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Advancing Disaster Risk Management and Climate Adaptation: Modular, Scalable, and Open Standards-Based Spatial Data Infrastructure for Local Action

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Our environment is characterized by a changing climate marked by rapidly increasing frequency and intensity of extreme weather leading to compound multi-hazard events. This evolving climate reality accentuates diverse needs across various sectors, as each grapples with unique vulnerabilities and adaptation requirements. Stakeholders, ranging from individuals, local communities to governmental bodies and private enterprises, need to take measures to mitigate these challenges.

These heterogeneous needs ask for tailored approaches to support disaster risk reduction, climate resilience and adaptive governance. However, significant barriers to access data and information products for an effective climate adaptation and increased preparedness exist. Despite the growing need for localized early warning and climate resilience (comp. UN initiative “Early Warnings for all”), the available data is often too generic and inaccessible to meet the specific needs of local stakeholders. This lack of actionable information hampers timely and informed decision-making, leaving communities and sectors ill-prepared for the impacts of extreme weather events. Furthermore, the limited interoperability of data, models, and information products exacerbates these challenges by creating inefficiencies and delays in decision processes. Addressing these issues is crucial for fostering adaptive capacity and enhancing preparedness at all levels.

The prototypical solutions developed in the European projects I-CISK and DIRECTED address the identified challenges by leveraging open-source, open-data, and open-science principles to enhance data accessibility, interoperability, and usability for local stakeholders. Central to this approach is a cloud-deployed research data infrastructure that produces tailored information products meeting diverse user needs across different climatic regimes and application scenarios. These products are co-developed in close collaboration with local stakeholders, ensuring alignment with specific information gaps and needs to improve preparedness and adaptive capacity.

The system builds upon open-source projects, including pygeoapi and React, and employs cloud-optimized data formats and storage to seamlessly integrate heterogeneous data sources. These

range from continental-scale data (e.g., Copernicus) to local datasets, enabling a comprehensive understanding of spatial and temporal climate variability. A federated design, grounded in open standards such as the latest OGC APIs (e.g., Processing, Features, Connected Systems), ensures modularity, interoperability, and ease of customization for both research and operational spatial information infrastructures. This approach fosters scalability, credibility, and reusability, empowering stakeholders to use tailored solutions that address their sector-specific challenges.

One notable challenge during the development of the prototypical solutions is the complexity and effort required for a co-design approach, where diverse stakeholders collaborate to define requirements and identify information gaps, guiding the development of the solution. While this participatory method enhances relevance and user satisfaction, it demands significant time, resources, and coordination, particularly when balancing varying stakeholder priorities and expectations.

Another key challenge lies in ensuring the continuity and usability of the services and tools developed during the project. A strong focus on the development of sustainable business use-cases will solidify the adoption of the tailored solutions beyond the project's lifecycle. This includes fostering stakeholder engagement, securing long-term funding, and adapting to evolving technological and climatic contexts.

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