



Risk-based early warning system

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	4
1.0 INTRODUCTION	5
2.0 FLOOD MODELLING	6
2.1 Modelling inputs.....	6
2.2 Modelling outputs.....	7
3.0 HAZARD IMPACT ASSESSMENT	7
3.1 Modelling inputs.....	7
3.2 Modelling outputs.....	8
4.0 RISK-BASED EARLY WARNING SYSTEM	9
5.0 CONCLUSION	9
REFERENCES	10

EXECUTIVE SUMMARY

Flooding poses a significant global threat, causing widespread damage and impacting human lives and critical infrastructure. To improve response effectiveness, the ARSINOE project has developed a risk-based early warning system that integrates real-time flood forecasting with impact assessment. Utilising the CAFlood open-source modelling tool, ARSINOE provides actionable intelligence to decision-makers, enabling proactive measures such as targeted evacuations, infrastructure protection, and efficient resource allocation. The system relies on comprehensive data inputs including terrain models (LiDAR), land cover information, real-time rainfall measurements, building layouts and uses, hazard-damage curves, and critical infrastructure locations. A case study in Torbay, UK demonstrates the feasibility of ARSINOE, providing a 2-hour lead time for emergency response with a focus on balancing accuracy and computational speed. This system represents a significant advancement over traditional flood warning systems by shifting the focus from hazard identification to impact mitigation, ultimately enhancing community resilience and reducing flood-related losses. Future work will include incorporating human safety and public health risks into the assessment.

1.0 INTRODUCTION

Flooding consistently ranks among the most devastating natural disasters globally, causing widespread damage across multiple sectors. Beyond immediate physical destruction, floods pose significant threats to human lives and well-being, compromise public health through water contamination and disease outbreaks, cripple critical infrastructure such as power grids and transportation networks, inflict substantial losses on national and local economies, and jeopardise ecosystems and biodiversity (European Parliament, 2007). More importantly, the compromised vital lifelines and services such as healthcare, clean water supply, sanitation, electricity, and telecommunication networks, can significantly amplify the overall impact and substantially prolong the recovery process. These cascading effects often lead to increased vulnerability among affected populations, hindering access to essential resources and exacerbating existing inequalities (Mühlhofer et al., 2024).

Building societal resilience to disasters requires a fundamental shift towards proactive civil preparedness, moving beyond reactive responses to develop long-term strategies and policies that empower communities and strengthen infrastructure (Niinistö, 2024). This includes fostering public awareness and understanding of disaster risks, equipping individuals with essential response skills, and establishing robust emergency management systems capable of anticipating and mitigating the impacts of future events. Accurate and timely understanding of upcoming threats of flooding, including the severity and extents of hazards, their potential impacts on properties, and the knock-on effects, is essential for enabling proactive crisis management strategies that minimize damage and protect vulnerable communities (EEA, 2024).

Traditional early warning systems often focus on the description of hazard attributes, which may not highlight the actual flood influences of the society. Thus, ARSINOE proposes the risk-based early warning system that incorporates real-time flood forecast and hazard impact assessment to alert stakeholders about the impending flood risks, enabling proactive crisis management to:

- **Prioritize Evacuations:** Target evacuation orders to areas facing the greatest threat.
- **Protect Critical Infrastructure:** Implement measures to safeguard hospitals, power plants, transportation networks and other critical infrastructure.
- **Allocate Resources Effectively:** Deploy emergency response teams and supplies to where they are most needed.
- **Inform Community Preparedness:** Provide residents with specific information about potential risks in their area, empowering them to take appropriate protective actions.

Ultimately, a risk-based early warning system transforms flood warnings from general alerts into actionable intelligence, significantly enhancing the effectiveness of emergency response and reducing human and economic losses.

2.0 FLOOD MODELLING

Risk-based early warning requires a fast evaluation of flood impact based on hazard severity. Thus, rapid flood mapping tool is necessary to simulate flood propagations and analyse potential hazard characteristics. To fulfil the objective, the CAFlood model (Guidolin et al., 2016) is adopted and integrated with real-time weather observations in the work for flood forecasting. CAFlood is an open-source flood modelling tool that utilises parallel computing technology and simplified transition rules, based on Cellular Automata (CA), to simulate overland flows from diverse sources (Guidolin et al., 2016, 2015). The model has undergone validation against several UK Environment Agency test cases, which demonstrated good consistency when compared to the commercial flood model Infoworks ICM (Ghimire et al., 2012; Guidolin et al., 2016, 2015; Wang et al., 2018).

In ARSINOE, CAFlood was employed to replicate the evolution of floods induced by heavy rainfall or external inflow to the modelling domain. The outcome was anticipated to provide flood nowcasting or forecasting, enabling local stakeholders swiftly implementing hazard mitigation actions to strengthen climate resilience.

2.1 Modelling inputs

The required inputs for modelling include terrain data, precipitation, land cover, and initial and boundary conditions.

Terrain data: Water movement on the surface is mainly driven by the gravity such that the terrain elevation is the main factor in flood modelling. Digital Terrain Model (DTM) that adopts a vast number of selected coordinate points to capture the spatial variations of surface elevation (Miller and Laflamme, 1958) is commonly used in flood model modelling. Usually, the terrain data could be obtained from various sources, including ground survey, LiDAR (Light Detection and Ranging), photogrammetry, Shuttle Radar Topography Mission (SRTM) (NASA JPL, 2020), Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model (ASTER/GDEM) (NASA/METI/AIST/Japan Spacesystems And U.S./Japan ASTER Science Team, 2001).

Different technologies are applied nowadays to represent the environmental features. DTM is referring to bare-earth elevation without buildings, vegetations, etc., while Digital Surface Model (DSM) represents the elevation of everything on the Earth's surface that include ground, trees and manmade structures (Guth et al., 2021). In this work, DTM was used to delineate the boundary of catchments for flood modelling. To consider the influence of urban features such as buildings, bridges, culverts, and walls on surface runoff, DTM was manually edited reflect those artificial structures' existence (EA, 2019).

Higher resolution of terrain data can better describe topographical changes and enable more accurate flood simulation. LiDAR can provide metre or sub-metre resolution that is superior to data gathered from other sources, and its availability has boosted significantly in recent years. Nevertheless, high resolution modelling often exponentially increases the computational loads of modelling that restricts the possibility for real-time flood forecasting with for limited computing capacity. For flood modelling in ARSINOE Torbay Case Study, the DTM were obtained from the Defra Survey Data 1m LiDAR resolution (Defra, 2025). It was aggregated to a coarser resolution data to enable real-time forecasting.

Land cover: Surface condition plays a crucial role in overland flow movement: the soil infiltration may reduce the surface runoff quality, while vegetations and surface cover will affect the flow velocity. These attributes are non-uniformly distributed such that spatially varied infiltration and roughness parameters are used in flood modelling to reflect their influence. To determine the values of these parameters, land cover data are required as flood model inputs. Land cover can be obtained from the Open Street Map using the top-level tag landcover (OSM, 2025) or the CORINE land cover (Copernicus Services, 2025). For

Torbay Case Study, the land cover information was obtained from the Ordnance Survey MasterMap Topography Layer (Ordnance Survey, 2025) and following Environment Agency's recommendation (EA, 2013) to determine the infiltration rate and Manning's roughness.

Precipitation: Heavy rainfall is the main driver leading to pluvial flooding. For risk-based early warning, the real-time rainfall observations are necessary to forecast flood hazards and the associated risk. The rainfall may be obtained via rain gauge or radar observations. Rain gauge records provide direct measurements that represent the 'ground truth' at specific locations where the instruments are installed. The actual rainfall situations in the space between gauges are not measured such that the rainfalls are often estimated using the values from the nearest rain gauges or the interpolations. The approach is unable to capture rapid rainfall variations over a region. On the other hand, the radar measurements are indirect rainfall estimation over a large area that may not be the actual amount falling on the surface. For Torbay Case Study, the real-time radar data are not freely available such that the observations from Environment Agency (EA, 2025) and Torbay Council's rain gauges are used for real-time modelling.

Boundary and initial conditions: The inflow from upstream catchments or the water level at downstream boundary may contribute to flood within the modelling domain. For Torbay Case Study, the full catchment boundary was identified such that no further upstream inflow was included. On the downstream side, the backwater effect at the outlets was ignored for real-time modelling. The initial condition of the catchment was based on the water depths from previous simulations.

2.2 Modelling outputs

CAFlood simulates the runoff movements caused by rainfall and inflow using discrete cell grid and time steps. The outputs include the snapshots of flood depths or velocities for all cells within the full modelling domain at selected output timing and the maximum values over the simulated events. The file size for these outputs could be huge when a big domain with high resolution cells is modelled such that the intervals for exporting the results are relatively large. For sites require more detailed flood attributes, a smaller time interval could be set to record the temporal changes of water depth and velocities at those locations. The velocities are represented as values at the four boundaries of each cell, normal to the cell edges, which require a post-processing program to calculate the resulting velocity and direction at each cell centre. The water level, as the sum of the water depth and elevation, at each cell was also calculated using a post-processing program.

3.0 HAZARD IMPACT ASSESSMENT

3.1 Modelling inputs

Hazard attributes: The hazard impact assessment model was designed to be a generic tool that can be applied to various hazard types such as flood, wind, or pollutions. For floods, deep water depth could cause threats to human lives or safety, damage properties and contents, or disrupt critical infrastructure or services. High velocity could also pose threats to human lives or safety, impact on structure integrity. The contamination in flood water could also affect public health.

In Torbay Case Study, the water depth obtained from flood modelling was used to evaluate the damage to properties and the disruption of critical infrastructure and service. The risks to human safety and public health were not included but could be further explored in future studies.

Building layouts and Building use: To determine flood damage to properties, the footprints of buildings must be used to identify if a building is flooded and the water depth inside a building. Various building use types consist different contents such that the damage could differ significantly for the same water depth. Thus, the layouts and use types of buildings are required. Building layouts and uses could be

obtained from OpenStreetMap using the tag combinations of building, landuse, office, shop, leisure, etc. (OSM, 2025). For Torbay Case Study, the Ordnance Survey MasterMap Topography Layer and Points of Interest (Ordnance Survey, 2025) layers were used to determine the building use.

Hazard-damage curves: Same hazards with different severity may cause different levels of damage such that the hazard-damage curves or hazard-loss functions are used to (Khanduri and Morrow, 2003; Smith, 1994). Flood depth and damage relationships for different building or land uses types (Gissing and Blong, 2004; Romali et al., 2015; ten Veldhuis and Clemens, 2010; Thieken et al., 2005) are widely adopted to estimate the losses caused by flood hazards. In the Torbay Case Study, the flood depth-damage curves developed in the Multi-Coloured-Handbook (Priest et al., 2024) were used to represent the typical building use types and the possible losses due to floods.

Location of critical infrastructure: The hazard disruption on critical infrastructure could lead to cascading failure that affect the regions that do not suffer the direct hazard damage (Australian Government, 2015; Pant et al., 2018; Pescaroli and Alexander, 2016; Schotten and Bachmann, 2023). Thus, the locations of critical infrastructure such as power grids, transportation network, telecommunication facilities, health care services, etc., and their exposures to hazards need to be considered to quantify the risks of disasters. Critical infrastructure data can be obtained in Open Street Map using tags such as power, telecom, railway, highway, public transport, emergency, healthcare, etc. For Torbay Case Study, critical infrastructure are identified using the Ordnance Survey MasterMap Topography Layer and Points of Interest (Ordnance Survey, 2025), the National Grid (National Grid, 2025), Mast Database (Wheatley, 2025) and Open Street Map.

Interdependencies and Interconnectivities: The operation of a property or an asset may depend on one or more other assets or services, the failure of a single asset may cause the malfunction of multiple assets. Thus, the interdependencies and interconnectivities between all assets, services and critical infrastructure determine how the knock-on effect of critical infrastructure failure spreads (Arrighi et al., 2020; Bedinger et al., 2020; Chang et al., 2007; Svendsen and Wolthusen, 2007). To accurately describe the relationships, it requires the data provisions from the service providers. In this work, the relationships were estimated primarily based on the geographic locations to demonstrate the proof of the concept.

Demographic information: To understand the societal resilience and identify vulnerable groups, demographic information such as ages, socioeconomic status, disabilities, education, etc. are important for hazard impact assessment. Normally, the information is collected via national census survey and aggregated to an area. For Torbay Case Study, the required data are extracted from the Office National Statistics' local statistics dataset (ONS, 2025).

3.2 Modelling outputs

The flood simulation results described in Section 2.2 were used to analyse the direct damages and indirect impacts. The snapshots of water depths at different timing and the maximum depth were combined with building uses, hazard-damage curves, the critical infrastructure and related information to evaluate the temporal evolution of flood risks. The flood damage maps present the monetary losses during the simulated event while the impact maps show the disruptions of critical infrastructure and services, and assets that are affected by the cascading failures.

4.0 RISK-BASED EARLY WARNING SYSTEM

The above-mentioned modelling procedures were integrated and applied to Torbay Case Study to create a risk-based early warning system. The real-time rainfall observations were retrieved from the Environmental Agency and Torbay Council's monitoring networks to trigger the flood modelling routinely. The flood simulation results were then used for hazard impact assessment to identify the locations and risks that the Torbay communities could have. The system aimed to provide 2 hours lead time for stakeholders deploying required measures such that the model was configured to complete required analysis and repeat every 15 minutes with the available computing resources. The risk-based early warning systems alert the managers about the potential risks and sites to prioritise emergency response measures for safeguarding vulnerable populations and critical infrastructure from flood impacts. A showcasing video of the risk-based early warning system is available at <https://youtu.be/xUyHvbXXKOE>.

The system includes three components: weather observations, hazard modelling and impact assessment to estimate the potential risks associated with upcoming disasters. This framework could be replicated in other regions where related information is available to support the analysis. This could be applied to other types of hazards such as heatwave or storm to quantify their impacts to communities.

The presented early warning is based on the latest rain gauge measurements. The rainfall nowcasting and forecasting data for near future could be further utilised to increase the lead time for crisis responses. However, weather prediction data often include a number of ensembles to reflect the uncertainties in modelling. As a result, to incorporate weather nowcasting and forecasting information will introduce extra computational loads that computing resources need to be upgraded without coarsening model resolution.

5.0 CONCLUSION

The development and implementation of ARSINOE risk-based early warning system demonstrates a crucial shift in flood management practices. Moving beyond traditional hazard-focused warnings, this new approach provides actionable intelligence by integrating real-time flood forecasting with comprehensive impact assessment. The Torbay case study highlights the potential for rapid simulations using CAFlood to deliver timely alerts, enabling proactive measures that safeguard vulnerable populations and critical infrastructure. While challenges remain in refining data integration and incorporating more nuanced factors like human safety and public health risks, ARSINOE represents a significant step towards building more resilient communities. The success of this approach underscores the importance of holistic flood management strategies that prioritize understanding and mitigating potential impacts, rather than simply predicting water levels. Ultimately, ARSINOE serves as a valuable model for developing similar risk-based early warning systems in other regions facing increasing flood threats, contributing to a future where communities are better prepared and protected from the devastating consequences of flooding.

References

- Arrighi, C., Pregnotato, M., Castelli, F., 2020. Indirect flood impacts and cascade risk across interdependent linear infrastructures. <https://doi.org/10.5194/nhess-2020-371>
- Australian Government, 2015. Critical Infrastructure Resilience Strategy: Plan.
- Bedinger, M., Beevers, L., Walker, G.H., Visser-Quinn, A., McClymont, K., 2020. Urban Systems: Mapping Interdependencies and Outcomes to Support Systems Thinking. *Earth's Future* 8. <https://doi.org/10.1029/2019EF001389>
- Chang, S.E., McDaniels, T.L., Mikawoz, J., Peterson, K., 2007. Infrastructure failure interdependencies in extreme events: power outage consequences in the 1998 Ice Storm. *Nat. Hazards* 41, 337–358. <https://doi.org/10.1007/s11069-006-9039-4>
- Copernicus Services, 2025. CORINE Land Cover [WWW Document]. Copernic. Serv. URL <https://land.copernicus.eu/en/products/corine-land-cover> (accessed 3.23.25).
- Defra, 2025. Defra Survey Data Download [WWW Document]. Defra Serv. Platf. URL <https://environment.data.gov.uk/survey> (accessed 3.22.25).
- EA, 2025. Rainfall API reference [WWW Document]. Environ. Agency. URL <https://environment.data.gov.uk/flood-monitoring/doc/rainfall> (accessed 3.22.25).
- EA, 2019. What is the Risk of Flooding from Surface Water Map? (No. Version 2).
- EA, 2013. Updated Flood Map for Surface Water - National Scale Surface Water Flood Mapping Methodology (No. Final Report version 1.0). Environment Agency, Bristol, UK.
- EEA, 2024. European Climate Risk Assessment Report. European Environment Agency.
- European Parliament, 2007. Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.
- Ghimire, B., Chen, A.S., Guidolin, M., Djordjevic, S., Savic, D.A., 2012. A New Two-Dimensional Cellular Automata Approach For Fast Urban Flood Inundation Modelling. *Underst. Chang. Cimate Environ. Find. Solut.*
- Gissing, A., Blong, R., 2004. Accounting for variability in commercial flood damage estimation. *Aust. Geogr.* 35, 209–222.
- Guidolin, M., Chen, A.S., Ghimire, B., Keedwell, E.C., Djordjević, S., Savić, D.A., 2016. A weighted cellular automata 2D inundation model for rapid flood analysis. *Environ. Model. Softw.* 84, 378–394. <https://doi.org/10.1016/j.envsoft.2016.07.008>
- Guidolin, M., Chen, A.S., Keedwell, E.C., Djordjevic, S., Savic, D.A., 2015. On Exploiting Advance Parallel Techniques for Fast Modelling of Potential Pipe Failure Flooding Events at Citywide Scale. Presented at the Advances in Numerical Modelling of Hydrodynamics Workshop.
- Guth, P.L., Van Niekerk, A., Grohmann, C.H., Muller, J.-P., Hawker, L., Florinsky, I.V., Gesch, D., Reuter, H.I., Herrera-Cruz, V., Riazanoff, S., López-Vázquez, C., Carabajal, C.C., Albinet, C., Strobl, P., 2021. Digital Elevation Models: Terminology and Definitions. *Remote Sens.* 13, 3581. <https://doi.org/10.3390/rs13183581>
- Khanduri, A.C., Morrow, G.C., 2003. Vulnerability of buildings to windstorms and insurance loss estimation. *J. Wind Eng. Ind. Aerodyn.* 91, 455–467. [https://doi.org/10.1016/S0167-6105\(02\)00408-7](https://doi.org/10.1016/S0167-6105(02)00408-7)
- Miller, C.L., Laflamme, R.A., 1958. The Digital Terrain Model -- Theory & Application. *Photogramm. Eng.* 24, 433–442.
- Mühlhofer, E., Bresch, D.N., Koks, E.E., 2024. Infrastructure failure cascades quintuple risk of storm and flood-induced service disruptions across the globe. *One Earth* 7, 714–729. <https://doi.org/10.1016/j.oneear.2024.03.010>

- NASA JPL, 2020. NASA SRTM-only Height and Height Precision Global 1 arc second V001. https://doi.org/10.5067/MEASURES/NASADEM/NASADEM_SHHP.001
- NASA/METI/AIST/Japan Spacesystems And U.S./Japan ASTER Science Team, 2001. ASTER DEM Product. <https://doi.org/10.5067/ASTER/AST14DEM.003>
- National Grid, 2025. Dataset - Connected Data Portal [WWW Document]. Natl. Grid. URL <https://connecteddata.nationalgrid.co.uk/dataset/> (accessed 3.23.25).
- Niinistö, S., 2024. Strengthening Europe's Civilian and Military Preparedness and Readiness. European Commission.
- ONS, 2025. Explore local statistics - ONS [WWW Document]. Off. Natl. Stat. URL <https://explore-local-statistics.beta.ons.gov.uk/> (accessed 3.23.25).
- Ordnance Survey, 2025. OS MasterMap Topography Layer [WWW Document]. Ordnance Surv. URL <https://www.ordnancesurvey.co.uk/products/os-mastermap-topography-layer> (accessed 3.22.25).
- OSM, 2025. Top-level tag [WWW Document]. OpenStreetMap Wiki. URL https://wiki.openstreetmap.org/wiki/Top-level_tag (accessed 3.23.25).
- Pant, R., Thacker, S., Hall, J.W., Alderson, D., Barr, S., 2018. Critical infrastructure impact assessment due to flood exposure: Critical infrastructure impact assessment due to flood exposure. *J. Flood Risk Manag.* 11, 22–33. <https://doi.org/10.1111/jfr3.12288>
- Pescaroli, G., Alexander, D., 2016. Critical infrastructure, panarchies and the vulnerability paths of cascading disasters. *Nat. Hazards* 82, 175–192. <https://doi.org/10.1007/s11069-016-2186-3>
- Priest, S., Viavattene, C., Penning-Roswell, E., Parker, D., Hardman, D., Morris, J., Morris, J., Chatterton, J., 2024. Flood and Coastal Erosion Risk Management: Handbook for Economic Appraisal, 0 ed. Routledge. <https://doi.org/10.4324/9780203066393>
- Romali, N.S., Sulaiman, M., S.A.K., Yusop, Z., Ismail, Z., 2015. Flood Damage Assessment: A Review of Flood Stage–Damage Function Curve, in: Abu Bakar, S.H., Tahir, W., Wahid, M.Ab., Mohd Nasir, S.R., Hassan, R. (Eds.), ISFRAM 2014. Springer Singapore, Singapore, pp. 147–159. https://doi.org/10.1007/978-981-287-365-1_13
- Schotten, R., Bachmann, D., 2023. Critical infrastructure network modelling for flood risk analyses: Approach and proof of concept in Accra, Ghana. *J. Flood Risk Manag.* 16, e12913. <https://doi.org/10.1111/jfr3.12913>
- Smith, D.I., 1994. Flood Damage Estimation - a Review of Urban Stage-Damage Curves and Loss Functions. *Water Sa* 20, 231–238.
- Svendsen, N.K., Wolthusen, S.D., 2007. Connectivity models of interdependency in mixed-type critical infrastructure networks. *Inf. Secur. Tech. Rep.* 12, 44–55.
- ten Veldhuis, J.A., Clemens, F.H., 2010. Flood risk modelling based on tangible and intangible urban flood damage quantification. *Water Sci Technol* 62, 189–95. <https://doi.org/10.2166/wst.2010.243>
- Thieken, A.H., Muller, M., Kreibich, H., Merz, B., 2005. Flood damage and influencing factors: New insights from the August 2002 flood in Germany. *Water Resour. Res.* 41, W12430. <https://doi.org/10.1029/2005wr004177>
- Wang, Y., Liu, H., Zhang, C., Li, M., Peng, Y., 2018. Urban Flood Simulation and Risk Analysis Based on Cellular Automaton. *J Water Resour Res* 7, 360–369.
- Wheatley, D., 2025. davwheat/mastdatabase.co.uk.

Systems Innovation Approach (SIA) addresses the growing complexity, interdependencies and interconnectedness of modern societies and economies, focusing on the functions of the cross-sectoral system as a whole and on the variety of actors. The Climate Innovation Window (CIW) is the EU reference innovations marketplace for climate adaptation technologies. ARSINOE shapes the pathways to resilience by bringing together SIA and CIW, to build an ecosystem for climate change adaptation solutions. Within the ARSINOE ecosystem, pathways to solutions are co-created and co-designed by stakeholders, who can then select either existing CIW technologies, or technologies by new providers (or a combination) to form an innovation package. This package may be designed for implementation to a specific region, but its building blocks are transferable and re-usable; they can be re-adapted and updated. In this way, the user (region) gets an innovation package consisting of validated technologies (expanding the market for CIW); new technologies implemented in the specific local innovation package get the opportunity to be validated and become CIW members, while the society (citizens, stakeholders) benefits as a whole. ARSINOE applies a three-tier, approach: (a) using SIA it integrates multi-faceted technological, digital, business, governance and environmental aspects with social innovation for the development of adaptation pathways to climate change for specific regions; (b) it links with CIW to form innovation packages by matching innovators with end-users/regions; (c) it fosters the ecosystem sustainability and growth with cross-fertilization and replication across regions and scales, at European level and beyond, using specific business models, exploitation and outreach actions. The ARSINOE approach is show-cased in nine widely varied demonstrators, as a proof-of-concept with regards to its applicability, replicability, potential and efficacy.



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