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Towards a Sustainable and Resilient Future: the Transformative Role of Data in Crisis Management

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Crisis management plays a role in achieving a sustainable and resilient future by preparing governments and communities to effectively respond to and recover from disruptions . Crisis management generates large volumes of heterogeneous data, including spanning structured databases, unstructured government reports, real-time news reports, and social media channels. Despite such an availability of data, the information remains siloed, inconsistently classified, and inaccessible across systems, leading to delays and inefficiencies in crisis recovery and response. This inability to rapidly synthesise diverse data streams impacts the efforts to achieve global disaster risk identification and reduction as outlined by the UNGA and in the Sendai Framework for Disaster Risk Reduction .

A decade since the Sendai Framework, there exist challenges in understanding disaster risk (Priority 1) and increasing information availability (Target 7) within the framework . The heterogeneous nature of crisis data, often owned by different institutions with varying formats, hinders open access and seamless data integration. This creates challenges for effective emergency response. The impact is twofold: first, it hinders governments' ability to accurately report on disaster impact, thus obstructing recovery planning; second, the lack of understanding of current impacts limits governments' capacity to predict and plan for future disasters –a key concern for the National Emergency Management Agency (NEMA) in Australia is improving its ability to assess and provide data on local economic damage impacts . Given the predicted increase in disaster frequency in Australia, coupled with the Defence Strategic Review emphasis on decentralised emergency plans, establishing robust data infrastructure is crucial to ensure effective reporting of disaster events and more accurate economic impact reporting.

To address challenges of establishing an effective data infrastructure and reporting, there needs, we need to achieve interoperability, harmonization and governance across the heterogenous data sources and ontologies. This paper introduces the Ontology Alignment, Structure, Integration, and Synthesis (OASIS) framework, an AI-driven framework designed to create and align ontologies across diverse systems and domains. A key contribution of this framework lies in its ability to enable the harmonization and governance of dynamic, real-time collaboration between humans and systems. This research focuses on the sourcing and transformation of crisis-related information through the integration of ontologies, knowledge graphs, and LLMs to empower effective decision-making. OASIS directly tackles the need for semantic interoperability for ontology engineers within the crisis management domain. The framework supports the complete ontology lifecycle, from alignment with established standards such as the Disaster Management Metamodel (DMM) and EM-DAT taxonomy, to ontology engineering using Protégé , and finally, to the synthesis of interconnected knowledge graphs utilizing Neo4j .

This research adopts an Action Research methodology , actively engaging domain practitioners in the iterative design, development, and evaluation of the OASIS framework and its outcomes. The framework's practical implementation was iteratively tested through two real-world case studies: Cyclone Jasper (2023) and Cyclone Alfred (2025), impacting Northern and South East Queensland, respectively. These events provided valuable opportunities to assess OASIS in distinct crisis contexts. In both cases, unstructured data—including post-disaster reports, emergency declarations, and news articles—was processed using advanced LLMs (GPT-4 and Gemini) to extract key entities, relationships, and structured attributes. These extracted elements were then automatically mapped to the developed ontology and integrated into a knowledge graph, enabling practitioners to visualize, explore, and query critical information such as disaster impacts and recovery funding allocation.

A quantitative and qualitative validation was performed for both case studies. We achieved a F1-score of 0.89

for structured data extraction following iterative prompt refinement and ontology alignment, thus showcasing the potential of LLMs to significantly accelerate information modelling when guided by structured ontology. Qualitative feedback was gathered from practitioners through interviews and collaborative workshops. Beyond its specific technical implementation, the OASIS framework offers a reusable, domain-agnostic model adaptable to other sectors, providing a repeatable methodology for rapid, AI-assisted knowledge base construction in dynamic and time-critical scenarios.

While not all crises can be anticipated or fully mitigated, for the events we can proactively plan for, this research highlights critical areas for improvement in disaster resilience. As the global community progresses towards the SENDAI 2030 agenda, this research offers a timely and practical contribution, demonstrating how data can be effectively leveraged through the proposed OASIS framework to enhance disaster preparedness and response.

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