The challenge was to have reliable and realistic local data in order to exchange with territorial actors on the risks to which their territory is exposed in the medium term (2041-2070).

The reader will be able to learn about the actions undertaken during the 2nd phase of the project, the results obtained, the limits we checked and the actions we propose to pursue in phase 3.

Main results:

- The medium-term increase in hazard and extreme precipitation risks is confirmed by modelling the national data from EXPLORE 2 with scenarios RCP 4.5 and 8.5.
- In the studied pilot territory of the upstream valley of the River Aa, taking into account the remarkable increase in the frequency of extreme precipitation, the flood risk associated with such precipitation will increase characteristic.
- Results from the MERIT DEM model or similar models are subject to discrepancies in their use.

1 Introduction

1.1 Background

The Hauts-de-France region covers an area of 31,806 km ² in the north of France and includes five departments: Aisne, Nord, Oise, Pas-de-Calais and Somme. It shares a border with Belgium. With nearly 6 million inhabitants, it is the second most populous region in metropolitan France.
The Hauts-de-France region is vulnerable to several categories of climate risks. With its geographical specificities- wide seafront, lowlands, clay soils etc -, the Hauts-de-France is subject to a high number of climate risks.
According to the 2023 edition of the report produced by the French Caisse Centrale de Réassurance "The prevention of natural disasters by the fund for the prevention of major natural hazards", 60% of the regional population is exposed to at least one hazard. With 2.2 million people affected, floods are the second largest source of population exposure (after drought and the risk of clay swelling) to natural disasters, including 1.5 million due to runoff. Overflows of rivers and marine submersions affect 0.6 million people.
The cost of insured damage due to natural disasters in the region recovered to €1 trillion over the period 1995-2019. Two phenomena are particularly pronounced: floods in the broad sense (overflow, runoff, upwelling and marine submersion) and geotechnical drought. Flooding caused almost 72% of the insured damage in the region.

Main objectives of the project

Phase 2 of the project is important to clarify the sub-regional hazards and risk analysis corresponding to the work of Phase 1.
This knowledge is essential for:

- comparing the results obtained in phase 1 thanks to the models made available by the Climaax consortium with local or national data.
- having historical data with high spatial resolution
- better identifying the issues impacted by hazards and risks identified with local data.

The data we were able to obtain from local stakeholders helped to refine the risk analysis scales.
Contacts with data holders or river managers also allowed us to identify limitations to GIS data obtained to understand the social and economic impacts of hazards. For example, the duration of a river flood not noticeable by maps is essential to quantify these impacts.
This phase of work also allows us to get in touch with economic actors such as banks or insurance companies concerned about climate risks. Some of them implement hazard and risk analysis tools.

This phase makes it possible to optimise and make reliable the results linked to the identification of hazards and local risks. In doing so, it makes it possible to communicate to local stakeholders on the basis of more comprehensive and realistic data, opening the discussion on the adaptation actions they can develop.
The exercise of drawing up the risk matrix applied to a territory in the region was also particularly rich in lessons learned.
The political steering of the project with the relevant Vice-Presidents of the Region was initiated during this phase on the basis of the results obtained using local or national data.

1.2 Project team

The project is led by the Climate Transition Management unit, in relation with the Geographic Information System and Knowledge Support unit (HDF Region). Three existing employees, an Adaptation Officer, a data administrator and a geomatics specialist, work on the project with support of a consulting firm to ensure consistency of indicators.

As part of a public-public partnership concluded with the Region, researchers from the ECRIN consortium at the University of Lille, responsible for the Regional Expert Group on Climate (GREC), contribute to the project. The AERIS/ICARE data centre, one of the four national atmospheric data centres in France, is housed at the University of Lille. AERIS/ICARE scanning has research engineer with skills as a Python developer.

The team project:

<u>Region:</u>

. Véronique THERRY, Climate Transition Project Officer, Project Coordinator

. Renaud VANDEN BOGAERDE, data administrator

. Céline LAHAYE, Geomatician

<u>University of Lille:</u>

. Coralie SCHOEMAECKER, Research Officer at the Centre National de la Recherche Scientifique (CNRS /French National Centre for Scientific Research)

. Nicolas PASCAL, Director of the AERIS/ICARE Data and Services Centre

. Robin MIRI, Research Engineer at AERIS/ICARE

. Sahar MASMOUDI, Research Engineer at AERIS/ICARE

. Nathalie WIERRE, Coordinator of the Hauts-de-France Regional Climate Expert Group (GREC) and Liaison Officer with territorial stakeholders for the ECRIN research project

POLENERGIE Association:

. Hélène BECU, Project Manager

<u>Project governance:</u>

- A Steering Committee bringing together the 4 Vice-Presidents responsible for public policies concerned by the project
- A project team
- A scientific committee with the participation of:
  - Olivier COHEN, Laboratory of Oceanology and Geosciences, UMR 8187 LOG – CNRS – University of Lille – University of the Littoral Côte d'Opale – Institute of Research for Development, specialized in current and recent coastal dynamics

- Guillaume PENIDE, Lecturer-Researcher, Laboratory of Atmospheric Optics, University of Lille
- Claire ALARY, Institut Mines-Télécom IMT – University of Lille, Lecturer-Researcher, specialized in Environmental Geosciences
- Jérôme RIEDI, University Professor, Laboratory of Atmospheric Optics, UMR 8518 – CNRS – University of Lille, expert in Remote Sensing / Atmospheric Observation / Cloud Physics
- Caroline NORRANT, Senior Lecturer, ULR Territories, Cities, Environment and Society, University of Lille

1.3 Outline of the document's structure

This document into five main sections, designed to present the project's context, methodology, results and future perspectives.

- Executive summary
- 1. Introduction
- 2. Climate risk assessment – phase 2. The central part of the report, detailling the:
    - 2.1. scoping phase, the objectives, the context, participation and risk ownership, application of principles, stakeholder engagement
    - 2.2. Risk Exploration
    - 2.3. Regionalized Risk Analysis detailling the fine-tuning to local context of CLIMAAX workflows for selected hazards: heavy rainfall, river floods, coastal floods and the integration of local data.
    - 2.4. Key Risk Assessment Findings which describe the evaluation of risks severity and urgency and resilience capacity for risk priorization
    - 2.5. Monitoring and Evaluation
    - 2.6. Work plan Phase 3
- 3. Conclusions Phase 2- Climate risk assessment
- 4. The progress evaluation
- 5. Supporting documentation
- 6. References

2 Climate risk assessment – phase 2

2.1 Scoping

Phase 2 of the natural climate risk assessment aims to refine the risk analysis based on local data with high spatial resolution.

Heavy rainfall

Regarding the “heavy rainfall” workflow, we worked from the EXPLORE 2 data used by Météo France for rainfall data. Météo France is a national public institution whose mission for the French territory is to monitor the atmosphere, the superficial ocean and the snowpack, to predict its evolution and to disseminate the corresponding information. It is also responsible for contributing to the memory and prediction of climate change.

To determine the thresholds for extreme events related to rainfall, we also touch on the national natural disaster database (CATNAT) with a focus on the risks of floods and mudslides. This database, published by the Caisse Centrale de Réassurance (CCR), lists the decrees of natural disasters (CATNAT decrees) in France, following declarations of damage by the municipalities, recovered by the State services.

Floods

Key developments in this scoping are:

- Obtaining and analysing local data held by different territorial actors on river or coastal floods.
- Sharing extreme rainfall analyses with these actors, which they had not diagnosed.

In phase 2, the flood risk analysis method has been adapted:

- **Moving from Python workflow methodology to data processing methodology using Geographic Information Systems (GIS).** Indeed, one of the objectives of the Climaax project is to propose a replication of data processing on the territory. Yet, the GIS community is extensive in the Hauts-de-France region, with significant expertise and many uses of GIS. Woven, engineering of the ‘Python programmer’ type is much rarer typical, limiting strong territorial ownership and following the processing replication.
- o **A pilot territory has been selected:** the SmageAa (upstream valley of the river Aa) which shared with us its flood data modelled following the floods of winter 2023-2024 and volunteered for the workshop specific to the development of the risk matrix. An exercise to identify the challenges was carried out on the territory of the SmageAa for the catchment area of the river Aa. Several test data processing operations were carried out using GIS on this territory in collaboration with local teams, **the ultimate objective being to automate this methodology** through automation GIS tools for better replication of analyses. This work will be developed in phase 3, with the aim to semi-automatically reproduce the same operations in other territories for which we will have hazard data.

- The work on drawing up the risk matrix allowed for a more in-depth consultation with stakeholders in a sub-regional territory than when the work carried out under the project was returned at regional level: the time specifically to this consultation was more carefully to collect the observations of the stakeholders themselves more systematically and more involved on the risks and issues of their territory.

2.1.1 Objectives

The ATLAS project aims to improve knowledge of the hazards and risks of the regional territory and to work on the implementation of adaptation strategies internal to the regional institution and by supporting the reflection of sub-regional territories.

The strategic objectives of phase 2 were the following:

- Improve knowledge of hazards and risks at sub-territorial scales
- Itemise existing local historical data
- Disseminate the results obtained

Organise a workshop with stakeholders at the level of a sub-regional territory, the territory of the upstream basin of Aa (SmageAa)

- To report the results obtained to the regional delegated representatives concerned and to territorial actors, at regional level.

Phase 2 focused on research, collection and processing of local data and their comparison with Phase 1 results. To do this, we had to make contact with multiple local actors. Some of them provided us with their data with reservations for their dissemination. In that case, we sometimes had to sign an undertaking fulfilling their terms of dissemination (example with the Syndicat mixte de l'Entente Oise Aisne).

The work on the development of the matrix allows us to engage stakeholders from a sub-regional territory in a constructive way. Representatives of residents self in the specific workshop on the development of this matrix.

For the risk analysis, we prioritised the identification of issues related to the risks of flooding or marine submersion rather than the financial impact of these risks. Indeed, by relying on the GIS land cover data available to the Region (Two-dimensional land cover - OCS2D), which are more precise than those of the Luisa database, we could not match the land cover classes used by Climaax and which make it possible to calculate the financial costs of the risks identified. As a result, we could not calculate the financial costs associated with these risks. However, some studies identified with local stakeholders include this financial estimate (as in the case of the Somme Bay PAPI).

The identification of the issues impacted by the risk (buildings, companies, public facilities, medico-social equipment, power stations, cultures, etc. …) leads to a concrete awareness of the assets exposed at the level of the study area.

<u>Local/regional dissemination of results:</u>

Between November 2025 and May 2026, the CLIMAAX methodology and the work of the ATLAS project were presented to several regional partners in order to engage in cooperation with each of them on the sharing of hazard and risk data.

At the end of May, the results obtained in phase 2 were presented to the main delegated representatives, Vice-Presidents of the Region in charge of regional strategy, water policy, the coordination of coastal policies, and biodiversity, to gather their observations and anticipated work to be carried out in phase 3.

The results obtained in phase 2 were disseminated during the development of the risk matrix on a sub-regional scale, in the territory of SmageAa, which subsequently centennial type floods during the winter of 2023/2024. SmageAa shared with us reliable and realistic data on the extent of these floods, based on a modelling of their watershed, which allows us to identify the issues (physical damage) and present them to stakeholders in the territory during a consultation workshop.

A regional restitution meeting/webinar was organised on 19 June, gathering around 40 participants representing: State departments and operators, local authorities, economic operators, regional resource centres and universities.

2.1.2 Context

The Hauts-de-France Region has the legal responsibility to draw up and publish a Regional Planning, Sustainable Development and Territorial Equality Scheme (SRADDET). The SRADDET, as a land use document, is a strategic, forward-looking, and integrative document that is applicable to certain levels of the community. This document specifies of an objective report that guides development projects in local authorities and a set of rules with which these local projects must comply with. The SRADDET includes a Climate, Air and Energy component, which includes the objective ‘Adapting territories to climate change’.

As such, the Hauts-de-France Region intends to apply for the CLIMAAX open call in order to:

- Better understand and share knowledge of climatic hazards and risks, including at sub-regional scales
- Engage in collective reflection to strengthen the regional adaptation strategy.

As part of phase 2, a steering committee bringing together the Vice-Presidents concerned with the regional strategy and climate change has been set up. The results obtained in phase 2 of the project were presented to them and were the subject of an opinion. Regarding the choice of RCP 8.5 to assess periods of return of extreme rainfall, the Vice-Presidents of the Region asked us to assess these risks with a less pessimistic RCP, especially since an article had just been published by Detlef P. Van Vuuren et al. in the scientific journal European Geosciences Union on the website https://gmd.copernicus.org/articles/19/2627/2026/#section6 which called into question the SmPC 8.5 scenario, which was considered unlikely. This article presents the new emissions scenario framework that will feed into climate models for the next IPCC assessment report, due in 2028.

The delegated representatives of the steering committee considered the knowledge of climate risks in the region as essential to secure the planning mission of the Region, through the SRADDET. It was also envisaged to rely on the project’s conclusions to secure the establishments managed by the Region (schools, training centres) and in the analysis of business establishment projects.

A second steering committee will be scheduled in October 2026 to prepare the recommendations to be included in the revision of the SRADDET, and the final seminar of the project in November 2026.

Multiple sectors of activity are likely to be affected by climate change in the Hauts-de-France region.

From the selected workflows, we can assess the footprint of the risk of river or coastal flooding on the territory. These risks affect the ability of networks and communication routes to be operational for the duration of the floods. These networks are essential for the maintenance of economic activities. otherwise, in addition to these impacts on networks, many public and private buildings have been degraded, depriving the population of essential services for several days (e.g. access to schools, workplaces ….), including in territories that have implemented a local adaptation policy (e.g.: the territory of SmageAa). After 3 days of flooding, a water management union told us that the crops were lost, and after 48 hours, the individual protections of the residences (cofferdams) were likely to become ineffective.

In phase 2, we met with financial operators (Banque de France, Crédit Agricole Nord) who are putting in place tools to help them better understand future hazards and take action to better protect their assets from them. Both financial actors are aware of the economic impact of ongoing climate change. Insurance companies are also concerned about this problem. We were aware of the findings of a study carried out by the agricultural profession at national level. This study highlights the impact of climate change on French agriculture in 2050. At national level, this study concludes that " without action, 90% of agricultural production and 80% of the territories will be weakened, resulting in a destruction of value of between EUR 4 and 7 trillion per year, or 30 to 50% loss of profitability for the farms studied in the area."

The consideration of hazards and risks by economic actors will cooperative influence the decisions of delegated representatives, at different spatial scales, and business leaders.

2.1.3 Participation and risk ownership

In France, the assessment and management of climate risks falls under the responsibility of the French State. It mobilises its departments and various operators under its authority to implement its adaptation policy (Météo France, CEREMA, water agencies…). It imposed regulations for the prevention of natural risks. At the beginning of 2025, the French State published a National Climate Change Adaptation Plan (PNACC 3) to prepare a France at +4 °C in 2100. The plan includes 52 measures to be implemented by 2030, 2050 and 2100.

Each French Region has legal competence over public policies relating to spatial planning, climate and the protection of biodiversity. This competence is addressed in particular through the publication and dissemination of the regional planning document, the Plan for Development, Sustainable Development, and Equality of Territories (SRADDET). *See the first deliverable for more details on the Region's action on adaptation to climate change.*

The most exposed areas in the region are coastal areas and areas close to rivers and streams. often, the Caisse Centrale de Réassurance (CCR), in its report for the Hauts-de-France region – 2023 edition, published in 2024 –, states that drought is the main source of people's exposure to natural disasters. According to the CCR, with 2.2 million people affected, floods are the second largest source of people's exposure to natural disasters. The majority of these exposed persons are exposed only in view of the phenomena of diffuse runoff throughout the regional territory.

During the winter of 2023-2024, part of the region, the departments of Nord and Pas-de-Calais, subsequent significant flooding, both spatially and by their duration and the damage generated. Following this event resulting from prolonged heavy rainfall, a resilience plan for the Pas-de-Calais Department, produced by the Pas-de-Calais Prefecture, is being prepared in consultation with territorial stakeholders, including the Region. To establish this plan, four thematic working groups brought together institutional, economic, agricultural and associative stakeholders in autumn 2025.

The plan proposes actions to:

- Develop a culture of risk among residents and businesses
- Integrate risk into urban planning documents through land planning and strategies, the dewatering of soils in cities in particular, nature-based solutions and soft hydraulics, and the maintenance of the territory's hydraulic functionalities.
- Support for the adaptation of agriculture by integrating agricultural representatives in the governance of water management, supporting the fight against runoff through development and the use of farming practices that promote the reduction of runoff risks.
- Develop corporate resilience through risk culture, identifying and transforming areas of exposed economic activity, governance between actors.
- Identify mobilizable financing arrangements and levers for action.

These topics were also the subject of discussions between the participants of the workshop organised in the SmageAa territory.

There are two main obstacles to reducing risk through collective planning solutions: the cost/results ratio of the adjustments and the perception that zero risk cannot be assumed in the light of changing contingencies. This is why, beyond the construction or development of physical protections, stakeholders consider it desirable to develop a culture of risk, at the individual or corporate level and at the collective level, in order to prepare for future extreme events as well as possible.

The level of security achievable depends on the technical capacity, the financial means available and the political consensus on the priorities for action. Some decisions, sometimes binding or difficulty to make, involve recognising limits and taking on arbitrations. Dead ends need to be clearly explained and understood, in order to maintain people's trust and ensure collective buy-in to the solutions implemented.

In order to reduce risks for vulnerable people (dependent, isolated people, people with low incomes), the integration of care workers (home helpers, nurses, pharmacies, doctors…) in the preparation of crisis management documents is essential.

2.1.4 Application of principles

The ATLAS project incorporates the principles of the Climaax framework. The application of these principles has guided the consultation of local stakeholders.

<u>Inclusiveness:</u>

Inclusiveness was implied in the workshop led by the project team in the SmageAa territory. Different categories of stakeholders, including two associations representing residents, expressed their views. Following the severe floods of winter 2023-2024 in this territory, the topics of the existing psychosocial impacts in the population including young people and the need to strengthen the culture of risk were discussed. During this session, the case of the most vulnerable populations was raised. Some stakeholders expressed the individual citizen solidarity that was widespread during the floods to provide assistance to elderly or isolated people in order to avoid, in particular, care breaks. Solid solutions to better organize this assistance were mentioned, such as integrating care workers into the Communal Safeguarding Plans (CSPs) established to organize crisis management.

<u>Quality, soundness, transparency:</u>

Quality and soundness were facilitated through meetings of the scientific committee of the project and consultations with various experts from the State or its operators. The members of the Scientific Committee provided their opinion on the results of the European models, in particular for the analysis of coastal flood hazards, and on the methodology developed to assess the hazards and risks associated with extreme rainfall.

The assessment of the latter was based on the use of national data 'Explore 2', with results more suited to the region as compared to EURO CORDEX and a finer spatial resolution (12 km -> 8 km), and the use of CATNAT data to specify the precipitation thresholds at risk at municipal level.

To ensure the transparency of the results of the project, a first meeting of the Steering Committee was organised by bringing together the Vice-Presidents of the Region responsible for regional strategy, water policy, coastal policy coordination and biodiversity.

In conjunction with the Northern Department, which was also the winner of the second CLIMAAX call for projects, a webinar meeting was also organised to report on the results obtained in phase 2, gather feedback from participants and ask them about the uses of the results they envisaged.

Precautionary approach:
The preventive approach was applied to the hazard and risk analysis of two workflows:

- By integrating the RCP 4.5 scenario into the analysis of extreme precipitation hazards to establish a comparison of the increase in precipitation frequency with RCP 8.5 which can be considered too pessimistic by some regional actors.
- By comparing coastal flood zones obtained from different models: MERIT DEM, zoning of TRIs (Territories at risk of significant flooding), Model used by the BRGM (Geological and Mining Research Office), a State operator having developed expertise in coastal risk assessment. During the presentations of coastal flood risks to territorial stakeholders, we reported on the results of the different existing models, alerting them to the precautions to be considered. Modelled local hazard data, where available, are a relevant benchmark for comparison.

2.1.5 Stakeholder engagement

To collect local data related to river and coastal flooding, the following partners were met, between November 2025 and June 2026:

Territorial partners:

- Mainly joint watercourse management authority: SYMSAGEL, USAN, SMAGEAA, Entente Oise Aisne, AMEVA
- Coastal risk managers: PMCO and member communities (CUD, CCRA, CAB…), Syndicat Mixte Baie de Somme Grand Littoral Picard, Réseau d'Observation du Littoral (ROL)

State services or operators: DREAL (flood unit), DDTM (Coastal Risk Prevention Plans), CEREMA (tools developed for DGPR: AGIRISK, CARTINO 2D), BRGM (SIRENES project: launched in December 2024, this project aims to develop a forecasting and warning system to better predict and protect against the impact of storms on the Hauts-de-France coastline.The work on this project is expected to be completed in 2028.)

Economic actors: Banque de France, Caisse Nord-Pas-de-Calais of Crédit Agricole. These financial actors set up contingency analysis tools with the aim of raising awareness, informing and advising their clients:

- companies for the Banque de France
- companies and local authorities for the Caisse Nord-Pas-de-Calais of Crédit Agricole. The latter is experimenting in the region with the ATLANTIDE tool which it has created before considering its generalisation at national and then international level.

We found that river management authorities estimated flood hazards on the basis of historical data based on the most significant floods. Not all have hazard data yet. We were able to retrieve the hazard data of some of them, sometimes under conditions of restricted dissemination.

We were able to study the coastal risk data of the Syndicat mixte Baie de Somme Grand Littoral Picard and compare them with the results of the MERIT DEM model made available by CLIMAAX.

Given the area of the region, we were able to deepen the analysis of the hazards of river floods in one territory, that of SmageAa, which suffered the floods of winter 2023/2024. We plan to continue this work of analysing river and coastal hazards during phase 3 on the basis of data collected from the Entente Oise Aisne (river hazards and risks in the Aisne and Oise catchment areas), the Intercommunal Institution of Wateringues and the Metropolitan Pole of the Opal Coast and its member communities along the Pas-de-Calais coast.

<u>Communication and feedback from those consulted</u>

During this phase, the intermediate results of the project were communicated to the members of the scientific committee of the project, the regional elected representatives in charge of public policies concerned by the workflows studied and to territorial and economic actors at regional level.

Regional elected representatives, meeting in the Steering Committee, wanted us to analyze the hazards and risks related to extreme rainfall according to scenario RCP 4.5 and not only scenario RCP 8.5

This remark of the regional elected representatives was also shared by participants gathered in a workshop for the development of the risk matrix in the territory of the upstream valley of the Aa (SmageAa territory).

Regional elected representatives affirmed the necessary knowledge of the natural risks linked to climate change to secure the Region's action, in particular through the SRADDET and opened up prospects for using the results for the Region's own use in the management of equipment falling within its competence or its economic development policy.

A researcher from the Scientific Committee alerted us to the lack of validity of the method for assessing the risks of marine submersions with the MERIT DEM model, applied to the polder zone between the cities of Calais, Dunkirk and St-Omer: to improve knowledge of the hazard, it would be preferable to identify potential shoreline breaches that could constitute a water entry point and to model the spread of the water table according to topography (slope), roughness and permeability of the soil and as a function of the sea level drops at downward tide.

Coastal flood maps from MERIT DEM modelling in the polder area cannot be disseminated as they are. They are exposed to criticism that could discredit the results of the project among local actors. This analysis is shared by several local actors to whom we presented them.

Together with the Department of the North, winner of the second CLIMAAX call for projects for the GREEN 59 project, we organised a regional feedback meeting on the work of the second phase of each project. It brought together some 40 participants representing government departments and operators, EPCIs and mixed watercourse management unions, economic operators, resource centres and universities.

We collected their intended uses of this work by workflow:

Heavy rainfall:

For CERDD, a regional resource centre on sustainable development, the use of data is envisaged in the context of interventions and training for regional actors.

The State services have expressed the interest in cross-checking these data with data from the General Secretariat for Ecological Planning (SGPE) to raise awareness among local authorities and with the models that will be used to update future risk prevention plans. They consider it desirable to know the volumes of rain for periods of return at 20 and 100 years, by 2100, by cross-checking them with existing data and those being prepared by Météo France.

Floods

CERDD considers that the replication of the methodology used on the territory of SmageAa could be requested by other territories and that it would be interesting to cross-reference river flood data with flood data posted by Météo France on the DRIAS portal (https://www.drias-eau.fr/)

The State services believe that these coastal flood data could be used, in addition to those of the SGPE, to raise awareness among its officials.

The Urban Community of Dunkirk wishes to value the coastal flood modelling work on which it is currently working and to be associated with the reflections that will be carried out in phase 3.

The SmageAa territory, where a specific workshop was organised, plans to use hazard and risk data in the development of its new PAPI:

- Knowledge of general trends in increasing the frequency of extreme precipitation
- Consideration of hazard analyses in the diagnosis of PAPI

In addition, the diversity of the issues studied aims to get local stakeholders to seize the results on the areas that concern them, in order to work to reduce their vulnerability: EPCIs with competence in economic development will be able to carry out actions towards affected companies according to their economic development strategies, the State and relief organisation services (SDIS) will be able to approach ICPE establishments with an over-risk of pollution in the event of floods, etc. …

Difficulties encountered:

The work at regional level makes it difficult to analyse the hazards and risks of river and coastal floods for several reasons:

- This work requires contacting multiple operators who do not all have hazard data. In addition, when river managers hold river flood hazard data, those we contacted were based on historical data. They did not have forward-looking studies using IPCC scenarios as in the Climaax methodology.
- As a corollary, the volume of hazard and risk data is high and requires significant working time. That is why we plan to continue this work in new territories in phase 3.

Furthermore, it is difficult at regional level to engage in in-depth consultation with citizens' representatives for their inclusion in an approach that strengthens the consideration of justice and social fairness. However, during the workshop held in the SmageAa territory, it was possible to consider the words of the inhabitants, represented by two associations.

2.2 Risk Exploration

2.2.2 Screen risks (selection of main hazards)

In phase 2, we extended the hazard and risk analysis carried out in phase 1 by adopting national or local data to refine this analysis.

The hazards and risks identified are the result of the observation of events that have occurred in the region for several years or of vulnerabilities linked to its geography (coastal risks). Part of the regional territory suffered severe river flooding during the winter of 2023/2024 and each river manager we met reported historical flooding episodes since the 1990s.

These hazards are:

- Extreme rainfall: the forward-looking analysis from the national EXPLORE 2 dataset, based on 9 (RCP 4.5) and 17 (RCP 8.5) global and regional combinations, shows a trend of increasing rainfall in the medium term, despite uncertainties related to the different models.
- River flooding
- Coastal flooding, due to the length of the coastline of the region likely to undergo marine submersions. For river or coastal flood hazard data, we met with different managers and retrieved the data available to them.

Several rivers in the region have caused overflows since 1990: the Oise, the Thérain, the Somme, the Canche and its tributaries, the Authie, the Wimereux, the Slack, the Liane, the Aa…

The coastal territories of the region may have different dynamics. Some suffer erosion of the coastline, while some coastal areas are accreting.

See the coastal erosion indicator available on the ROL site (Coastal Observation Network of Normandie - Hauts-de-France):

https://maps.rolnhdf.fr/portal/apps/experiencebuilder/experience/?id=f4963bbb7c6d492489084eb5821a5d42&page=Sections---MapJournal&utm_campaign=Newsletter%20-%20mai%202026&utm_medium=email&utm_source=brevo

For the heavy rainfall workflow, we worked with EXPLORE 2 data at regional level. Forward-looking data were analysed based on IPCC scenarios RCP 4.5 and 8.5.

Given the regional area and the volume of data to be processed, we focused on analysing the hazards and risks of river flooding in the SmageAa territory, which had fine and realistic data from the 2023/2024 flooding of the River Aa. We have established the risk matrix in this territory with the involvement of stakeholders.

We plan to use other local data in phase 3 on the catchment area of the Oise and Aisne, the territory of the wateringues and the coastal rivers of the Boulonnais.

For the coastal floods workflow, we found a divergence of opinion on the results related to the Climaax methodology for the polder area between the cities of Dunkirk, Calais and Saint-Omer.

Some actors (BRGM, Caisse Nord-Pas-de-Calais du Crédit Agricole) use models similar to MERIT DEM for the analysis of hazards when other actors (elected officials and local technicians, researcher) consider that the results are not precise enough and do not take into account either existing protections or dynamic flood data. It is not desirable to distribute flood maps from the MERIT DEM model in this area. The risk is that they are considered unreliable.

We obtained 2015 data from PAPI Baie de Somme Grand Littoral Picard. Comparing the forward-looking flood models gives results comparable to those obtained with the MERIT DEM model for medium-term flood rights-of-way, assuming a 100-year storm. This tends to show that this model is valid for the low plains of the Picardy coastline. As the PAPI has very precisely examined the hazards and risks of the Picardy coastline, we have not done this analysis again.

We plan to study in phase 3 the data transmitted by SYMSAGEB and the local authorities to study the hazards and risks on the Pas-de-Calais coast.

2.2.2 Choose Scenario

One of the objectives of the ATLAS project is to be able to make recommendations for the future revision of the SRADDET, which sets adaptation targets for 2050. We therefore worked on forward-looking data for the medium-term horizon (2041-2070).

As part of the third phase of the project, we plan to use the results of the project to develop recommendations for inclusion in the climate change adaptation component of SRADDET. During the steering committee of the main regional elected representatives concerned, we noted their interest in the future integration of flood risks into regional planning, economic development and ecological transition policies.

The following scenarios were selected for the three hazard types:

- Extreme precipitation: The scenarios used are RCP 4.5 and RCP 8.5 in the medium term.
- River floods: The local data obtained from SmageAa are based on historical data that we compared to the JRC model for a return period of 100 years.
- Coastal floods: The MERIT DEM model is based by default on RCP 8.5. We compared its results on a territory that carried out prospective modeling: the Picardy coast.
  In this territory, as part of the PAPI, the diagnostic study based its analyses on a hydrometeorological scenario at 2065 (50 years) with a centennial storm and river module flows, to protect the issues exposed to these hazards.

2.3 Regionalized Risk Analysis

In Phase 2, the project team used national data to assess extreme precipitation hazards and risks or local hazard data provided by river or coastal flood risk managers.

To assess the risks associated with river flood hazard data on a sub-regional territory, the Region’s Geographic Information Service (GIS) team used the databases at its disposal to identify the challenges facing the territory.

This exercise was carried out on the upstream basin of the Aa River (SMAGEAA territory).

As regards the analysis of coastal flood hazards, we retrieved the data provided by the Syndicat mixte de la Baie de Somme, Grand Littoral Picard, which carried out a precise study of hazards and risks as part of its Flood Prevention Action Programme. The PAPI study precisely identified challenges related to population, environment and heritage and economic activities, according to different storm and river flow scenarios and different time horizons (current situation, at + 20 years and + 50 years). It also estimated the financial costs corresponding to the damage of these different scenarios and time horizons by geographical sectors.

Indirect impacts considered

During the workshop held on the territory of SmageAa, indirect impacts were apprehended. We consulted local stakeholders on the psychosocial impacts of residents who suffered severe flooding during the winter of 2023/2024. We also consulted them on the most vulnerable populations and the social climate that followed the floods.

Workshop participants confirmed the psychosocial impacts of floods on the population, including young people. The traumas that followed these floods often lead to a form of denial, avoidance of hardship for those most affected, which is an obstacle to the collective memory of the risk and how to prepare for it.

According to them, the image of the territory and its attractiveness have deteriorated. Concern was expressed about the insurability of goods and the increase in the cost of insurance in the future.

Some participants also indicated the underestimation of the impacts of floods on biodiversity and natural environments. Some question the ability to maintain access to drinking water if this type of event occurs again.

2.3.1 Hazard #1 - Heavy rainfall fine-tuning to local context

Table 2-1 Data overview workflow #1Heavy Rainfall

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
…EXPLORE Climate data	*CATNAT Database*		*Evolutions of critical impact based threshold in terms of return period an intensity*
…	…		

2.3.1.1 Hazard assessment

Climate data and methodology

The assessment of climatic hazards carried out in phase 2 of the CLIMAAX project is based on the EXPLORE-2 climate data, made available by Météo-France via the DRIAS Climate portal.1 This dataset is the result of EURO-CORDEX simulations, but has been specifically adapted to the climatic context of metropolitan France in order to improve the representation of regional phenomena. The data are provided on an extended Lambert II grid with a spatial resolution of about 8 km.

1: https://www.drias-climat.fr/

In order to assess the future evolution of extreme precipitation in the Hauts-de-France region, two time horizons were considered: the reference period 1976-2005 and the medium-term projections 2041-2070. Two climate scenarios were analysed: RCP 4.5 (Intermediate Emission Stabilization Scenario) and RCP 8.5 (High Emissions Scenario). The analysis is based on a set of nine GCM-RCM pairs available in common for both scenarios. A multi-model approach was applied to reduce the influence of individual models. The results presented correspond to the median (Q50) of all simulations.

24-Hour Extreme Precipitation Evolution

Accumulated 24-hour extreme precipitation was analyzed for a return period of 25 years.

Figure 1.1a shows the historical accumulations of extreme precipitation over 24 hours associated with a return period of 25 years. At the regional level, the values obtained are generally between 50 and 70 mm. The highest cumulations are observed locally on the coastal façade as well as in certain sectors in the north of the region. Climate projections indicate an overall increase in extreme precipitation intensity by 2041-2070. Under the RCP 4.5 scenario, this increase remains moderate and exhibits significant spatial variability. Developments are generally between 0 and +15%, with some areas being more pronounced locally.

Under the RCP 8.5 scenario, the increase becomes more widespread across the territory. Many areas show an increase of between +10 and +25%, reflecting a greater increase in heavy rainfall events. These results suggest that short-lived intense rain events may become more frequent and severe in the future, especially in the high emissions scenario.

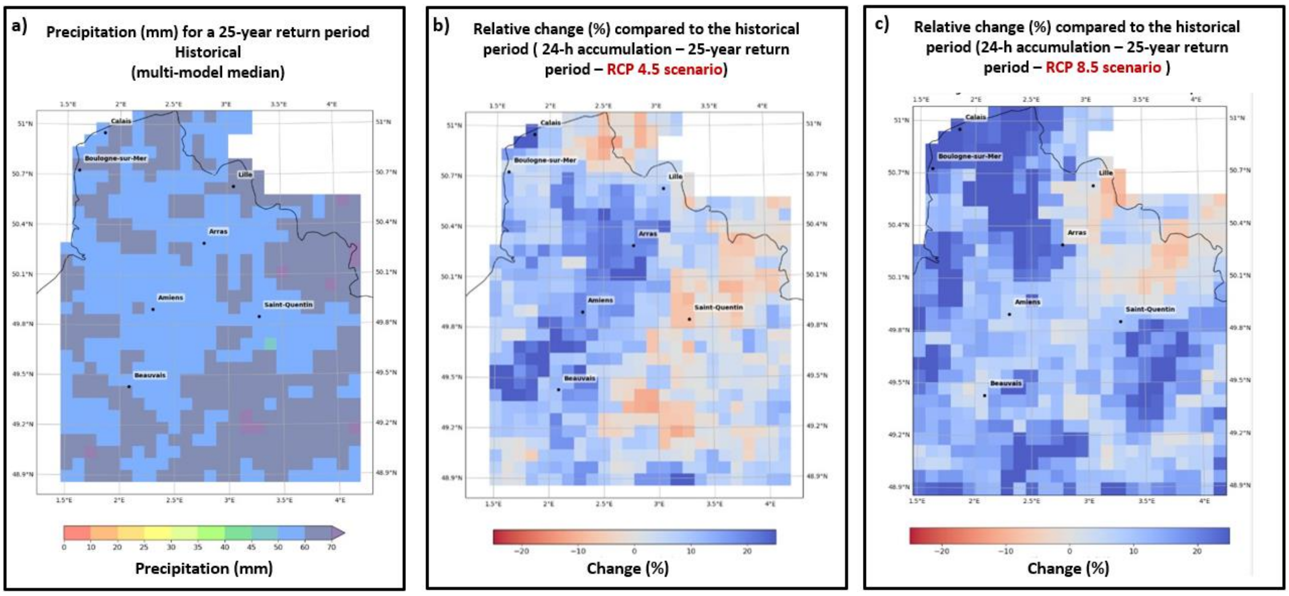


Figure 1-1 (a) Historical extreme precipitation (1976-2005) for a 24-hour cumulation and a 25-year return period (multi-model median); (b) Relative change (%) in extreme precipitation projected to 2041-2070 under scenario RCP 4.5 compared to the reference period; (c) Relative change (%) in extreme precipitation projected to 2041-2070 under scenario RCP 8.5 relative to the reference period.

Evolution of extreme precipitation over 360 h (15 days)

Flooding events in the Hauts-de-France are frequently associated with persistent rain events lasting several days or weeks rather than extremely intense rains on a single day. In order to better characterise this type of event, a second analysis was carried out on cumulative rainfall of 360 hours (15 days) (see mission to support the prefect of the Hauts-de-France region following the floods of winter 2023/2024). The methodology used to estimate extreme rainfall intensities for different return periods is identical to that applied to 24-hour cumulations.

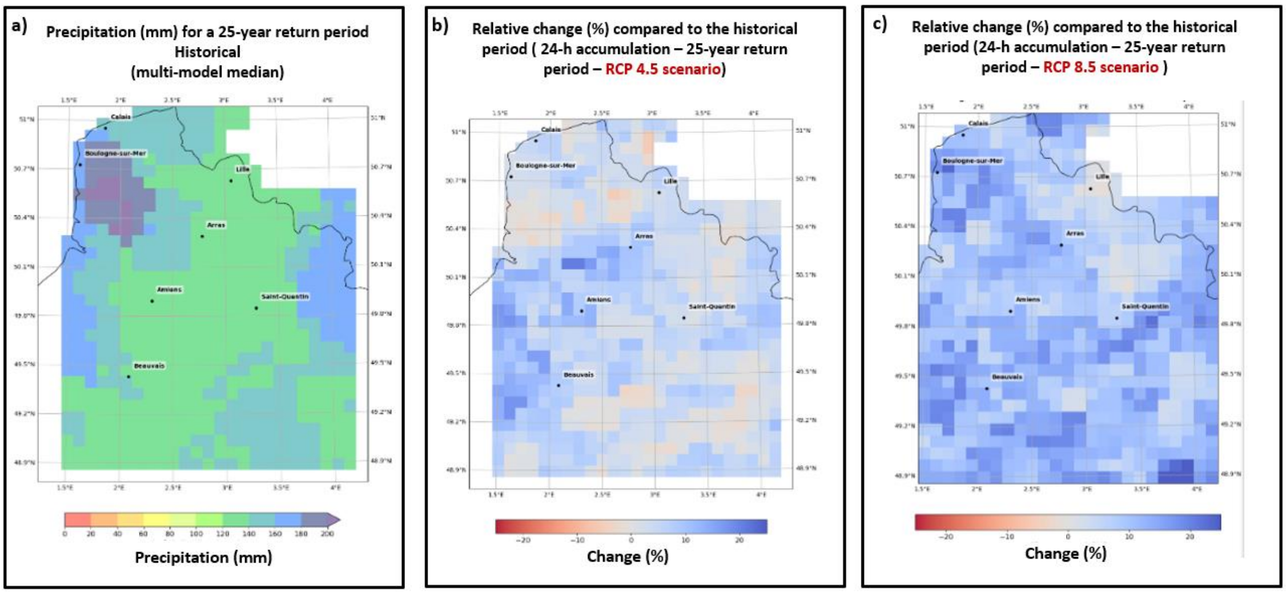


Figure 1-2 (a) Historical extreme precipitation (1976-2005) for a cumulation of 360 hours and a return period of 25 years (median multi-model); (b) Relative change (%) in extreme precipitation projected to 2041-2070 under scenario RCP 4.5 compared to the reference period; (c) Relative change (%) in extreme precipitation projected to 2041-2070 under scenario RCP 8.5 relative to the reference period.

Figure 1.2 shows the cumulative extreme precipitation over 360 h (15 days) for a return period of 25 years, as well as their projected evolution to 2041-2070 according to the climate scenarios RCP 4.5 and RCP 8.5. Historical results show cumulations generally between 100 and 180 mm over 360 h according to the sectors of the region. The highest values are observed mainly in the northern and northwestern parts of the territory. Under scenario RCP 4.5, the projected changes remain relatively limited. Variations are generally between -5% and +10%, reflecting a moderate change in cumulative extreme precipitation over 15 days. Under scenario RCP 8.5, increases become more homogeneous across the territory, but remain moderate overall. Increases range from 10% to 20%.

2.3.1.2 Risk assessment

Thresholds for cumulative precipitation

At the end of the first phase of the project, it appeared necessary to improve the method of estimating the risk thresholds related to extreme rainfall in the Hauts-de-France region.

In Phase 1, a single precipitation threshold value was used for the entire territory. This value corresponded to the "rain-intense" orange vigilance threshold of Météo-France, set at 40 mm of cumulative rainfall over 24 hours. This approach has certain limits, however, because it does not take into account local specificities. Indeed, vulnerability to extreme rainfall varies from one municipality to another depending on many factors such as topography, land use, the hydrographic network or the level of urbanization.

The objective of this second phase is therefore to develop an approach to estimate risk thresholds that are more representative of local characteristics. In addition, the analysis has been extended to winter events, which in the Hauts-de-France are often associated with persistent rainy episodes. Two types of events are distinguished:

- **Summer events,** characterised by cumulative rainfall over 24 hours;

- **Winter events,** characterised by cumulative rainfall over 360 hours (15 days).

Use of CATNAT database

To estimate these risk thresholds, we used the CATNAT database (Orders for natural disasters in metropolitan France 2), which lists the natural events that caused significant damage (mud flows, floods, etc.), specifying in particular the municipality concerned, the date of the event and its nature.

A first approach was to associate each CATNAT event observed during the reference period (1976-2005) with the corresponding rainfall accumulation in the municipality concerned. The objective was to directly determine the amounts of rain that actually generated damage. However, this method proved difficult to implement due to the lack of adequate data. The ERA5 reanalyses have a spatial resolution of about 25 km, much coarser than that of the data used in this study (8 km), which limits their use for analysis. The networks of ground-based measuring instruments do not cover the whole territory. In addition, satellite data also have limitations for this use. Scrolling satellites observe the same area only intermittently and therefore do not allow direct estimation of rainfall accumulations over a given period. In addition, no instrument currently on board geostationary satellites provides a direct measure of cumulative precipitation.

In the face of these limitations, an alternative approach has been adopted. This is based on the use of CATNAT data to estimate the frequency of damage events expressed as return periods. Thus, for each municipality with at least two CATNAT events linked to extreme rainfall over the reference period (1976-2005), a return period for these harmful events is calculated according to the following formula:

Return period = Duration of the reference period / Number of CATNAT events

For example, a municipality that has registered two CATNAT events over 30 years is given an estimated return period of 15 years. Once this return period has been determined, the results of the hazard analysis presented above are used to identify the accumulation of extreme precipitation corresponding to this return period. This cumulation is then considered as the critical threshold of precipitation associated with the risk of damage for the municipality studied.

This method is applied separately to summer and winter events. The former relate to short events, attributed to cumulations of precipitation over 24 hours, the latter are related to events spread over time corresponding to cumulations over 360 hours.

However, some municipalities do not have CATNAT entries related to extreme rainfall during the reference period. In these situations, it is not possible to estimate locally a period of return of damaging events. In the absence of sufficient data, regional threshold values are retained:

- **40 mm** for **cumulative rainfall over 24 hours**,
- **175 mm** for cumulative precipitation **over 360 h.**

The threshold of 175 mm was defined on the basis of the analysis carried out as part of the mission to support the prefect of the Hauts-de-France region following the floods in the winter of 2023-2024. Figure 1-3 shows that this 15-day threshold is representative of a high-intensity event, close to the cumulations associated with return periods between 50 and 100 years for most stations.

2: https://www.data.gouv.fr/datasets/arretes-de-catastrophe-naturelle-en-france-metropolitaine-2

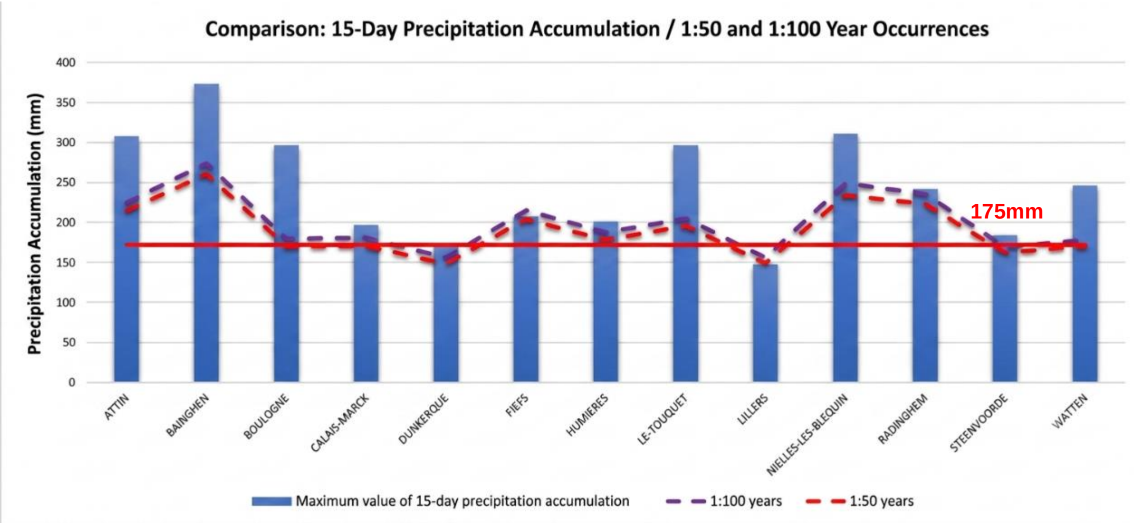


Figure 1-3. Comparison of the maximum accumulations of precipitation over 15 days observed during the winter of 2023-2024 with the reference cumulations associated with the return periods of 50 and 100 years at different stations in the departments of Pas-de-Calais and Nord.
Source: Meteo-France data, processed by the mission.3 (Palhol et al., 2024)

Figures 1-4 and 1-5 present estimates of extreme precipitation return periods and corresponding thresholds for summer (24 h) and winter (360 h) events, respectively.

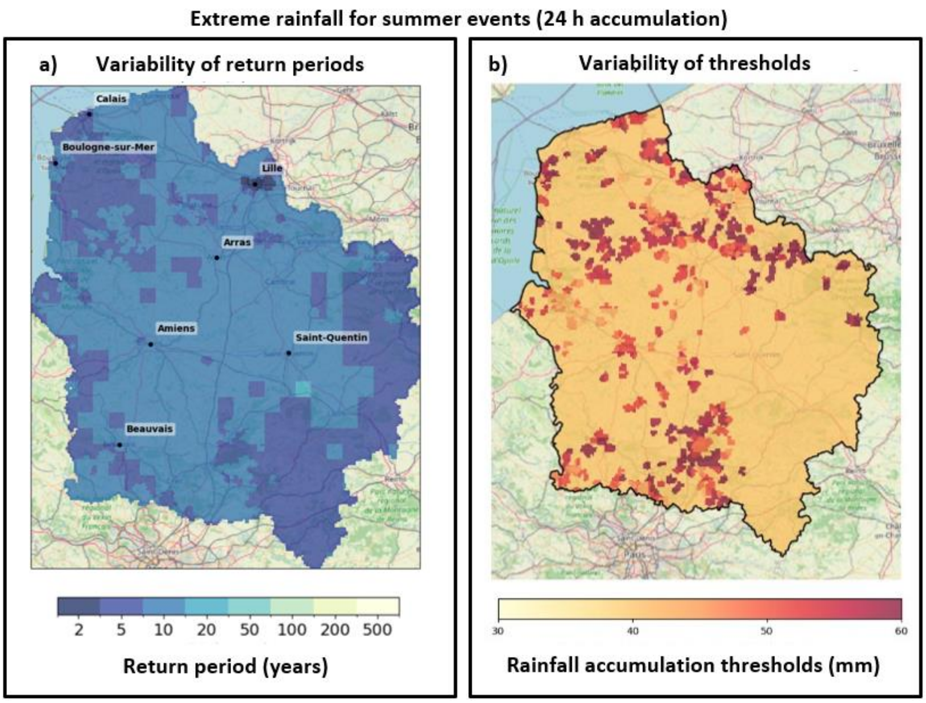


Figure 1-4 (a) Historical return periods (1976-2005) of extreme precipitation events associated with damage for summer events (24-hour cumulation); (b) corresponding critical precipitation thresholds (mm). Both maps were derived from the median of all EXPLORE-2 climate simulations and adjusted using the CATNAT database when local information was available. In the absence of sufficient CATNAT data, the regional threshold of 40 mm resulting from the vigilance criteria of Météo-France was used.

3 Palhol et al. (2024), Mission to support the prefect of the Hauts-de-France region to strengthen the resilience of territories affected by floods. Report No 015477-01 / 24005-R / 24018.

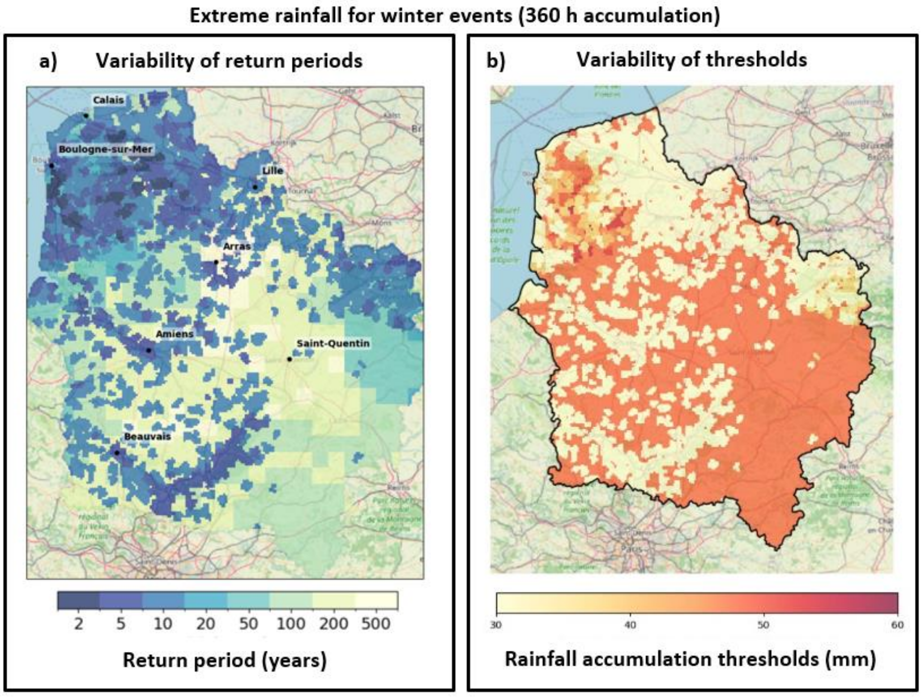


Figure 1-5(a) Historical return periods (1976-2005) of extreme precipitation events associated with damage to winter events (360-h cumulation); (b) corresponding critical precipitation thresholds (mm). Both maps were derived from the median of all EXPLORE-2 climate simulations and adjusted using the CATNAT database when local information was available. In the absence of sufficient CATNAT data, the regional threshold of 40 mm resulting from the vigilance criteria of Météo-France was used

Once the extreme event return periods have been estimated from the CATNAT database, it is necessary to convert them into critical precipitation thresholds. For this purpose, hazard maps obtained from EXPLORE-2 climate simulations are used. Figure 1-6 illustrates the relationship between extreme precipitation accumulations and their associated return periods over 24 hours, by presenting the average values obtained on the Hauts-de-France region for the historical period (1976-2005) as well as for the climate projections to 2041-2070 according to the scenarios RCP 4.5 and RCP 8.5. These curves make it possible to establish a two-way function between precipitation thresholds and return periods. Thus, when a return period is estimated from CATNAT data, it is possible to determine the corresponding accumulation of extreme precipitation. Conversely, for a given precipitation threshold, the curves make it possible to estimate its associated return period.

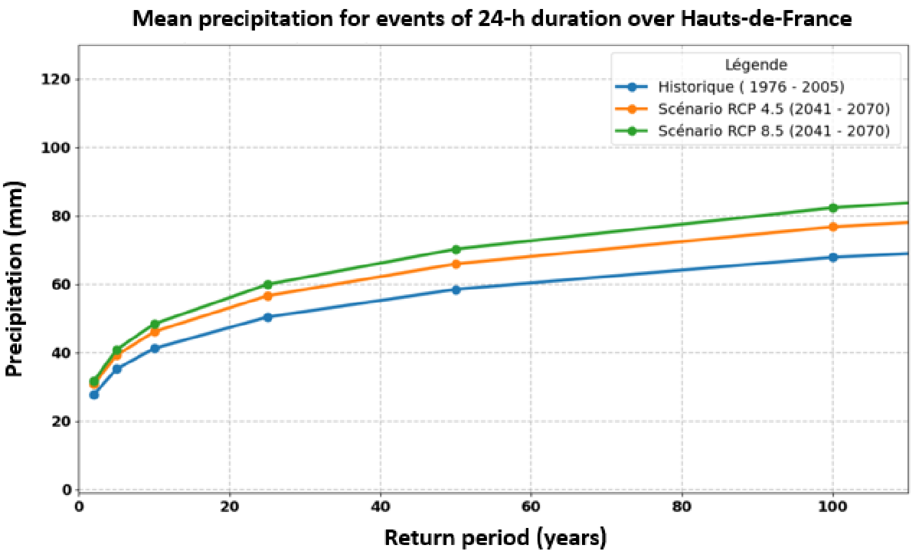


Figure 1-6. Accumulated extreme rainfall over 24 hours depending on the associated return periods for the Hauts-de-France region. The curves correspond to the mean values derived from the median of all EXPLORE-2 climate simulations for the historical period (1976-2005) and future projections (2041-2070) according to scenarios RCP 4.5 and RCP 8.5.

Statistical analysis of developments in return periods of risk events

Once the return periods of risk events were estimated for the reference period (1976-2005), their evolution towards 2041-2070 was assessed using the climate projections from the EXPLORE-2 dataset.

As a reminder, the simulations available in EXPLORE-2 include 17 combinations of global and regional climate models for the RCP 8.5 scenario, while only 9 combinations are available for the RCP 4.5 scenario. In order to ensure a consistent comparison between the two climate scenarios, only the 9 model combinations common to the RCP 4.5 and RCP 8.5 scenarios were selected for this analysis.

The evolutions of the return periods were then analyzed from the distribution of the results obtained for these 9 simulations. Three statistical indicators were considered: the 25 e percentile (Q25), the median (Q50), representing the central trend of all models, and the 75 e percentile (Q75), to quantify the uncertainty associated with climate projections.

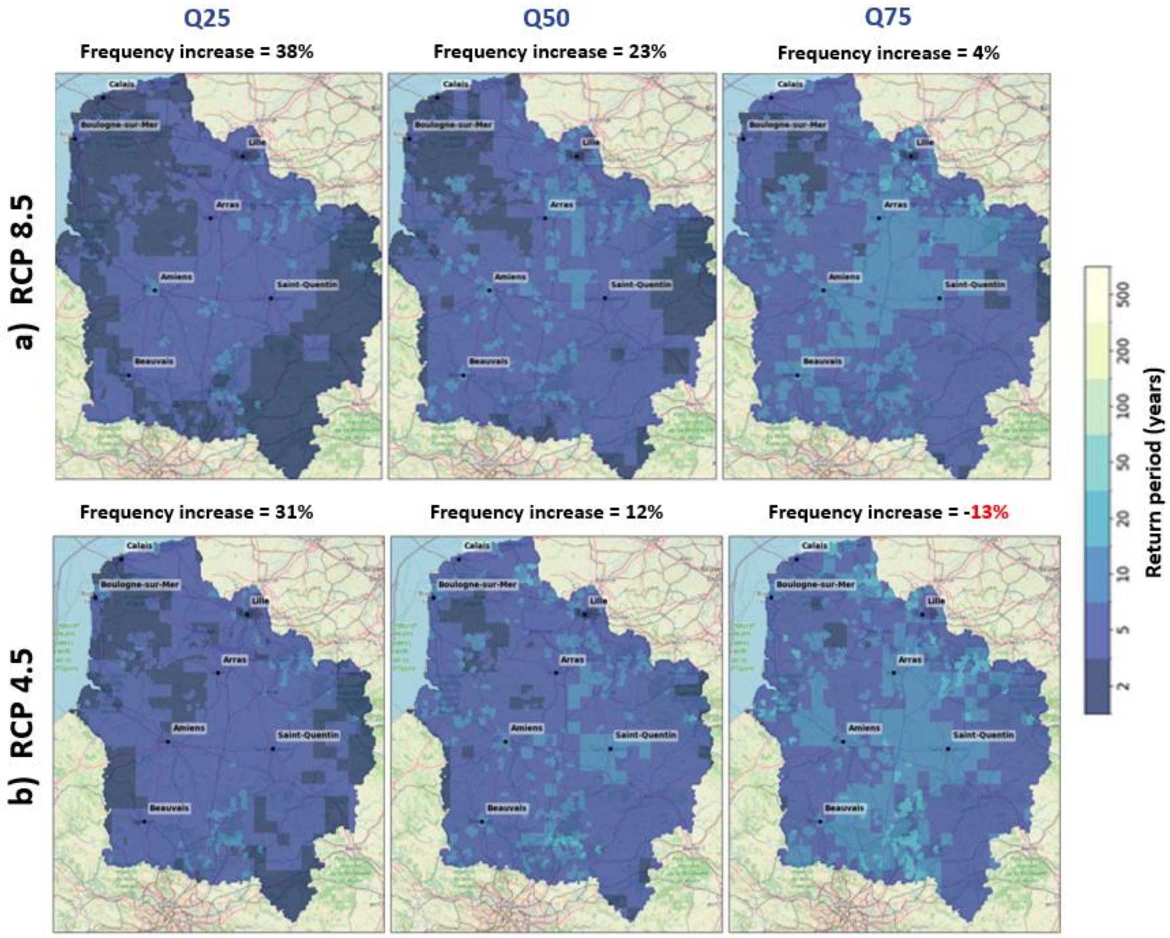


Figure 1-7 Projected evolution of return periods of extreme precipitation events for summer events (24-hour cumulation) to 2041-2070. (a) Scenario RCP 8.5; (b) RCP scenario 4.5. The results are presented for the quantiles Q25, Q50 (median) and Q75, calculated from the nine climate simulations common to both scenarios. The percentages shown correspond to the average change in the frequency of extreme events compared to the reference period (1976-2005).

Figure 1-7 shows the projected evolution of the return periods of extreme precipitation events for summer events (24-hour cumulation) to 2041-2070 for scenarios RCP 4.5 and RCP 8.5.

For both scenarios, the median (Q50) indicates an overall decrease in return periods, reflecting an increase in the frequency of extreme events. This average increase is estimated at 12% under scenario RCP 4.5 and 23% under scenario RCP 8.5. The results also show significant variability between models. In the projections (Q25), the frequency increase reaches 31% and 38% respectively for scenarios RCP 4.5 and RCP 8.5. Conversely, the projections (Q75) suggest a limited evolution or even a slight decrease in the frequency of extreme events in the RCP 4.5 scenario (-13%). Despite this dispersion, all the results show a consistent signal of increased risk associated with extreme precipitation, more pronounced under the RCP 8.5 scenario than under the RCP 4.5 scenario. Differences in quantiles, however, underscore the uncertainty associated with climate projections and justify the use of a multi-model approach for future risk assessment.

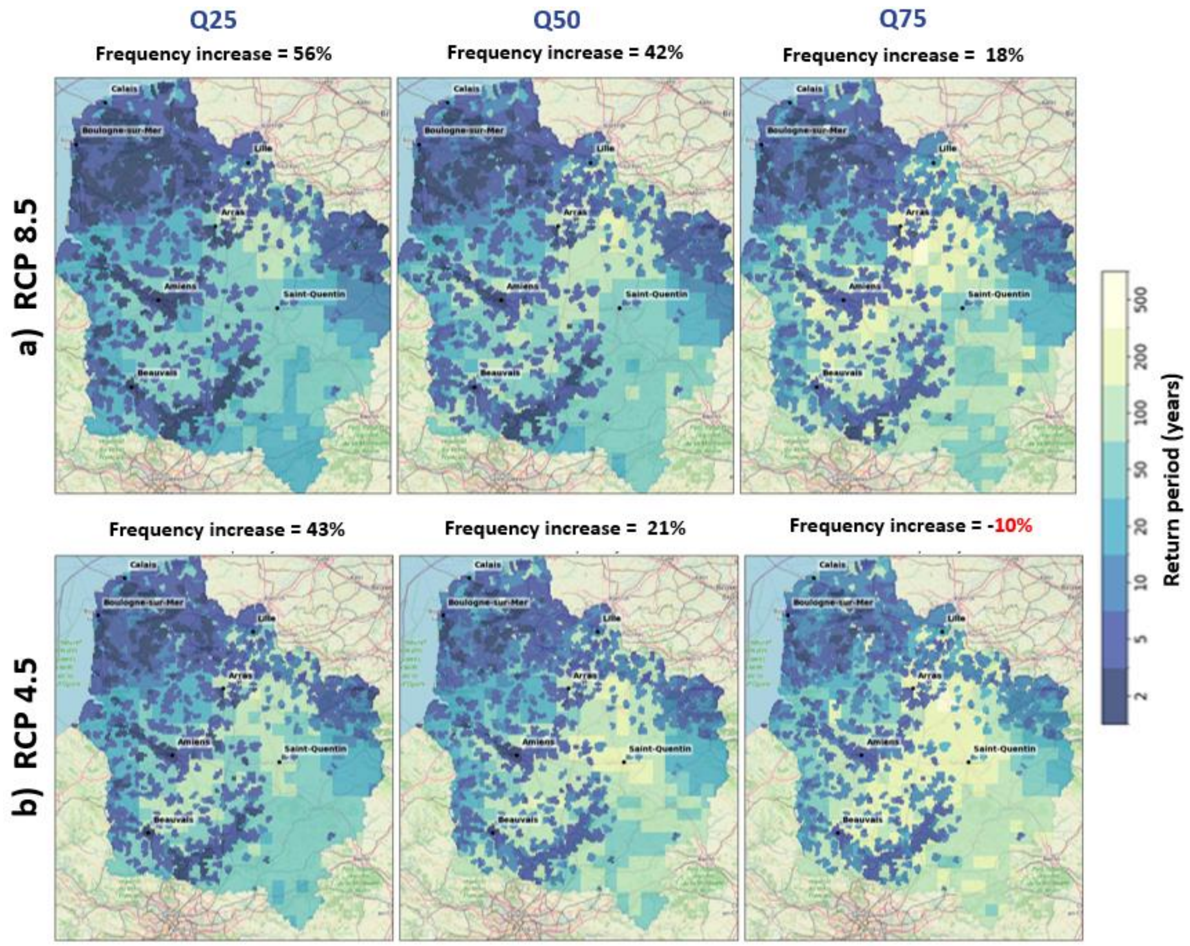


Figure 1-8 Projected evolution of return periods of extreme precipitation events for winter events (360-h cumulation) by 2041-2070. (a) Scenario RCP 8.5; (b) SmPC scenario 4.5. The results are presented for the quantiles Q25, Q50 (median) and Q75, calculated from the nine climate simulations common to both scenarios. The percentages shown correspond to the average change in the frequency of extreme events compared to the reference period (1976-2005).

Figure 1-8 shows the projected evolution of return periods of extreme winter precipitation events associated with a cumulative 360 h (15 days) over the 2041-2070 horizon for IPCC scenarios RCP 4.5 and RCP 8.5.

The results indicate a generalized decrease in return periods, reflecting an increase in the frequency of extreme winter events. This trend is observed in both climate scenarios, but appears more pronounced under scenario RCP 8.5. For the median of the models (Q50), the average frequency increase is 21% under scenario RCP 4.5 and 42% under scenario RCP 8.5.

The comparison with the results obtained for the 24-hour cumulations shows that the projected evolutions are generally more marked for the long-term events (360 h). This result suggests that climate change could further increase the frequency of persistent winter rain events than that of short-lived extreme events in the Hauts-de-France region.

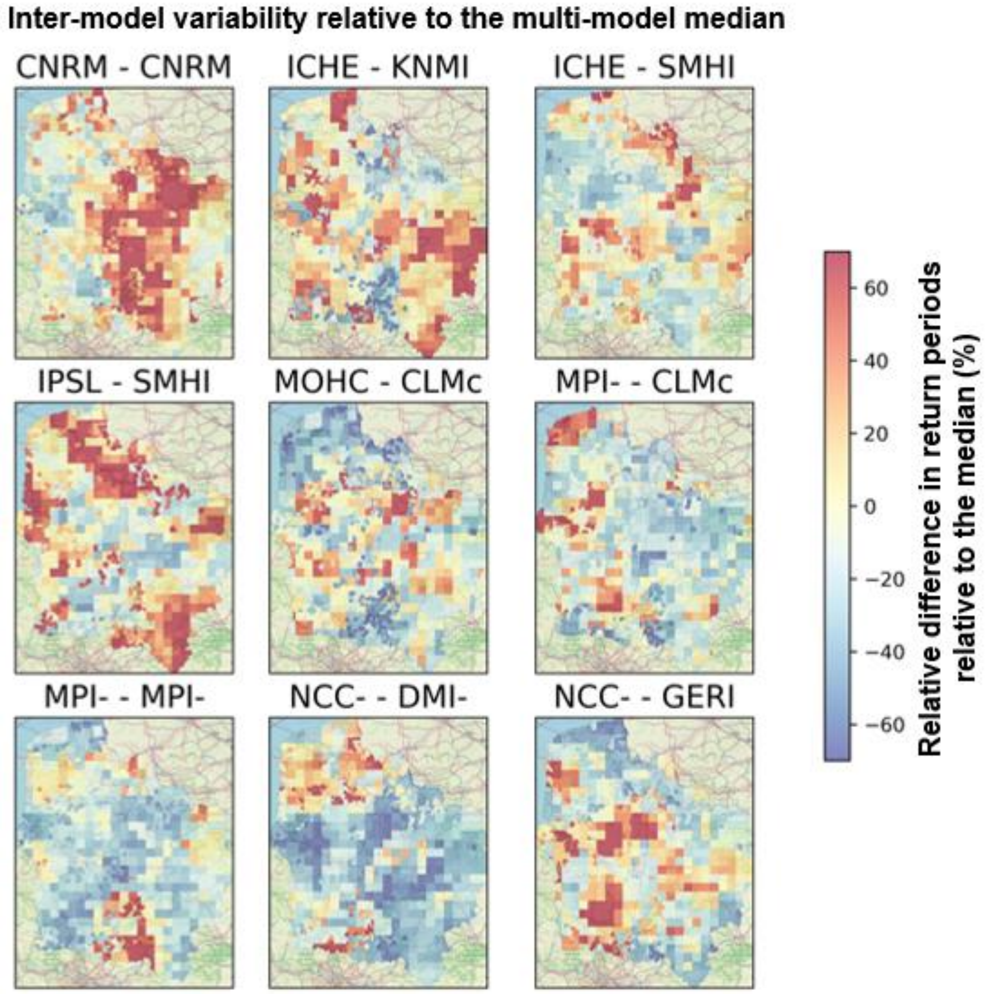


Figure 1-9. Relative deviations (%) of projected return periods of extreme summer precipitation events (24-h cumulation) from the EXPLORE-2 median multimodel for scenario RCP 4.5 (2041-2070).

Figure 1-9 presents the relative deviations of projected return periods from extreme summer precipitation events (24-hour cumulation) for each of the nine climate model combinations selected in Scenario RCP 4.5. The deviations are calculated from the median multi-model, used as a reference in this study.

The results show significant variability between the different combinations of climate models in the Hauts-de-France region. Some simulations predict locally lower return periods than the median, reflecting an increase in the frequency of extreme events, while others project higher return periods, corresponding to a decrease in this frequency. This heterogeneity reflects the uncertainties associated with the representation of extreme precipitation in climate models.

Despite this dispersion, the analysis of the different quantiles presented above shows that a majority of the simulations converge towards a decrease in return periods and therefore towards an increase in the frequency of extreme precipitation events. The results thus suggest an overall trend of increased risk associated with extreme precipitation in the region, although the magnitude of this change remains variable according to the models considered. However, these results should be interpreted with caution given the observed inter-model variability. This analysis highlights the value of a multi-model approach to characterize uncertainties associated with climate projections and avoid basing conclusions on a single simulation.

2.3.2 Hazard #2 – River floods finetuning to local context

Table 2-2 Data overview workflow #2 river floods

*Existing data **not taken into account** in phase 2 of the ATLAS project:*

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Floods Maps (JRC - Join Research Center)	*Water heights available*		*Data limits: low spatial resolution, protections not taken into account, large watersheds not covered by the model*
Regulatory hazard from PPRIs (DREAL)	*Water heights available*		*Data limits: sometimes old hazard, some watersheds are not covered*

***Data compiled and retained in** phase 2 of the ATLAS project:*

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
***2024 Raw Modelling** (SmageAa)*	*Water heights available*		*Modelling carried out by the SmageAa following the centenary flood of 2024.*
	Issues directly impacted by the hazard + issues in the immediate vicinity (less than 150m from the hazard)	***Public Equipment Base - BPE** (INSEE 2024)*	*Schools, colleges, high schools, gymnasiums, libraries, gendarmeries, town halls, EPHAD, leisure receptions, hotels, ambulances, doctors, surgeons, dentists, nurses, pharmacies, midwives, supermarkets, etc …*
	Issues directly impacted by the hazard + issues in the immediate vicinity (less than 150m from the hazard)	***Sirene base of enterprises** and their establishments (INSEE 07/2025)*	*Possible differentiation between employer and non-employer establishments, categories by size bracket*
	Issues directly impacted by the hazard + issues in the immediate vicinity (less than 150m from the hazard)	***ICPE (Classified Facility for Environmental Protection)** (Georisques 2026-03)*	*Establishments posing an additional risk (potential pollution) should they be affected by a flood hazard*

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
	Issues directly impacted by the hazard + issues in the immediate vicinity (less than 150m from the hazard)	***Establishments Seveso*** *upper and lower threshold (Georisks 2026-03)*	*Establishments posing an additional risk (potential pollution or technological risk) should they be affected by a flood hazard*
	Issues directly impacted by the hazard + issues in the immediate vicinity (less than 150m from the hazard)	***PLU/PLUI in the GPU*** *(Urbanism Geoportal 2026-03)*	*Zonings in "1Au" in the GPU, which corresponds to zonings dedicated to urbanization. The objective is to identify these zonings and to limit or adapt the constructions on these spaces in the face of risk.*
	Issues directly impacted by the hazard + issues in the immediate vicinity (less than 150m from the hazard)	***Wastewater Treatment Stations*** *(Sandre 2024-12)*	*Stations posing an additional risk (potential pollution) should they be affected by a flood hazard*
	Issues directly impacted by the hazard + issues in the immediate vicinity (less than 150m from the hazard)	***Transformer stations*** *on the high or very high voltage network (>= 63 kV) (IGN - BD TOPO 2025-12)*	*Identify vulnerable substations to limit the impact of a power supply disruption*
	Issues directly impacted by the hazard + issues in the immediate vicinity (less than 150m from the hazard)	*Public distribution* ***substations*** *(HTA/BT substations). (Enedis 2025-09)*	*Identify vulnerable substations to limit the impact of a power supply disruption*
	Issues directly impacted by the hazard + issues in the immediate vicinity (less than 150m from the hazard)	***Buildings*** *(BDNB version OpenData 2026-03)*	*Possible differentiation between housing and other types of buildings + estimated population per residential building*
		Soil Occupancy in 2 Dimensions (OCS2D 2021) *https://www.geo2france.fr/portal/occupation_du_sol_2d*	*Work data used only to qualify the use of BDNB buildings (hâbitat or not)*
		Tiles 200m Filosofi (INSEE 2021) *https://www.insee.fr/fr/statistiques/8735162?sommaire=8735243*	*Work data that was used only to distribute the tile population in the BDNB housing buildings*
	Issues directly impacted by hazard	***Graphical Parcel Benchmark*** *(RPG 2024)*	*Area (in m² and hectare) and crop type impacted by*

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
			hazard (specific crop, or crop group)

Accuracy and methodology on data:

- **Hazards data "2024 Raw Modelling (SmageAa)": it is not yet available in OpenData, but will be available in autumn 2026.** It is the result of a fine modelling of the Aa watershed with water flow input data, carried out following the 2024 floods in order to reproduce as closely as possible the hazard envelope and the heights observed during this flood, probably classified as a hundred-year flood.
- **Data on "RPG" issues: the parcels are cut** according to the flood hazard of the SmageAa, so that the areas impacted can be calculated. **The data is therefore published in duplicate:** the original data of the GPR, and the data cut by the flood hazard of the SmageAa
- **For all other data on issues, the data are at the level of the entire Hauts-de-France Region and are completed with a specific field for each hazard that may impact them:** in our pilot phase, it is the field "smag_inond _2024 _cic _v2" that contains the water height information (in meters) or proximity information (within 150m of the SmageAa flood zoning)
- **BPE data: all the equipment on the base has been studied,** i.e. all the categories of equipment available. **In the cartographic representations, only certain categories of equipment are displayed:** they have been selected according to their importance and relevance, and also to gain readability.
- **Population data:** to best estimate the population impacted by the flood hazard, we could have directly crossed the INSEE grid data with the flood hazard, and estimated proportionally the share of the population impacted. This method had the limit of not taking into account the reality of the geographical distribution of the buildings that accommodate the population. **The population has therefore been broken down into residential buildings** in order to obtain a more detailed geographical distribution. The main steps are as follows:
    - Selection of residential buildings through land use (OCS2D)
    - Distribution of the population of each INSEE tile in residential buildings according to their size

☒ Information on the type of building (residential or non-residential) is available in the field **ocs2d _type _us**

☒ Information on the number of inhabitants per building is available in the field **pop_bati** (in number of inhabitants, 2 digits after the decimal point for better statistical analysis)

2.3.2.1 Hazard assessment: River Floods

In phase 1, the hazard data provided was that of the JRC. After discussing the hazard and the results of the Phase 1 workflows with the Scientific Committee, it emerged from this data that:

- There was no consideration of the future period under IPCC scenarios
- Geographic resolution was low
- Existing protections were not taken into account
- Only large watersheds were covered by this model

Based on this observation, contacts were made with many of the local structures already mentioned, in order to obtain more qualitative data.

3 data were compared:

- JRC hazard
- The regulatory hazard arising from the PPRIs
- Flood modelling hazard (here the one carried out on the territory of the SmageAa)

These comparison results are visible on the two triptics of maps below, the first representing the territory of the SmageAa, the second being a zoom on two sectors of the territory of the SmageAa in order to better visualize the differences.

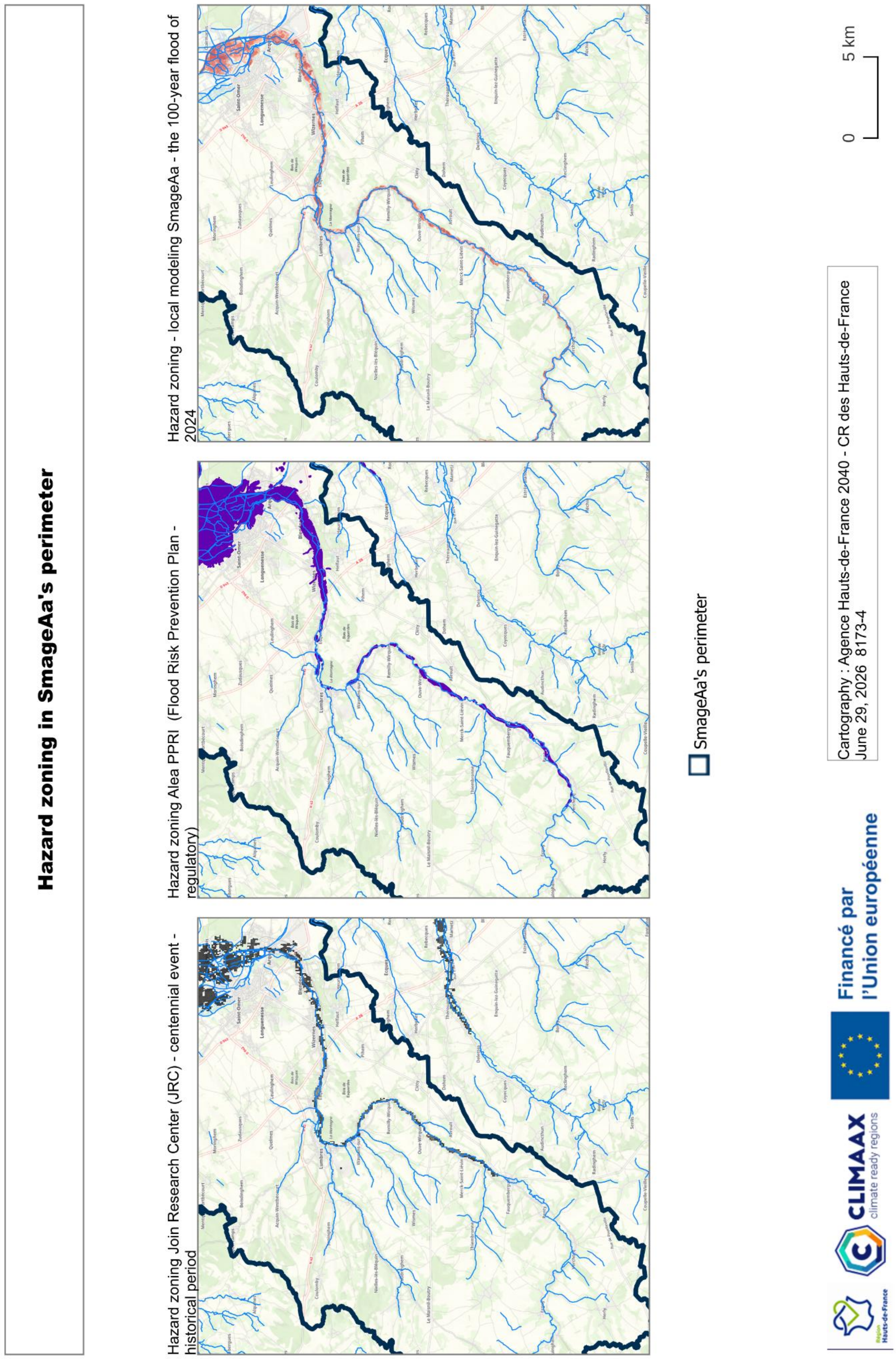


Figure 2.1: Hazards zoning in SmageAa's perimeter

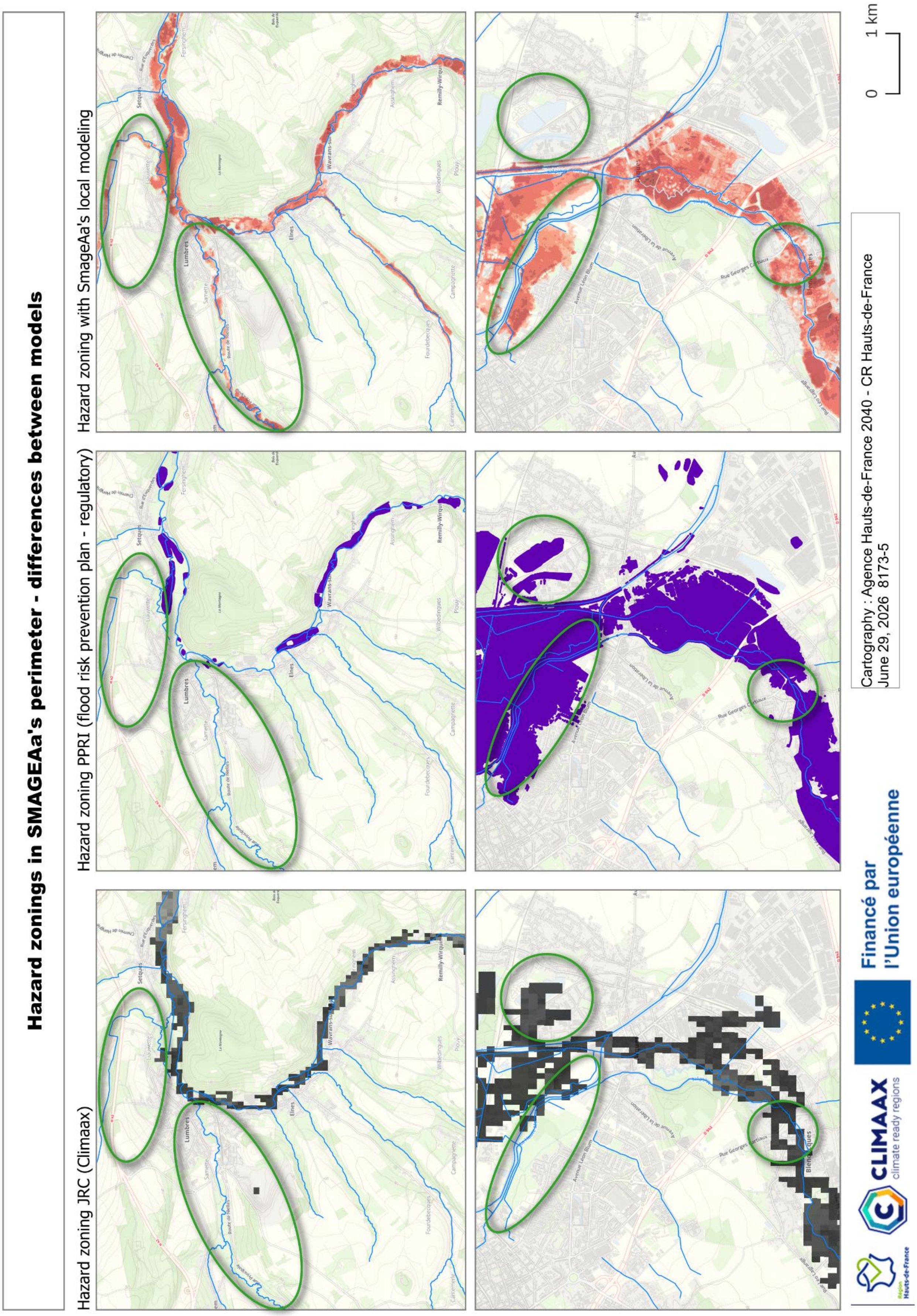


Figure 2.2: Hazard zoning in SmageAa's perimeter : differences between models

Here are the results of this comparison:

	JRC (centenal event)	*PPRI (regulatory hazard)*	*Modelling (Centennial Growth 2024 SmageAa)*
Taking into account the future period under IPCC scenarios	*No*	*No*	*No*
Spatial resolution	*Low*	*Good*	*Very good*
Existing protections taken into account	*No*	*Partly*	*Yes*
Covered watersheds	*Only >150km ²*	*Not all covered*	*All are covered*
Tributaries	*Not covered*	*Not partially covered*	*Covered*
Correspondence with the reality observed during the flood of 2024	*Average*	*Good*	*Very good*
Availability throughout the Hauts-de-France Region	*The whole region except watersheds <150km ²*	*PPRIs cover part of the territory. When they are absent, there may be TRIs that are located in high-stakes territories*	*Only in a few territories that have modelled their watershed*

The data that allows us to refine our risk assessment the most is local modelling. However, **the limit to all our data sources is that the impact of climate change is not taken into account.**

We then took up the results of the risk analysis 'Extreme Precipitation' referred to in the previous chapter. **Assuming an increase in the frequency of extreme rainfall events, if risk events** (crue decennale, fiftieth, centennale, etc. …) **become more frequent, action should be taken to reduce the vulnerability of the territories to these risks.**

As a reminder, a 100-year flood means that there is a 1 in 100 probability that a flood of this magnitude will occur each year. **It can then be assumed that the period of return of this type of flood is reduced (**1 out of 90, 1 out of 80 …?). It is therefore necessary to list at best the stakes of the territory in order to work to reduce their vulnerability to a risk that will become more frequent.

The hazard chosen for phase 2 is therefore the local modelling of SmageAa, which is the finest data available. It should be noted that, in the absence of local modelling data on other territories, the use of PPRI zoning would be a possible alternative.

In addition, this type of modelling could be adapted according to inlet water flows: an exploration track for SmageAa could be to exploit the results on extreme precipitation to modify the input water flow data to see how their model evolves.

2.3.2.2 Risk assessment: River Floods

To assess the risk of river flooding, **assuming an increase in the frequency of extreme rainfall events, should risk events become more frequent, action should be taken to reduce the vulnerability of territories to these risks** (see Extreme Precipitation risk).

The Scientific Committee concluded that the financial estimate obtained in phase 1 was unsatisfactory. Moreover, Luisa's non-match with precise and locally available land cover (OCS2D) did not allow us to associate the LUISA damage curve with OCS2D: a financial estimate of the damage on OCS2D could therefore not be made.

The issues studied were therefore the following:

- equipments
- Economic activity
- Facilities presenting an over-risk (ICPE, Seveso, wastewater treatment)
- Networks
- Buildings
- Population
- Vegetable and agricultural crops
- Urban planning (PLU/PLUI)

The GIS methodology made it possible to cross-reference data on issues with the hazard of SmageAa. To avoid biases related to the geolocation of stakes (an address point may not be impacted while the corresponding building is) and to extend research to strategic vulnerabilities (police station, rescue services, etc.) in the immediate vicinity, stakes located less than 150m from the zoning were also studied.

Here are some examples of maps, with different zooms on the territory of the SmageAa:

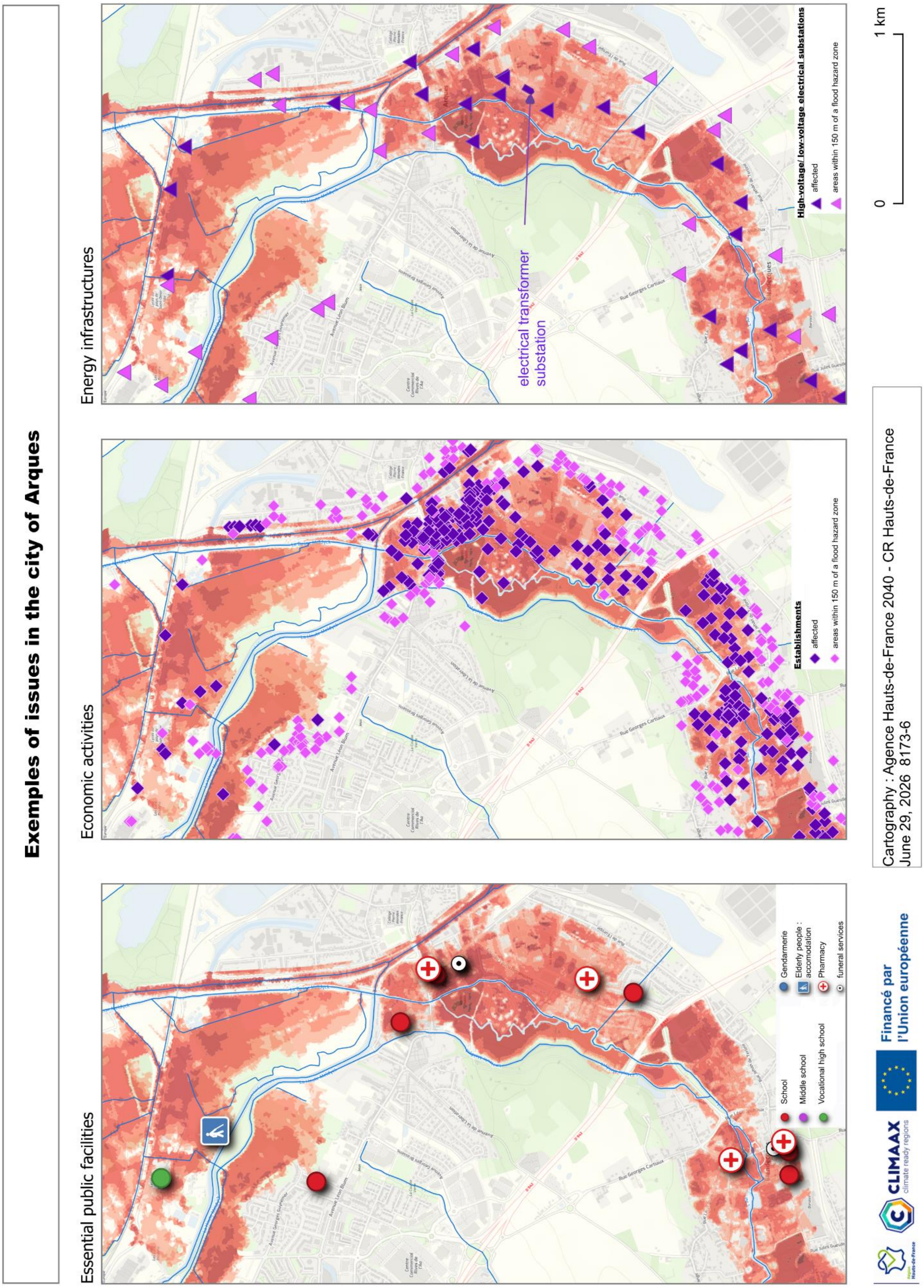


Figure 2.3: Examples of issues in the city of Arques

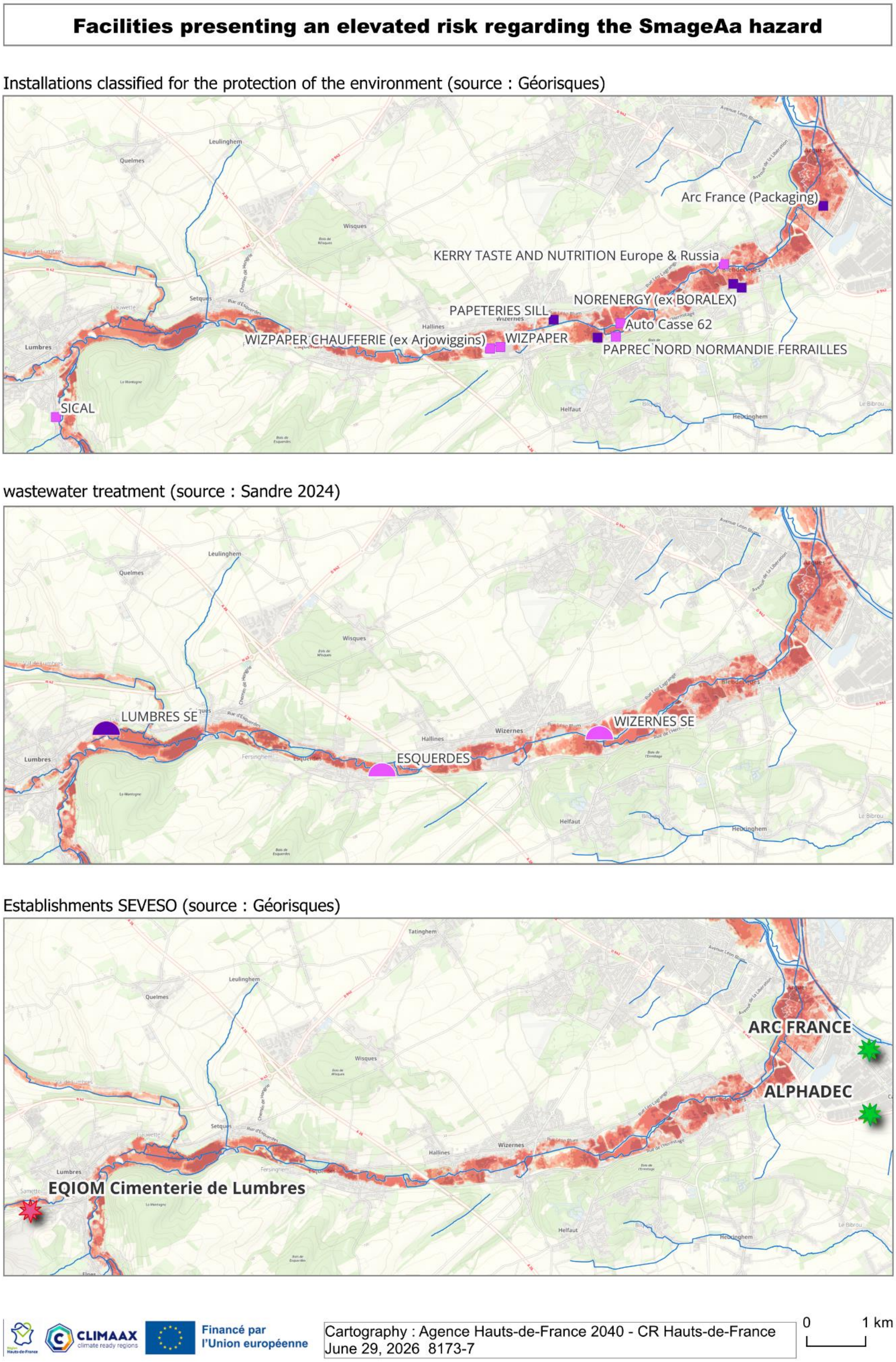
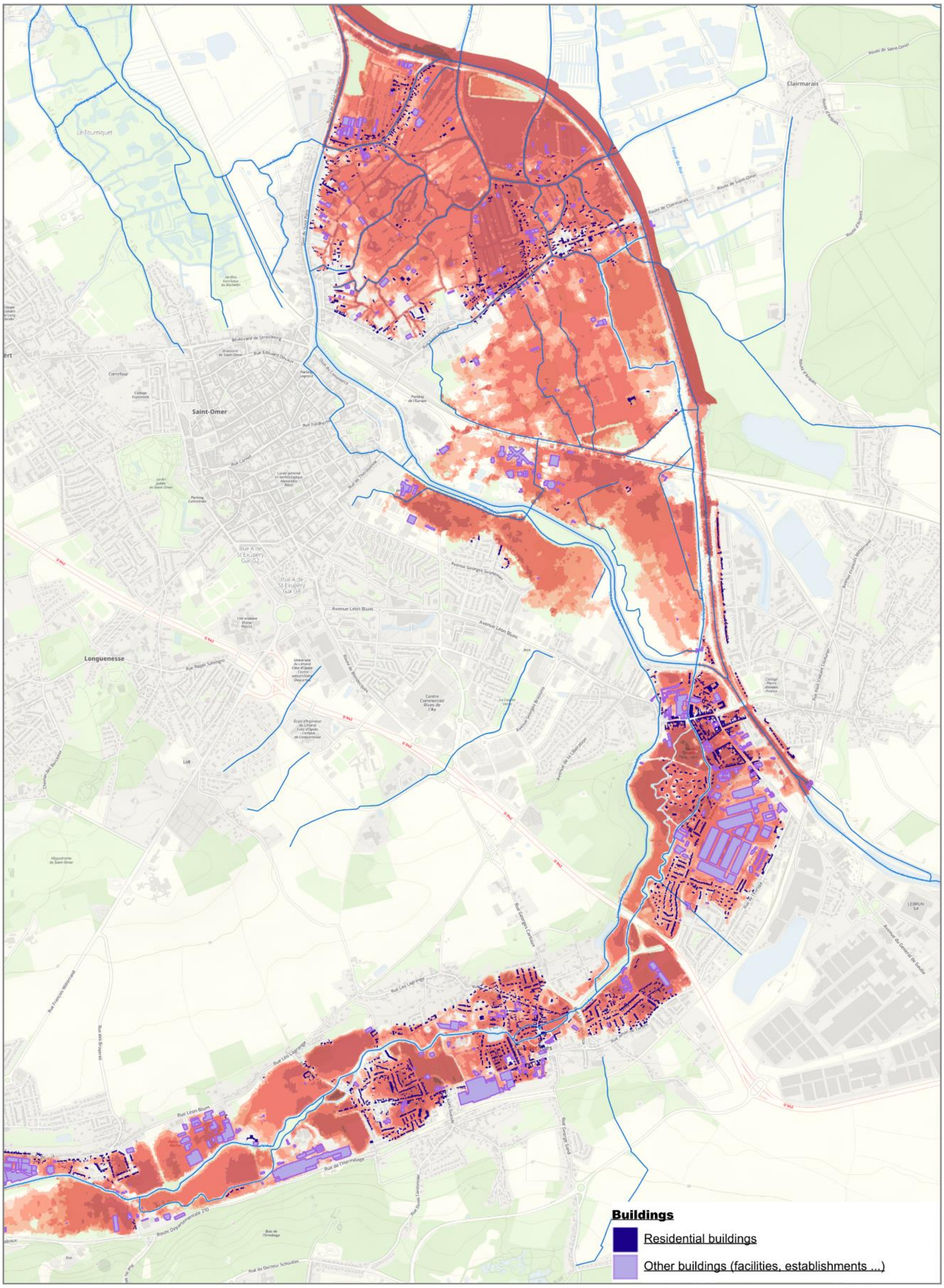


Figure 2.4: Establishments with an over-risk on SmageAa hazard

Impact of the SmageAa hazard on inhabited and uninhabited buildings



Financé par l'Union européenne

Cartography : Agence Hauts-de-France 2040 - CR Hauts-de-France - June 29, 2026 8173-8

0 0,5 km

Figure 2.5: Impact of the SmageAa hazard on inhabited and uninhabited buildings

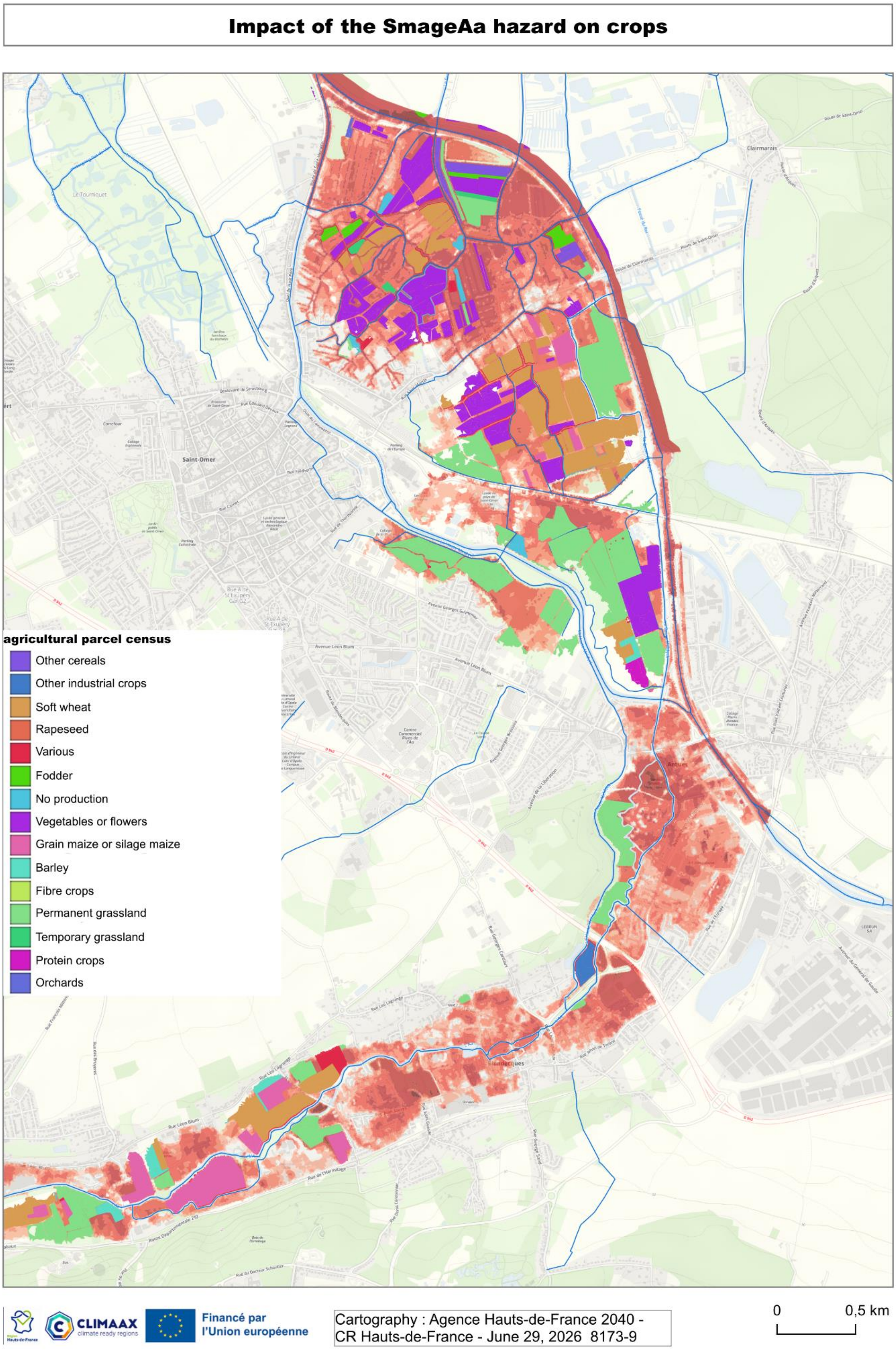


Figure 2.6: Impact of SmageAa hazard on crops

<u>Detail on the flood risk on the agricultural issue in the SmageAa territory:</u>

684 ha of impacted agricultural parcels including 478 ha of permanent grassland

- Distribution of the remaining 206 ha:

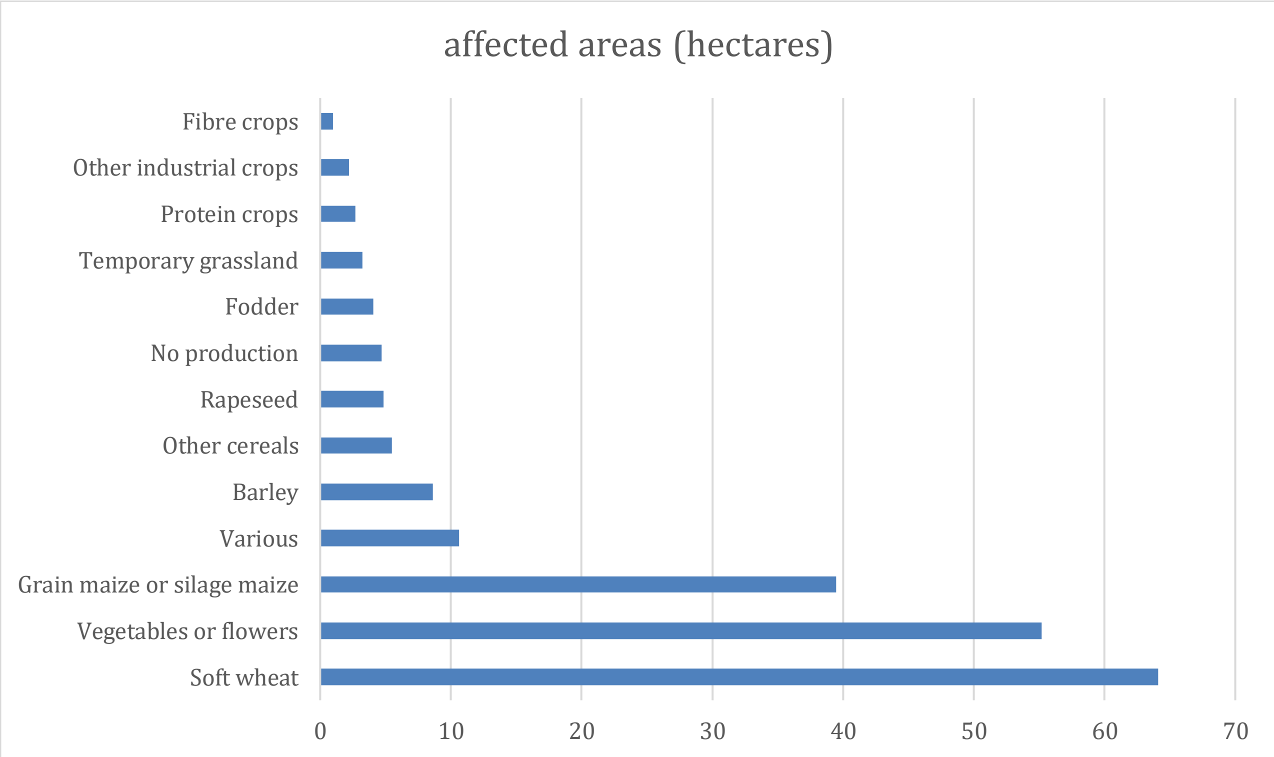


Figure 2.7: Agricultural areas impacted (in ha)

684 ha of agricultural plots are impacted, including 478 ha of permanent grassland. It is interesting to note that more than 2/3 of agricultural parcels are permanent grasslands, grasslands that play a major role in regulating flooding.

In addition, listing the types of crops makes it possible to see whether or not the crops are adapted to the risk. Indeed, a crop with sowing in spring will be less vulnerable to a flood event that is mostly present in winter. Adapting the crop type to seasonality according to the exposure to hazard means reducing the vulnerability of hazard and limiting potential losses for the farmer.

Overall results on the territory of SmageAa:

	Impacted by SmageAa modeling	**Less than 150m from SmageAa modelling (excluding flood zoning)**
equipments	222 equipment: - Health and social work: 60 - Services for individuals: 106 - Tourism: 3 - Shops: 19 - Educational institution: 7 - Sports, leisure and culture: 25 - Transport and travel: 2	497 equipment: - Health and social work: 118 - Services for individuals: 237 - Tourism: 3 - Shops: 65 - Educational institution: 32 - Sports, leisure and culture: 40 - Transport and travel: 2
Economic activity	971 establishments, including 160 employer establishments. Breakdown: 1 to 19 employees:136 20 to 99 employees: 17 more than 100 employees: 7	1775 establishments, including 811 employer establishments.
ICPE	6 establishments	18 establishments
Seveso	None according to GIS treatment although buildings in a seveso site have been impacted (see map)	None according to the GIS treatment although buildings from a second seveso site were impacted (see map)
Wastewater treatment	3 stations	5 stations
Electrical transformer substation	3 posts	None
HTA/BT substations	81 posts	203 posts
Buildings	6 934 building	13,969 buildings
Population	7 778 inhabitants	15,604 inhabitants
Agriculture and market gardening	684 ha of agricultural parcels including 478 ha of permanent grassland	/

Map comments and analysis of results:

Map of essential equipment (figure 2.3) :

The identification of equipment must enable the competent authorities to organise the crisis situation and the post-crisis situation in the best possible way.

On the map presented, we made a distinction between the impacted educational institutions: unavailability of the site for the reception of pupils, such equipment cannot also accommodate an audience that would need emergency accommodation.

An elderly accommodation facility is also impacted: how to anticipate its evacuation or, failing that, the safety of the occupants ? How to ensure continuity of care if accessibility is cut or networks (water, electricity…) are degraded.

Pharmacies are also affected, as are doctors, nurses and other medical personnel (not represented on the map but available in the database. We identified 60 of them, directly impacted on the territory studied). How to ensure continuity of care for the patient of these health professionals?

Identification and mapping can make it possible, thematically, to prioritise what needs to be protected, evacuated, or taken over by other actors or structures. Knowing the impact of a major flood event is the first step in reducing the vulnerability of this essential equipment on a daily basis.

Map of economic activities (figure 2.3) :

971 establishments are directly impacted. While many are self-employed, 160 are employer establishments. The objective of this map is to enable the intermunicipalities in charge of economic development to measure the impact of a major flood on their territory, and to work with the companies concerned to reduce their vulnerability to risk: What steps have they taken to protect themselves in the event of a new flood event? What are their brakes? Are certain sectors or companies strategic for the territory concerned? The detailed database with the names of the companies and the estimated water heights is shared with the SmageAa, which will relay it to the EPCIs who wish to do so.

Energy infrastructure map (figure 2.3) :

In collaboration with the electricity system operator, the objective of identifying power stations threatened by a flood is to identify equipment or structuring companies dependent on these stations and for which a power cut would have significant consequences. This includes, for example, reducing the vulnerability of hospitals, housing for the elderly, strategic companies or pump systems that are responsible for discharging water so that they do not find themselves cut off from the electricity grid.

Triple map of ICPEs, Seveso facilities and wastewater treatment facilities :

Over-risk, or cascading risk, concerns structures, which, when impacted by a major risk, in turn entail a risk related to their activity.

Wastewater treatment stations, depending on their configuration, could lead to environmental pollution in the event of overloading or overflowing on one of their basins.

A Seveso establishment or a Classified Facility for Environmental Protection (ICPE) also fits into this scenario. For example, an ICPE facility storing chemicals could pose the risk that they will disperse to the environment.

Moreover, while the GIS treatments did not highlight them, two Seveso establishments were impacted in 2024 by the Aa flood: Equiom and Arc France. Indeed, the geolocation of establishments is done at the address point. Outside, these companies often occupy very large plots and several buildings, and the latter can be impacted for some even if the address is not. The State and relief organisation services (SDIS) will then be able to approach the ICPE and Seveso establishments concerned in order to work to reduce the vulnerability of these sites.

Map of buildings:

The population of the territory was broken down into residential buildings, which made it possible to estimate at 7 778 inhabitants impacted by the modeling of the SmageAa.

Urban planning:

An area to be urbanised (1Au) has been identified in the Local Urban Plans in the SmageAa flood zone. The municipality has to limit or adapt the constructions on this area identified as vulnerable.

Conclusion on the risk of river floods:

In the case of an increase in the frequency of extreme rain events, drawing up a complete inventory of the issues at stake may make it possible **to prioritise the actions to be taken** by the actors concerned in order to reduce the vulnerability of the territory:

- **Developing a culture of risk:** through Axis 1 of the PAPIs (Improvement of risk awareness and awareness through awareness-raising and information actions), and through the Communal or Intercommunal Safeguard Plans (PCS/PICS) to anticipate crisis management
- **Developing collective arrangements and protections:**
    - Creation of flood expansion zones
    - Elevation of dykes
    - Installation of pumps
    - Establishing controlled urbanization
- **Put in place ‘individual’ protections:**
    - Equipment for individuals or businesses in cofferdams
    - Lifting of electrical installations during renovation work, raising of house equipment, etc.
    - Moving sensitive equipment to higher levels for companies (IT servers, … etc.).

2.3.3 Hazard #3 - Coastal floods finetuning to local context

*Existing data **not taken into account** in phase 2 of the ATLAS project:*

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Centennial event 2050 – RCP 8.5 (MERIT-DEM)			*- Not taking into account existing protections* *- The depth of flooding is based on a static model, not a dynamic one*
Area exposed to sea level rise at high tide: rise from 0.5m to 50years (BRGM)			*- Not taking into account existing protections* *- The depth of flooding is based on a static model, not a dynamic one*
TRI (Territories at high risk of flooding): regulatory hazard			*- Limited study rights*

The other data on mobilizable challenges are identical to the risk of river floods

2.3.3.1 Hazard assessment: coastal floods

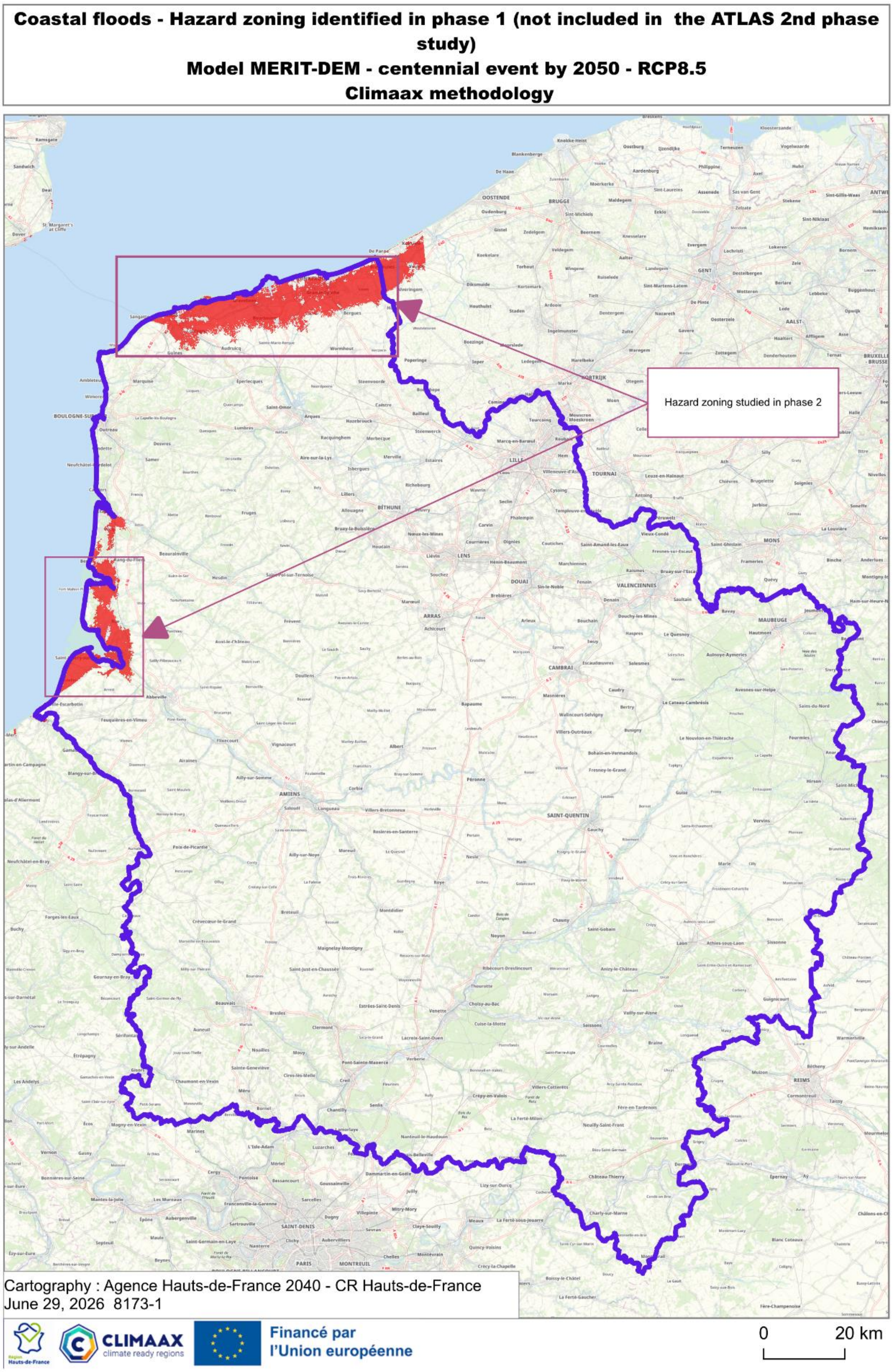


Figure 2.8: Hazardszoning identified in phase 1 – MERIT DEM model – 100-year event 2050 – RCP 8.5

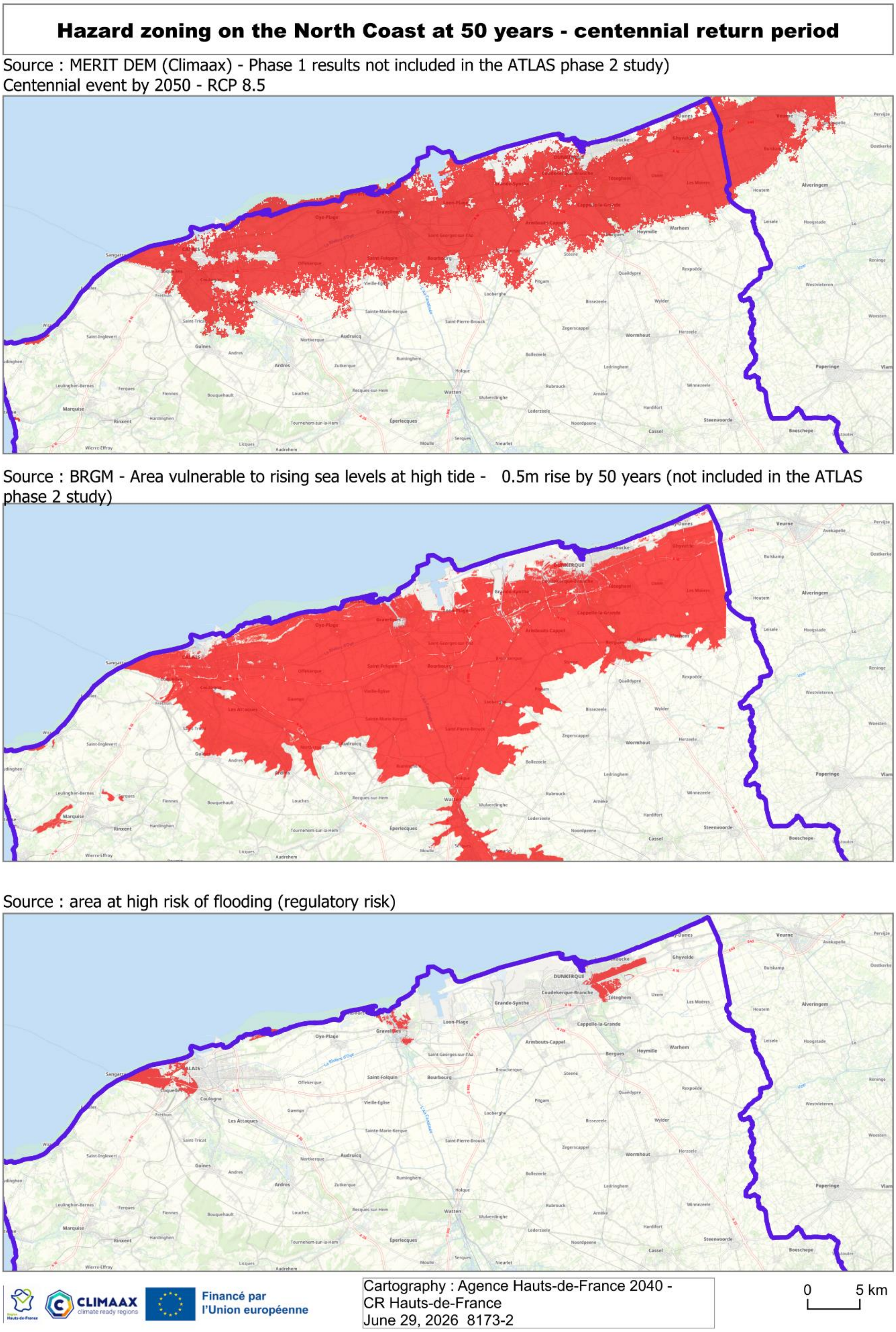


Figure 2.9: Hazard zoning on the North Coast at 50 years – centennial return period

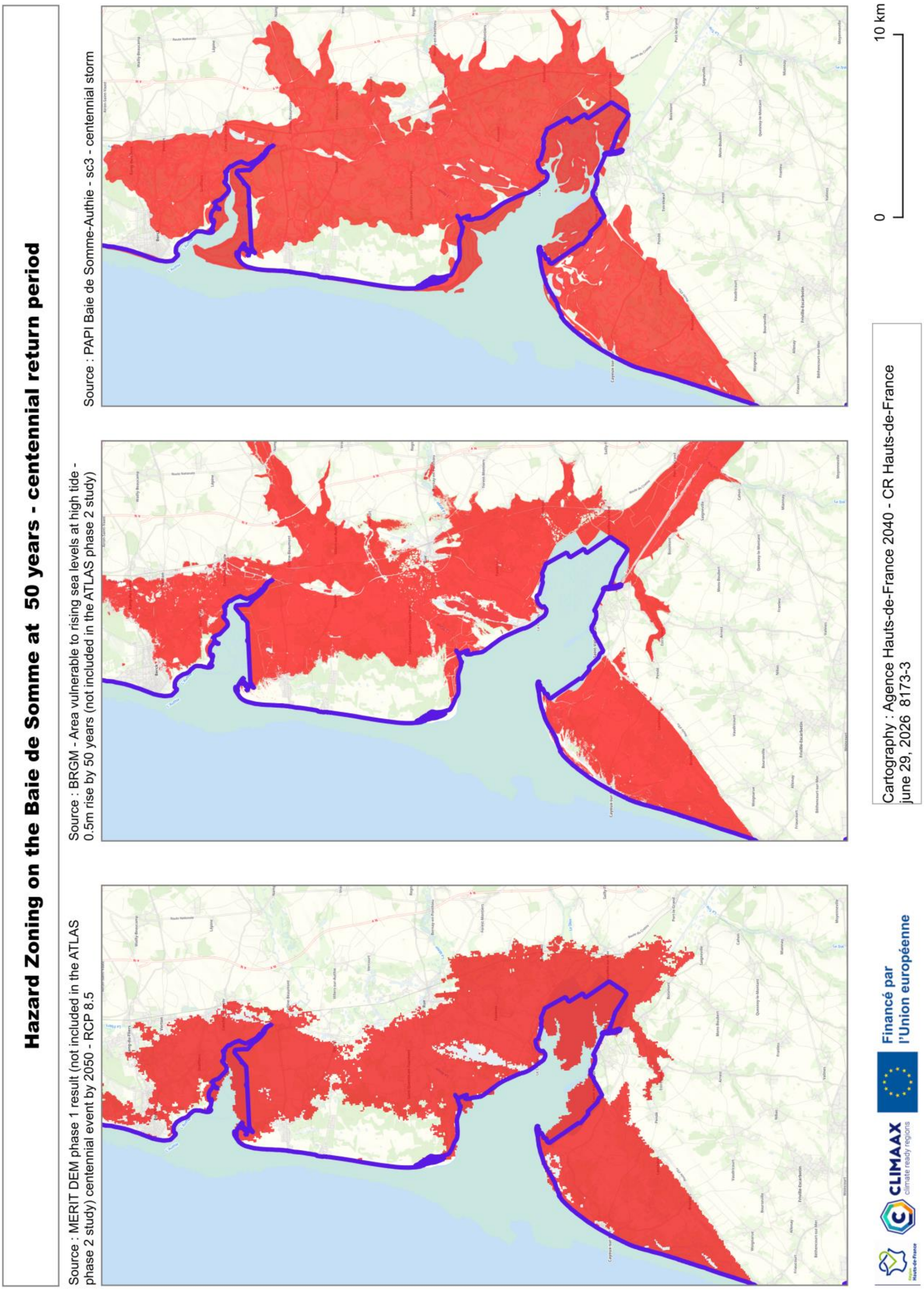


Figure 2.10: Hazard zoning on the Bay of Somme at 50 – return period of 100 years

To study the risk of coastal floods in phase 2, the work focused on two territories in the Hauts de France, with different geographical and geomorphological conditions:

- the coastline between Calais and Dunkirk (also known as the Polders or Wateringues area for the hinterland of the cordon littoral)
- the Coastal Bay of Somme - Authia

The hazard data available were as follows:

- Centennial event data 2050 – RCP 8.5 (MERIT-DEM)
- The area exposed to sea level rise at high tide: rise from 0.5m to 50 years (BRGM)
- TRI (Territories at high risk of flooding): regulatory hazard

On the coast between Calais and Dunkirk:

Following the presentation of the results of Phase 1, based on the exploitation of the results from the Merit-Dem hazard, the Scientific Committee alerted us to the lack of validity of the method for assessing the risks of marine submersions with the MERIT DEM model, applied to the polder area between the cities of Calais, Dunkirk and St-Omer. The overly schematic results were not realistic and did not take into account existing protections. In addition, the flood depth of this model is based on a static, non-dynamic model (which would take into account the propagation of water by structural failure or dune breach):

<< *This method takes into account data on sea level rise found in IPCC forecasts (+ 1 m in 2100) and wind and barometric depression-related sea level rises during storms (surges). These data are quite correct. By contrast, subsequently, the method consists of vertically varying the water levels on a relief map (Digital Terrain Model NTM). In low-lying areas, such as polders, this actually means that the topographic basin fills with water from below, i.e. from its lowest point, and that the water spreads homogeneously all around this imaginary water inlet point. This is not at all realistic and too schematic. Such maps have already been produced and widely publicised by the Climate Central Group (https://www.climatecentral.org/). They have been the subject of fierce criticism from the scientific community. Taking into account a level corresponding to a maximum tide (More High Astronomical Seas) today, we thus obtain in the polders of the Flemish maritime plain, a flood zone on almost the entire polder. However, the polder is not flooded because it is isolated from the sea by dune cords and anthropogenic infrastructure (dikes, docks).*

For the inner part of the polder, a coastal flood must be treated as a continental flood in a valley. As a first step, it is necessary to determine a water injection point at shore level, when crossing a port dock or breaking a dyke or dune cord. Secondly, the propagation of the water table is modelled according to the topography (slope), the roughness and permeability of the soil and, of course, according to the sea level at descending tide.

Coastal flood maps from the MERIT DEM modelling of the polder area cannot be disseminated as they are. They are exposed to criticism that could discredit the results of the project among local actors. This analysis is shared by several local actors to whom we presented them>>

The Merit-Dem data is closer in its logic of constitution to the data produced by the BRGM, which displays the same methodological limits.

The only alternative data available in this territory is that of TRI. The difference between this data and the previous two is very important, and it is not possible to determine whether these zonings are representative of what could be an episode of marine submergence impacted by climate change by 2050.

Nevertheless, some studies are under way with local authorities in the same territory, and should make it possible to better understand the risk in the coming months. Since the GIS methodology for cross-referencing data on hazards and challenges is similar between river and coastal floods, it will then be entirely possible to carry out the same treatments to map the vulnerability of these territories to a better-defined coastal flood risk.

On the coast Baie de Somme – Authie (BSA):

On the Baie de Somme – Authie coast, the Mixed Union of Bay of Somme - large Picardy coastline has already carried out submersion studies in 2015 and 2025 as part of their PAPI.

In this context, we were able to retrieve GIS data from PAPI 2015, which allowed us to compare them with the other sources of hazards available (Merit-Dem and BRGM). As can be seen on the map of the Bay of Somme, and unlike the Calais-Dunkerque coastline, the 3 models converge in broad lines, for similar events.

It should be noted that the PAPI BSA (Bay of Somme) pushes the analysis in depth, because it analyses the concommitance of the risks of marine submersion AND river flooding, through multiple scenarios varying the return periods of the various hazards.

In addition, the IPCC's global warming scenarios are also taken into account in the constitution of the hazards of the PAPI BSA.

2.3.3.2 Risk assessment: coastal floods

On the coast between Calais and Dunkirk:

In view of the warnings and limits set out for the hazards available on the coast between Calais and Dunkirk, the risk analysis cannot be carried out reliably in that territory.

However, since the GIS methodology for cross-checking data on hazards and challenges is similar between river and coastal floods, it will be possible to study the risk as soon as the data currently being developed in this territory will be available.

On the coast Baie de Somme – Authie (BSA):

In this territory, hazard models (Merit-Dem, BRGM, PAPI BSA) converge (in part), with local models that take climate change into account.

Applying the GIS processing methodology with PAPI BSA hazard data could have been relevant. Nevertheless, this work of analysis of the stakes has already been carried out in this territory in a very precise way through the PAPI BSA 2025.

The full risk analysis is available via this link:

https://www.baiedesomme.org/actu/9035-le-nouveau-papi-est-en-ligne-consultez-le-et-donnez-votre-avis

Regional risk analysis

In this context, applying a general risk analysis methodology with very large deviations between the proposed contingencies was not appropriate.

An analysis of issues similar to river flood risks remains possible as soon as local coastal flood hazard data is available.

Point of vigilance:

Some actors use the Merit-Dem model (or similar models) for their uses. In particular, some banks and insurance companies use them to assess the risk of their portfolio of assets, whether they are assets to be financed or assets to be insured against risks.

As these data are controversial, some territories may find themselves penalized in the financing of their development projects if they find themselves on land wrongly identified as at risk. It is therefore important to compile accurate hazard data on these territories, and that these data are freely accessible (opendata) for use shared by as many stakeholders as possible.

2.4 Key Risk Assessment Findings (matrix)

2.4.1 Mode of engagement for participation

With the support of SmageAa, different categories of stakeholders from the territory were invited to a workshop with the aim of:

- Sharing knowledge and collective reflection to reduce the vulnerability of the territory
- To discuss the issues already identified by the SmageAa
- Prioritize the issues to be protected from future hazards according to the resilience capacities of the territory.

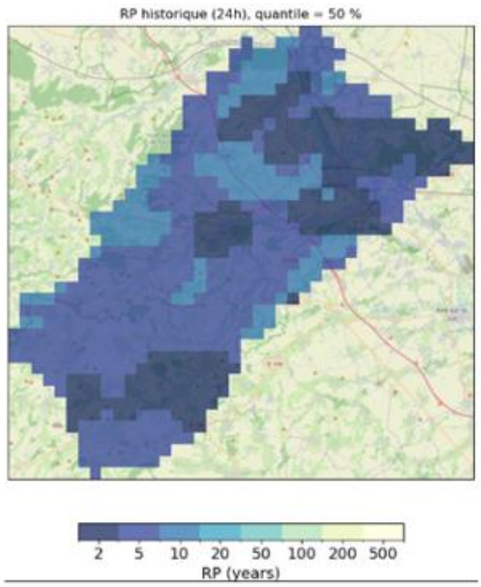
The discussions to reflect collectively on the severity and urgency of the risks and then on the resilience capacity of the territory were based on the situation experienced by the participants during the floods in the winter of 2023-2024.

1. 2.4.2 Gather output from Risk Analysis step

The development of the matrix was established during a participatory workshop to which stakeholders from the territory were invited: elected officials, technical agents of municipalities, EPCI or river managers, representatives of associations of inhabitants or civil protection and firefighters, representatives of associations of management of natural environments, the representative of a large company was present. (26 participants).

Application of EXPLORE 2 data for the risk assessment of extreme precipitation specifically in the SmageAa territory.

Historical period	Prospective data RCP 8.5
Median of the accumulation on 24 h	Median of the accumulation on 24 h



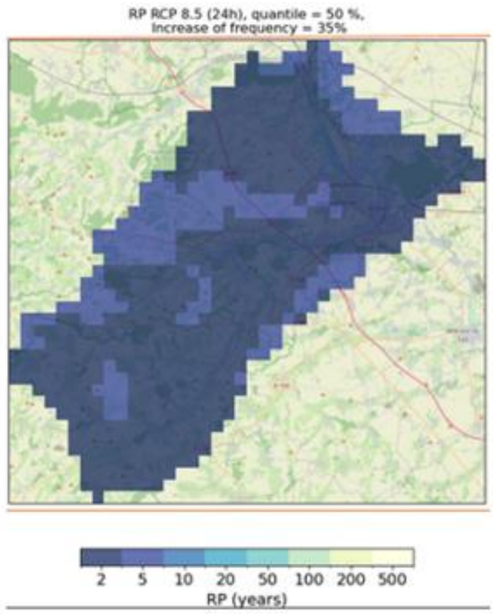
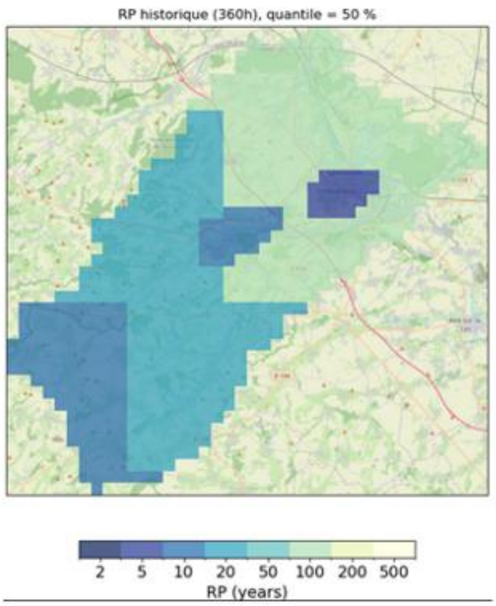


Figure 2.11: Comparison of the modeling of the median of the frequency of extreme precipitation over 24 hours with the RCP 8.5 between historical period and medium term on the territory of SmageAa

The results show a medium-term increase in the frequency of extreme precipitation over 24 hours of **35%** in median with the RCP 8.5 scenario compared to the median of the historical period on the territory of SmageAa.

Historical period

Median of the accumulation on 360 h



Prospective data RCP 8.5

Median of the accumulation on 360 h

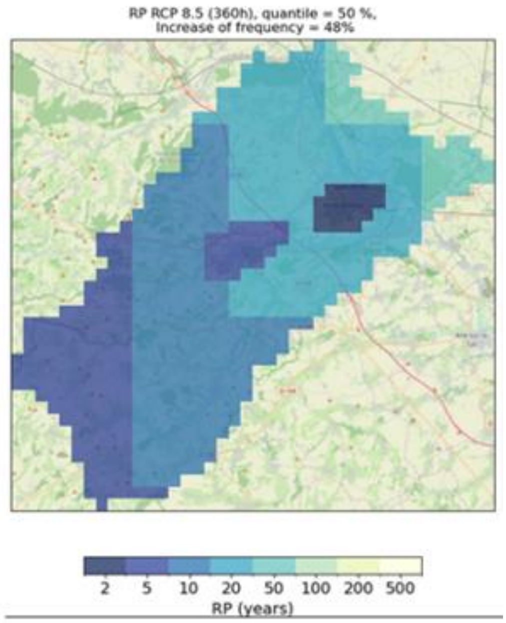


Figure 2.12: Comparison of the modeling of the median of the frequency of extreme precipitation over 360 h with the RCP 8.5 between historical period and medium term on the territory of SmageAa

The results show a medium-term increase in the frequency of extreme precipitation over 360 h of **48%** in median with the scenario RCP 8.5 compared to the median of the historical period on the territory of SmageAa.

2.4.3 Assess Severity

The flood data presented in the workshop reflect the reality. They made it possible to identify the issues impacted during the flooding of the 10-year-old Aa and its tributaries that occurred during the winter of 2023-2024.

For extreme precipitation, the models agree on an increase in the frequency of risks, but it seemed useful for participants to complement the risk analysis with the RCP 4.5 scenario and study them by 2050 and 2100. A manager of the Institution Intercommunale des Wateringues (Aa River downstream) stated that, although the modelling presented was pessimistic, the precipitation and flooding events of winter 2023-2024 exceeded this one.

The views of the workshop participants were divided on the increase in risk in the future.

The consequences of the floods were different upstream or downstream of the river due to the duration of the exposure (longer duration downstream in the marsh area).

The need to improve crisis management has been largely consensual. Suggestions for improvement were made: inclusion of residents and care workers in the preparation of municipal safeguarding plans, identification of resources and fall-back rooms to be mobilised in times of crisis, creation of a network of referrals by neighbourhoods to organise mutual assistance. Municipal safeguarding plans must be dynamic tools and the organisation of regular crisis simulation exercises should be implemented.

Concerns were expressed about continued access to drinking water, especially in case of pollution during crises.

The deteriorating insurability of assets is a concern for participants. Compensation costs are higher in modern homes with electronic (home automation) equipment. Households with low incomes, housed in areas more prone to flooding for reasons of affordability of residences, were found to be more vulnerable.

Some areas of the territory have become uninhabitable: a district of a municipality has been demolished because it is too exposed to the risk of flooding.

The flooding caused impacts on roads and works of art, power grids with interruption of supply to certain neighbourhoods.

The activity of a few large companies has been interrupted. This crisis has led some to the implementation of new procedures or work to better deal with future events. Electricity system operators shall also take measures to strengthen the resilience of their equipment, in particular those located in flood-prone areas.

Economic losses were noted and some individual entrepreneurs were only able to resume their activities several months after the floods.

Impacts on biodiversity have been underestimated, particularly for soil fauna, and there has been an increase in invasive alien species following flooding.

The psychosocial impacts of floods are repeated during rain or thunderstorm events.

Participants raised the risk of companies being relocated. The attractiveness of the territory is considered to be declining by several of them.

Decision-making and action capacities were considered to be very long and insufficient in planning or climate change adaptation planning documents in some exposed territories. This may be linked to the difficulty of designing the level of risk from which it would be desirable to protect oneself and a question about the effectiveness of the improvements already made in the event that the level of risk increases. Moreover, national regulatory procedures are likely to delay the implementation of adaptation projects.

Heavy rainfall and river floods:
Current: <u>Substancial</u> - Future: <u>substancial</u>

2.4.4 Assess Urgency

The risk of flooding can be associated with sudden storm-like events causing runoff. During the last floods, residents had to be evacuated urgently.
The participants considered that there was an urgent need to act, but that a distinction had to be made between different temporalities: time for reflection, necessary studies and work planning; the need for urgent work; the time of public awareness, communication to maintain the memory of risk, upstream of crisis situations.
These different temporalities refer to the question of prioritizing the different risk reduction measures.

Heavy rainfall and river floods: <u>Immediate action needed</u>

2.4.5 Understand Resilience Capacity

An action plan exists on the territory of SmageAa under the PAPI.

Nevertheless, actions to be strengthened were mentioned by the participants: an integrated vision of development, the development of permeable surfaces in urban areas and the improvement of sustainable stormwater management, the rehabilitation of hydraulic traps in the marsh area to retain water.

Governance with coordination between public services should be improved as well as vigilance systems. The culture of risk remains to be developed, particularly among residents to encourage the establishment of personal protection systems, including for movable property (e.g.: cars, domestic animals …).

There is a discrepancy between the State and local authorities on the assumption of protection costs: sparsely urbanised areas are considered to be less of a priority than more populated areas.

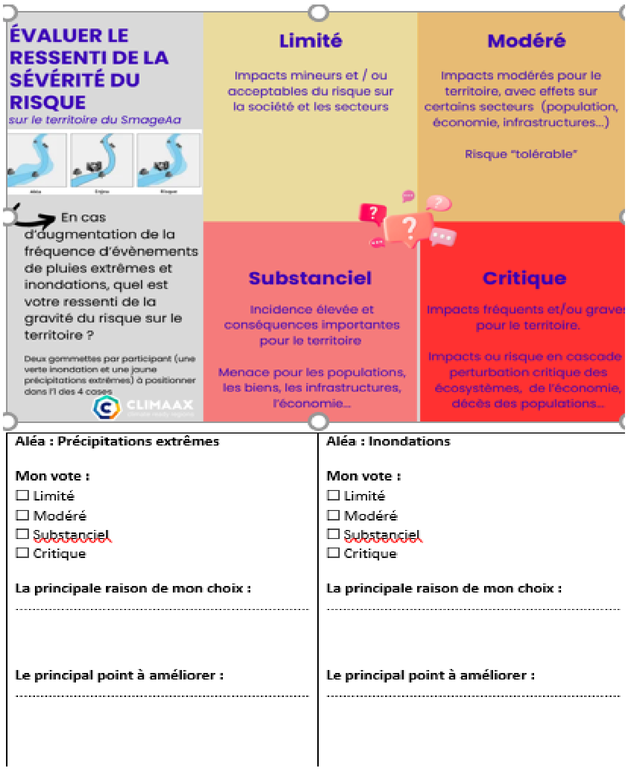
SmageAa is working on a new PAPI that integrates climate change into risk models. The protection objective of this next PAPI is to protect the territory from a 50-year flood. The arbitration of induced costs will be offered to local elected representatives in autumn 2026. SmageAa found that companies were not yet engaged in risk reduction actions but were waiting for actions. The development of risk culture should support the implementation of risk culture. The SmageAa can support companies with less than 20 employees under the PAPI.

Heavy rainfall and river floods: <u>Medium</u>

2.4.6 Decide on Risk Priority

Stakeholders in the SmageAa territory were consulted on their perception of the severity and urgency of the risks and on the resilience capacities of the territory based on the guide questions proposed by Climaax. At the end of the exchanges of each sequence, the participants were asked to vote individually on their assessment of the level of severity or urgency of the risks and then of the resilience capacity of the territory.

Example of a voting medium given to each participant in the workshop:



At the end of the workshop, we summarised all the participants' votes for each exchange sequence. This made it possible to determine the results which garnered a majority of votes.

Heavy rainfall: High priority. The hazard can occur at any time, its frequency will increase, it has immediate effects on the resource and facilities and requires improved vigilance and communication, particularly between actors. There is scope for progress on developing a culture of risk, controlling urbanisation, managing stormwater and ditches, and adapting retention structures.

Floods: High priority. The risk increases but there are differences within the territory on the stakes and the need to act. Consideration of the impacts of floods on biodiversity and the use of nature-based adaptation solutions need to be improved. There was room for improvement in the training of the population (risk education, training in first aid for citizens), the coordination of actors and the control of urbanisation.

Table 2-4 Key Risk Assessmentthrough risk ranking, considering severity, urgency and reslience capacity

Hazard	**Severity**		**Urgency**	**Resilience capacity**	**Priority**
	Current	Future			
Flood river	substancial	substancial	Immediate action needed	Medium	**High**
Heavy rainfall	substancial	substancial	Immediate action needed	Medium	**High**

Severity	**Urgency**	**Resilience Capacity**	**Risk Ranking**
Critical	Immediate action needed	High	Very high
Substantial	More action needed	Substantial	High
Moderate	Watching brief	Medium	Moderate
Limited	No action needed	Low	Low

2.5 Monitoring and Evaluation

Methodological transition
Regarding flood risks, the project initially relied on Python scripts for data processing. Consideration has been given to switching to a GIS (Geographic Information System) approach, which is more adapted to the needs and geography of the territories concerned. This transition took time to assess gains and constraints, delaying the decision to abandon scripts.

Mandatory manual test phase
Before automating the processing (e.g. via a service provider, which would have justified the use of the financial envelope), it was necessary to manually validate the GIS processes. This step confirmed the technical feasibility, but also revealed that the time remaining before the end of phase 2 no longer allowed for external consultation.

Incompatibility with global planning
Once the manual tests have been completed, the deadline for:

- Launch a consultation,
- Select a provider,
- Develop and validate an automated solution,

would have exceeded the project deadlines. The envelope could therefore not be mobilised in this context.

Possible postponement to the next phase
If the financial envelope remains available and can be reallocated to **phase 3 of the project,** an analysis can be carried out to assess whether the automation needs (via GIS or otherwise) justify its use in this new context.

The second phase of the work allowed us to draw new lessons confirming the value of a regionalised analysis of hazards and risks.

We obtained confirmation of the **territorialised increase in the frequency of extreme precipitation in the** medium term with the two scenarios RCP 4.5 and 8.5:

Results obtained with scenarios RCP 4.5 and 8.5:

- Increase in the frequency of extreme winter rains (duration of 15 days) on the heights of Pas-de-Calais , l'Avesnois - Thiérache, Picardie maritime
- for 24-hour rains, even with drier models, increase in the frequency of rains over the north-west and south-east thirds of the region; the whole area south of a Creil-Avesnes-sur-Helpe line and the whole area north of an Amiens-Armentière line are subject to a higher risk of high daily rain.

With scenario 8.5, the increased frequency of risk increases compared to scenario 4.5 .

Long-term events (360 h) are more sensitive to climate change than short-term events (24 h): with scenario 4.5, 21% increase in the frequency of precipitation in the median for a period of 360 hours compared with 12% for a period of 24 hours.

We were able to collect local data on river flood hazards and found that data holders had knowledge of hazards based on historical flood data.

Several local actors or State operators are implementing studies or tools intended to have a more detailed knowledge of the hazards and risks of coastal flooding. The results of this work are not yet available.

These hazards and risks are currently listed in coastal risk protection plans (PPRL), but these regulatory tools are often about ten years old and need to be updated.

We were able to see from the pilot area of SmageAa, which suffered the floods in the winter of 2023-2024, that the identification of the challenges was of concrete interest to local stakeholders: knowledge of the realistic exposure of the goods affected by the hazards, use of the issues analysed with the regional GIS data in the context of the development of the next SmageAa PAPI.

The consultation of stakeholders from the SmageAa territory highlighted different topics:

- The importance of developing a culture of risk among residents and businesses;
- The need to continue raising awareness and informing local elected representatives in order to encourage them to implement integrated public planning policies based on contingency modelling.
- The need to improve alert systems and coordination of public services in crisis situations
- The difficulty of implementing collective risk-reduction arrangements due, on the one hand, to the cost-effectiveness of the works and, on the other hand, to persistent uncertainties despite modelling on the level of risk to be anticipated.
- Insufficient assessment of the impact of floods on biodiversity
- The need to strengthen the consideration of certain adaptation levers such as nature-based solutions.
- Risks to the maintenance of the insurability of assets or a significant increase in contributions.

These topics can be taken up again in phase 3 where we will explore adaptation solutions in new voluntary territories.

Given the volume of data collected and to be processed at regional level, we need to continue processing this data in new territories to identify local challenges and discuss appropriate adaptation solutions with local actors and decision-makers.

2.6 Work plan for Phase 3

In phase 3, we plan to extend the analysis of hazards and flood risks in new territories: Basin of Oise and Aisne, downstream basin of Aa on the territory of Wateringues, coastal flooding of Pas-de-Calais. This analysis will serve as a basis for discussion with these territories and their stakeholders. The aim is to gather their observations in order to make the results more reliable and to identify the adaptation strategies already implemented and, possibly, to be developed.

A peer-to-peer exchange time will be scheduled in these territories to share operational information, best practices and feedback, including consideration of vulnerable populations and nature-based solutions.

We plan to automate the methodology used in phase 2 to identify challenges, through automation GIS tools for better reproducibility of risk analyses.

All the results obtained will be the subject of pedagogical publications with the aim of facilitating the understanding of the hazards and risks analysed in the framework of the project via various media: online publications on the Agence Hauts-de-France website, linkedIn posts on various … accounts. A final publication on the project will be produced.

We will work to identify how these results can be reported in the SRADDET to better inform regional and local decision-makers on the evolution of climate change and flood risks with the aim of incentivising the implementation of regional and local adaptation strategies.

We plan to draw up a report of recommendations for the revision of the SRADDET, based on the results of the project, both in terms of hazards and risks and the territorial adaptation strategies observed.

On the basis of all this information, we plan to organise a final seminar involving territorial actors and regional partners.

Regional elected representatives will be involved in the orientations given at this seminar during the second steering committee of the project. The recommendations for SRADDET will be discussed with them with a view to obtaining their validation.

Finally, we will participate in the Climaax workshop in December 2026.

3 Conclusions Phase 2 - Climate risk assessment

The second phase of the ATLAS project allowed us to strengthen the assessment of regional risks at different scales according to the workflows studied.

It also identified local hazard and risk data held by local river and coastal flood risk managers and reviewed ongoing studies and tools to refine modelling.

During this phase, we widened the consultation on the results obtained with regional decision-makers and new territorial and economic actors and gathered their observations. These will be used during the continuation of the project in phase 3. We became aware of the growing interest of a variety of regional actors in the precise identification of hazards and the need to implement adaptation actions, in their respective areas of competence.

Main results / workflow:

Heavy rainfall:

Phase 2 of the ATLAS project identified medium-term hazards and risks of extreme precipitation hazards and risks from the EXPLORE 2 dataset and the national natural disaster database with scenarios RCP 4.5 and 8.5.

We retained the confirmation of the hazard and **the territorialised increase in the frequency of extreme precipitation in the medium term with the two scenarios RCP 4.5 and 8.5.**

River floods:

We concretely tested the assessment of river flooding issues in the pilot territory of the SmageAa - upstream valley of the river Aa, and noted the interest of territorial risk managers in the results obtained. The cross-referencing of the hazards analysed by these managers with the data on issues provided by the Regional Geographic Information Service constitutes for these actors a definite added value for their ongoing work on the adaptation and development of the new PAPI.

<u>Coastal floods</u>

We carried out a comparative and critical analysis of the different models on two coastal features of the territory and observed a distinction in the reliability of the MERIT DEM model in these two territories.

The lessons learned from stakeholders in the SmageAa territory gathered in a workshop alert us to topics to be discussed in phase 3 with new territories to consolidate local adaptation solutions.

We need to continue the risk assessment of river and coastal floods in phase 3 in new voluntary territories to deepen the risk assessment at regional level and draw conclusions that will allow us to draw recommendations for improving the SRADDET objective “Adaptation of territories to climate change”.

4 Progress evaluation

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
… 1 risk matrix designed to assess the probability of danger and impact, using the methodology and tools provided by CLIMAAX	Achieved
… At least 9 regional maps showing the climatic hazards at different timescales in the future. These maps can be adapted to sub-regional scales where data is available and relevant to adaptation	Achieved
For a least 2 workflows (river floods, coastal floods), cross-referencing risk data with land-use data held by the region's geographic information service (GIS): buildings, facilities for vulnerable people (e.g. hospitals), critical infrastructure (transport, …)	Applied for river flood Coastal flood: Planned for phase 3

Table 4-2 Overview milestones

Milestones	*Progress*
…workshop between the stakeholders	Achieved
… Creation of a complete database through its preparation and structuring *Preparation, publication and selection of the contract for assistance to the project*	Ongoing (across the project implementation) In reflection, several avenues of work are being considered

5 Supporting documentation

Datasets

Heavy rainfall Hazards

- *Explore 2*
- *Euro-Cordex*
- *Météo France :*
    - *hautsdefrance_heavy_rain_risk_tab_comparison_meteo_france_explore_2.csv*

Heavy rainfall risks

- https://handbook.climaax.eu/resources/datasets/precipitation_idf_europe.html
- *Catnat data :*
    - *hautsdefrance_heavy_rain_hazard_communes_HDF_RP_disaster.geojson*

River floods

- *Flood modeling for the SmageAa territory*
    - *hautsdefrance_riverflood_hazard_modeling_smageaa.geojson*
    - *hautsdefrance_riverflood_hazard_modeling_smageaa_buffer150m.geojson*
- *Data on assets at risk: listed and explained (p. 33) :*
    - *hautsdefrance_riverflood_exposure_bdnb.geojson*
    - *hautsdefrance_riverflood_exposure_bpe.geojson*
    - *hautsdefrance_riverflood_exposure_gpu.geojson*
    - *hautsdefrance_riverflood_exposure_icpe.geojson*
    - *hautsdefrance_riverflood_exposure_rpg.geojson*
    - *hautsdefrance_riverflood_exposure_rpg_smageaa.geojson*
    - *hautsdefrance_riverflood_exposure_seveso.geojson*
    - *hautsdefrance_riverflood_exposure_sirene.geojson*
    - *hautsdefrance_riverflood_exposure_substations_hta_bt.geojson*
    - *hautsdefrance_riverflood_exposure_transformer_stations.geojson*
    - *hautsdefrance_riverflood_exposure_wastewater_treatment_stations.geojson*

Coastal floods

- *MERIT – DEM*
- *TRI regulatory data*
- *BRGM data*

6 References

1 *Arnaud Héquette, "Landside Natural Hazards in Nord-Pas-de-Calais, France", VertigO - the electronic journal in environmental sciences [Online], Hors-série 8 | October 2010, published online on October 21, 2010. URL: http://journals.openedition.org/vertigo/10173; DOI: https://doi.org/10.4000/vertigo.10173*

2 *Central Reinsurance Fund: Natural disaster prevention through the Major Natural Hazards Prevention Fund - Hauts-de-France - 2023 edition*

3 *National Climate Change Adaptation Plan 3: https://www.ecologie.gouv.fr/sites/default/files/documents/PNACC3.pdf*

4 *DRIAS Climate portal: https://www.drias-climat.fr/*

5 *CATNAT database: https://www.data.gouv.fr/datasets/arretes-de-catastrophe-naturelle-en-france-metropolitaine-2*

6 *Information about CLIMAAX on the GREC Hauts-de-France website: https://www.grec-hautsdefrance.fr/climaax/*

7 *AGIRISK tool developed by CEREMA: https://agirisk.cerema.fr/*

8 *Banque de France, "The impact of floods on business performance and location" [Online]: https://www.banque-france.fr/fr/publications-et-statistiques/publications/limpact-des-inondations-sur-la-performance-des-entreprises-et-leur-localisation*

9 *PAPI documents Baie de Somme Grand Littoral Picard:* https://www.baiedesomme.org/actu/9035-le-nouveau-papi-est-en-ligne-consultez-le-et-donnez-votre-avis

10 *Study "Agricultural resilience" - Towards a sovereign, profitable and sustainable French agriculture by 2050 https://www.invivo-group.com/sites/default/files/documents/2026-04/Study_Resilience_Agricultural_2050_InVivo_VF.pdf*

11 *Links LinkedIn posts published on the project:*

https://www.linkedin.com/mwlite/feed/update/urn:li:activity:7473296815832993792?showCommentBox=true&origin=email