Establishing Technical Guidelines Before Procuring IT Solutions for Crisis Management

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ABSTRACT

This paper presents a technical guideline framework to inform joint-cross border Pre-Commercial Procurement (PCP) decisions for Information Technology (IT) solutions in crisis management, with a specific focus on EO-driven water resilience across the EU to improve situational awareness and provide better decision support. Grounded in co-designed User Story Lines (USL) that reflect operational scenarios (floods, wildfires, infrastructure impacts), the approach prioritizes open standards, open-source components, and operational readiness at Technology Readiness Level (TRL) 8. We synthesize state-of-the-art practices for PCP in crisis IT, report initial outputs such as evaluation criteria, a candidate inventory, and capability-based shortlists; and outline next steps for documentation, adoption monitoring, and standardization pathways. The contribution is a practical, reusable guideline and governance model that reduces vendor lock-in risk, accelerates integration, and strengthens cross-border crisis information flows.

Keywords

Pre-commercial procurement framework, crisis management IT, water resilience, open standards, earth observation

INTRODUCTION

Across Europe, the frequency and intensity of water-related crises, including floods, droughts, wildfires, and cascading infrastructure impacts, are increasing due to climate change. This heightens the need for interoperable information systems that turn Earth Observation (EO) and space-based data into actionable intelligence for crisis response and water management increasing situational awareness and provide better decision support. The European project “Pre-Commercial Procurement for European project Water Management Innovations for Climate Resilience” (PCP-WISE) aims to customize and pre-operationalize water management innovations from space via pre-commercial procurement, advancing solutions through design, prototyping, and field validation toward TRL 8. The project pursues common operational information products, robust interoperability mechanisms, and an active user-network spanning water managers, environmental authorities, first responders, cities, and agriculture. By focusing on local dynamics in water availability and anticipating extremes through an integrated water intelligence system grounded in a unified water taxonomy and EO-based modelling, the project targets scalable resilience across EU borders.

This Work-in-Progress paper demonstrates how establishing technical guidelines before procurement aligns supplier innovation with operational needs in crisis management. We report on the completed initial phase that identified and evaluated software components, tools, and open standards relevant to EO-enabled water intelligence, with an emphasis on open data products and compliance with Open Geospatial Consortium (OGC) standards and Infrastructure for Spatial Information in Europe (INSPIRE) recommendations and best-practices. While the software solutions remain the intellectual property of the supplying organisations, the resulting WISE information products are designed to be openly accessible: user organisations can collect them via standardised APIs and ingest them interoperable into their own environments, including open-source visualisation and analysis tools. The outcome provides an actionable catalogue to inform tenderers and reduce integration risk. Early guidance built on open standards enables transparent validation, reuse across pilots, and smoother progression from prototypes to near-operational services.

Original Contribution

The technical guidance agenda addresses three ISCRAM-relevant elements: (1) coherent information products that plug into decision workflows; (2) interoperability by design through API conformity, data/metadata standards, and reference service patterns; and (3) sustained user involvement to validate constraints such as latency, reliability, explainability, and maintainability. Even if this paper does not present an IT-system or component it provides fruitful insights in giving guidelines and best-practices for such systems and therefore adds to the "IT solutions for Crisis Management" track.

The initial evaluation used a structured process to scan, shortlist, and assess candidates from crisis management, geo-data, EO processing, and data infrastructure domains. Criteria covered functionality, reliability, maturity, community support, and standards compliance. Favouring open-source components minimizes licensing barriers and strengthens long-term sustainability beyond the PCP.

This paper makes several principal contributions: a pre-commercial procurement framework for curating and evaluating components and standards for EO-enabled water crisis services; a vetted foundation for interoperability and compliance to lower integration risks; and a plan for guidance documentation and usage monitoring that closes the loop between guidance and operational practice. We summarize the evaluation methodology, present key findings, align them with crisis response needs, and outline next steps. As a Work-in-Progress, the paper highlights practical lessons and decision rationales to support ISCRAM efforts coordinating innovation, interoperability, and procurement in data-intensive crisis domains.

Existing ISCRAM literature primarily advances technological solutions for crisis response, focusing on event specific tools such as decision support systems, early warning platforms, and situational awareness technologies. While this research contributes valuable technical insights, it frequently treats governance, procurement, and institutional adoption as contextual factors rather than core design variables. In parallel, public procurement and PCP literature has significantly developed the legal and procedural understanding of pre commercial procurement as a demand side innovation instrument but tends to analyse PCP mainly as a mechanism for stimulating R&D and market creation, with limited attention to systemic preparedness or post project uptake.

Against this background, the intended innovation novelty of the five use cases of PCP WISE lies in integrating procurement, governance, and technology into a coherent crisis preparedness framework. PCP WISE shifts the focus from isolated, hazard specific solutions to cross hazard capability development, addressing shared functions such as anticipation, coordination, and adaptive decision making. It treats PCP not merely as a purchasing procedure, but as a strategic governance lever that actively shapes collaboration, learning, and resilience ecosystems. Moreover, PCP WISE embeds legal compliance, institutional capacity, and adoption pathways from the outset, positioning uptake and scalability as explicit innovation outcomes. In doing so, PCP WISE goes beyond both ISCRAM and procurement literature by framing pre commercial procurement as a systemic instrument for sustainable, implementable crisis preparedness.

A structured procurement approach under PCP WISE translates preparedness into operational improvements for disaster management. For example, instead of procuring a flood specific monitoring tool, PCP WISE structures a PCP around interoperable sensing and data sharing capabilities that can be used by civil protection authorities across floods, heatwaves, or industrial accidents. Similarly, by embedding legal compliance and governance requirements from Phase 0, PCP WISE enables crisis coordination across jurisdictions.

Through structured demand articulation in Phase 0 of PCP, operational users—such as civil protection agencies and first responders—co design realistic scenarios and performance requirements. For example, multi-agency exercises are used to define response time thresholds, data access rules, and accountability arrangements, ensuring that resulting solutions fit real operational constraints rather than abstract technical specifications.

During phased PCP implementation, competing suppliers develop and validate solutions in test sites. These prototypes are evaluated not only for technical performance, but for interoperability, legal compliance, and ease of deployment across jurisdictions. Overall, the structured approach embeds readiness, scalability, and governance into procurement outcomes, significantly improving crisis coordination and response effectiveness.

STATE OF THE ART

The EAFIP step-by-step methodology, developed under the European Commission's European Assistance for Innovation Procurement (European Commission), provides a structured process for public sector innovation procurement across the stages of preparation, contract award, and execution, with strong emphasis on thorough upfront planning to ensure feasibility, need alignment, and efficient use of funds. Built on the PDCA cycle (Plan, Do, Check, Act), it starts by identifying organizational needs and developing a demand plan to prioritize short- and medium-term requirements and inform suppliers. After defining a need, public authorities assess whether innovation procurement is suitable by exploring market capabilities, engaging vendors, and conducting cost–benefit analyses; if no adequate market solution exists and the case is viable, they proceed.

Key preparatory steps include needs identification; State-of-the-Art (SOTA) analysis with IPR review focusing on patents and standards; validation via Open Market Consultation (OMC); and a business case to confirm economic feasibility. These inputs shape technical/functional requirements and selection/award criteria, supporting strategic and transparent procurement aligned with market capabilities. Technology Readiness Level (TRL) assessment, derived from SOTA and market consultation, is pivotal for strategy: TRL 3–6 indicates significant R&D needs and suggests a Pre-Commercial Procurement (PCP) route; TRL 7–9 signals near-market maturity, supporting Public Procurement of Innovative solutions (PPI) under EU directives. Subsequent steps cover tender preparation/publication, supplier selection, award of framework agreements and phase contracts to multiple suppliers and competitive contract execution in three phases of solution design, prototype development and test piloting to compare alternative solutions.

The SOTA analysis results and the Open Market Consultation conducted both under the scope of PROTECT CSA and PCP WISE confirmed the grounds to implement a Pre-Commercial Procurement (PCP) approach to procure research and development services up to TRL 7-8, given that the solutions available in the market could not tackle all the functional needs defined by the end-users in 5 use cases and the set of mandatory requirements. As there are no commercial solutions, the development and testing of new innovative solutions, beyond state-of-the-art, are required. A key finding of the SOTA analysis was that the complex, climate-related needs require the combination of solutions from multiple disciplines. Accordingly, the analysis encompassed the latest developments in the domains of hydrology, soil physics, crop and biophysiology, meteorology, climatology, remote sensing, etc. and the joint application of those disciplines into sound combination methodologies. Such hybrid approaches require state-of-the-art methods for combination, inverse, and forcing modelling, digital twinning and simulation, and AI/ML/ICT integration. Another aspect is the technical readiness in terms of operational production of such hybrid systems. New methodologies are required to produce stable solutions which are locally valid for operational application. This requires new methods for convergence in multi-parameter solution spaces.

The search of existing patents revealed that, predominantly, the individual and domain-specific applications (and thus mostly part) of such hybrid solutions have been IPR protected, however much less patents were found on the complex hybrid solutions in the WISE domain. The development of new IPR-protected validation methods for enriching those hybrid solutions with additional (local) knowledge, intelligence, and proxies (data) by applying newly developed AI/ML mechanisms is expected to generate future patent activity, though such solutions are not yet available.

It is important to realize that the extremes in water management conditions in rural and urban context are directly and indirectly leading to severe crises and with that huge potential impact to our society due to increased climate dynamics in the past decades. It is the pre-disaster conditional aspect of the physical state our subsoil systems which until now has (still too often) been underestimated in our contemporary crisis management mechanisms. Until now crises like wildfires or floods induced by drought or water excess had been anticipated with short-term warnings/alerts by our weather services. Although extreme weather forecasting has become a new discipline in meteorology, which also requires state-of-the-art technology solutions, the PCP-WISE project has a unique approach of anticipating such crises by monitoring the soil-moisture-vegetation conditions on a longer time scale as a result of accumulated impact of weather conditions of the past (months, even years) causing structural (patterns of) drought in space and time. Another important aspect is that the spatial details of the WISE information products are delivered (also timely) on a local management scale in rural and urban contexts other than the current weather information which is available mostly on less detailed spatial scales. This new approach offers crisis organizations resiliency (the time to take timely measures) in the pre-disaster phase of the crisis cycle. It helps the crisis organizations to develop disaster risk reduction (scenarios) mechanisms in space and time for better anticipation of potential near future crises. On top of that PCP-WISE produces also sector related risk assessment information, which could help crisis response organizations to prioritize (relief) actions during the crisis event itself!

From a crisis management perspective, existing platforms often provide partial capabilities (e.g. visualization without real-time ingestion, or modelling without interoperable APIs), but lack integrated, cross-border-ready architectures combining EO analytics, operational workflows, and governance compliance. This gap justifies the structured PCP approach. Patent landscape analysis further indicated fragmentation across thematic domains (e.g. hydrology, EO analytics, urban infrastructure monitoring), with limited cross-domain integration, reinforcing the need for open, standards-based innovation rather than proprietary ecosystem expansion.

For example, crisis organizations would be able to monitor in real time the balance in soil-water-vegetation for continuous monitoring, preparedness and faster reaction to events of crisis that could origin in excess or scarcity of water and the related consequences. Where patterns and trends indicate the event of a future crisis scenario, the data would provide insights to for decision making to mitigate the risks.

PRE-COMMERCIAL PROCUREMENT APPROACH

Pre Commercial Procurement (PCP) (European Commission, 2007a, 2007b) is an innovation oriented procurement approach used when no suitable solutions yet exist on the market or when existing solutions require further R&D. PCP enables contracting authorities to purchase R&D services in a way that stimulates market innovation while sharing risks and benefits under competitive, market based conditions.

PCP is implemented through a phased and competitive process, typically comprising three stages: solution design, prototyping and testing, and original development with limited field validation. Multiple suppliers are supported in parallel, allowing different approaches to be compared and progressively evaluated after each phase, with only the most promising solutions advancing. This structure promotes iterative improvement, early user feedback, and value for money, while leaving open the option of a later Public Procurement of Innovative Solutions (PPI).

PCP focuses exclusively on R&D services, excludes large scale commercial deployment, applies open and non-discriminatory procedures, and features balanced IPR sharing, with contractors retaining ownership and authorities receiving usage rights.

The PCP approach offers the methodology and legal ground to procure R&D outside the scope of the procurement directives, based on common needs and functional requirements of multiple end-users across EU. The PCP framework targets the development of radical innovation by different research teams where the cycle of solution design, prototype development and operational validation in parallel lanes steer and speed that solutions reach up to TRL8. In the competitive process, several suppliers develop alternative engineering prototypes suitable for situational awareness, decision support, inter-agency coordination, and crisis information flows which will be piloted and compared.

The PCP process established a clear evaluation scheme to select the groups of researchers and award the R&D service contracts. The scheme included selection criteria, *must have* functional, technical and contract performance requirements, and *nice to have* criteria. The selection was based on the suitability to pursue the professional activity; project management non-technical oversight; the ability and experience related to R&D integration and technical leadership both for the rural and urban context; the ability to combine knowledge and experience regarding R&D biophysical processes; the ability and experience both in the rural and urban context for hydrology modelling, crises prediction, preparedness, monitoring and impact assessment, remote-sensing, AI, Data Science and ICT skills in operational information production (upscaling) in back and front processing; GIS and spatial data analysis, legal knowledge in the field of AI, IPR and European Interoperability Standards; climate adaptation and resilience at local to regional scales. The teams should also perform up to original development of the first products or services in an EU Member State and/or a HE Associated country.

Each requirement has a unique ID and name. The functional requirements describe the core actions the solution must perform, aligned with the project's primary challenges and expected system behaviour. The technical requirements define the specific implementation to fulfil functional or non-functional requirements. They outline the technologies, protocols, standards, system architecture etc. that must be followed to ensure the overall quality of the developed solutions. In layman's terms: they describe not what to implement, but how to implement it. The contract performance requirements cover operational and management considerations, including prototype deployment and feedback mechanisms from pilot activities.

The nice to have criteria are related to: (a) Impact on the challenge, including level of match with: data handling, analysis and intelligence, interfaces and interoperability, governance and security, operational support, standardization across EU; and remote sensing based information products; (b) Validity of the technical approach, including: quality of the methodology – design, development and installation of the solution, use of data; technical validity and robustness of the solution; (c) Quality of the tender, including: coherence/integration of the overall proposal, commercial potential, risk mitigation plan, and the methodology to implement the PCP phases.

METHODOLOGY

The project consolidated and refined more than twenty preliminary use cases which were partly derived from PROTECT CSA (PROTECT knowledge hub), into five representative clusters to guide a Pre-commercial Procurement (PCP) of climate resilience solutions. The work aimed to align innovation activities with operational needs across diverse European contexts and to de-risk procurement through technical, legal, and economic evidence. The chosen methodological approach ensured traceability from user needs to formalized technical requirements and procurement-ready specifications.

In the context of PCP-Wise considerations, we decided to conduct a comprehensive requirements analysis, as disaster management requirements are often not adequately met by existing disaster management software (Hellmund & Moßgraber, 2024). This reinforced the need to systematically capture operational gaps, functional expectations, and performance criteria before translating them into procurement specifications.

The methodology integrated four complementary analytical approaches. First, an iterative funneling process was conducted through bilateral interviews and six targeted user-buyer workshops (18 Feb; 5, 18 Mar; 23 Apr; 14, 26 May 2025), supplemented by structured scoping exercises. Each use case was documented using a standardized scoping template covering user needs, technical requirements, validation criteria, candidate test sites, and expected benefits.

Second, a systematic State-of-the-Art (SOTA) and market analysis reviewed scientific literature, existing technologies, patent landscapes, and Commercial-Off-The-Shelf (COTS) products to assess maturity levels (TRLs), capability gaps, innovation potential, and alignment with operational requirements.

Third, an IPR and standards analysis identified legal, technical, and interoperability constraints affecting procurement and solution integration.

Fourth, a preliminary business case and cost-benefit analysis integrated user and buyer inputs with Monte Carlo-based financial modelling to estimate economic impact, value creation, and feasibility of investing in innovative climate resilience tools.

Use Case Refinement and Clustering

The use cases reflect climate impacts on Soil-Water-Vegetation (and Atmospheric) systems across Northern, Eastern, Southern, and Western Europe, with emphasis on recurring droughts and water excess that disrupt ecosystems and infrastructure. Intensive engagement with public BUYERs and USER organizations ensured prioritization of cross-cutting operational needs for the PCP process. The funnelling process drew on individual use case documents prepared by all BUYERs/USERs, as well as interviews that elicited information requirements and explored clustering and cooperation opportunities. Multi-criteria clustering was applied based on the following dimensions: urban versus rural setting; test site availability and compliance; geographic position (North, East, South, West Europe); thematic comparability (e.g., groundwater depletion, excess surface water, vegetation stress); and primary hazard focus (floods, droughts).

This structured clustering ensured that technological development would address shared functional requirements while still allowing contextual adaptation to specific climatic, hydrological, and governance settings. The process resulted in the following group clusters:

Group 1 (Urban drought, North-West EU) focuses on urban drought in North-Western Europe and water distribution problems in city undergrounds due to human and external factors, aiming to mitigate water shortages that impact infrastructure and living conditions.

Group 2 (Urban water excess, East-North EU) addresses urban water excess in Eastern and Northern Europe, where abundant water affects city infrastructure, including problems exacerbated by sea-level rise.

Group 3 (Rural drought, North-East EU) tackles rural drought in North-Eastern Europe, where extreme climate variations impact agriculture and nature, causing wildfires and production losses.

Group 4 (Rural drought and flooding, South EU) addresses structural drought periods and intense rainfall in Southern Europe that create significant agricultural challenges.

Group 5 (Rural drought and flooding, North-East EU) focuses on extreme groundwater conditions in North-Eastern Europe that impact land use and infrastructure, including the prevention of organic soil oxidation and underground peat fires.

Scoping via User Story Lines

The scoping documents were iteratively developed through workshops and bilateral sessions, enabling buyers and end users to harmonize priorities and align requirements across heterogeneous local and national settings. This process supported selection of representative test sites and clarified validation criteria for subsequent PCP phases.

To support the structured development of user stories, we designed a dedicated template, which was then distributed to the cluster groups. These groups completed the templates with our support through collaborative workshops where needed. This process ensured that the technical members of the project team could gain a clear understanding of the type of software to be developed, as well as the key constraints to be considered.

The template was structured in two main parts:

- **Section 1 (Current State Analysis):** In the first section, users detailed their primary tasks and overarching objectives, collectively referred to as the *mission*. They described current challenges and obstacles in the *pain points* section, capturing operational inefficiencies, capability gaps, and recurring difficulties. The *tools* section outlined the existing software solutions used in daily operations, while the *data sources* section identified the types of data currently leveraged within those tools.
- **Section 2 (Future State Definition):** The second section focused on potential improvements and solution ideas. In the *solution* field, users proposed how the identified issues might be addressed. *Technical requirements* and *non-technical requirements* captured specific needs for future software tools, distinguishing between functional specifications and broader organizational or procedural considerations. Further expectations and conditions were described in the *acceptance criteria* section, establishing measurable benchmarks against which proposed solutions would be evaluated. Finally, the *benefits* section summarized the anticipated advantages of implementing the proposed high-level solutions.

The USLs were validated during end-user workshops, in which the participants reviewed and enriched the initial cluster-leader inputs and co-created early pen-and-paper prototypes to illustrate desired functionality and user interactions. This two-step process ensured the integration of real end-users rather than relying solely on assumed information.

A representative example from the Bratislava workshop (3 July 2025, see Figure 1) illustrated a mobile application for visualizing potential flood extents under varying severity scenarios, annotating points of interest such as vulnerable populations and critical assets, and highlighting protected evacuation areas (see Figure 1). These prototypes served to verify and refine the elicited technical requirements, ensuring alignment between stakeholder expectations and envisioned system capabilities.

TECHNICAL GUIDELINE FRAMEWORK

Building on the USL approach, the reviewed USLs and early-stage prototypes were translated into a consolidated set of functional and technological requirements. The findings were then harmonized by grouping similar needs into overarching requirements. For example, when one user requested WMS and WFS data support and another highlighted the need for general geodata integration, these inputs were merged into a broader requirement for compliance with established OGC standards. Highly specific requests were either removed or clearly marked as use-case specific to maintain a balanced distinction between general needs and context-dependent features.

The resulting technical framework reflects both mandatory baseline requirements and additional value-adding ("nice-to-have") criteria defined in the PCP tender documentation, which also implemented a set of 16 selection criteria related to the capabilities to be complied by the suppliers participating as a single entity or in consortia.

To provide clarity for subsequent development phases, all requirements were categorized into thematic areas such as data handling, analysis and intelligence, interfaces and interoperability, governance and security, and operational support. Finally, each requirement was assessed in terms of priority, differentiating between mandatory elements and those considered beneficial but not essential. This structured consolidation created a coherent technical guideline framework that links operational needs to actionable development directions.

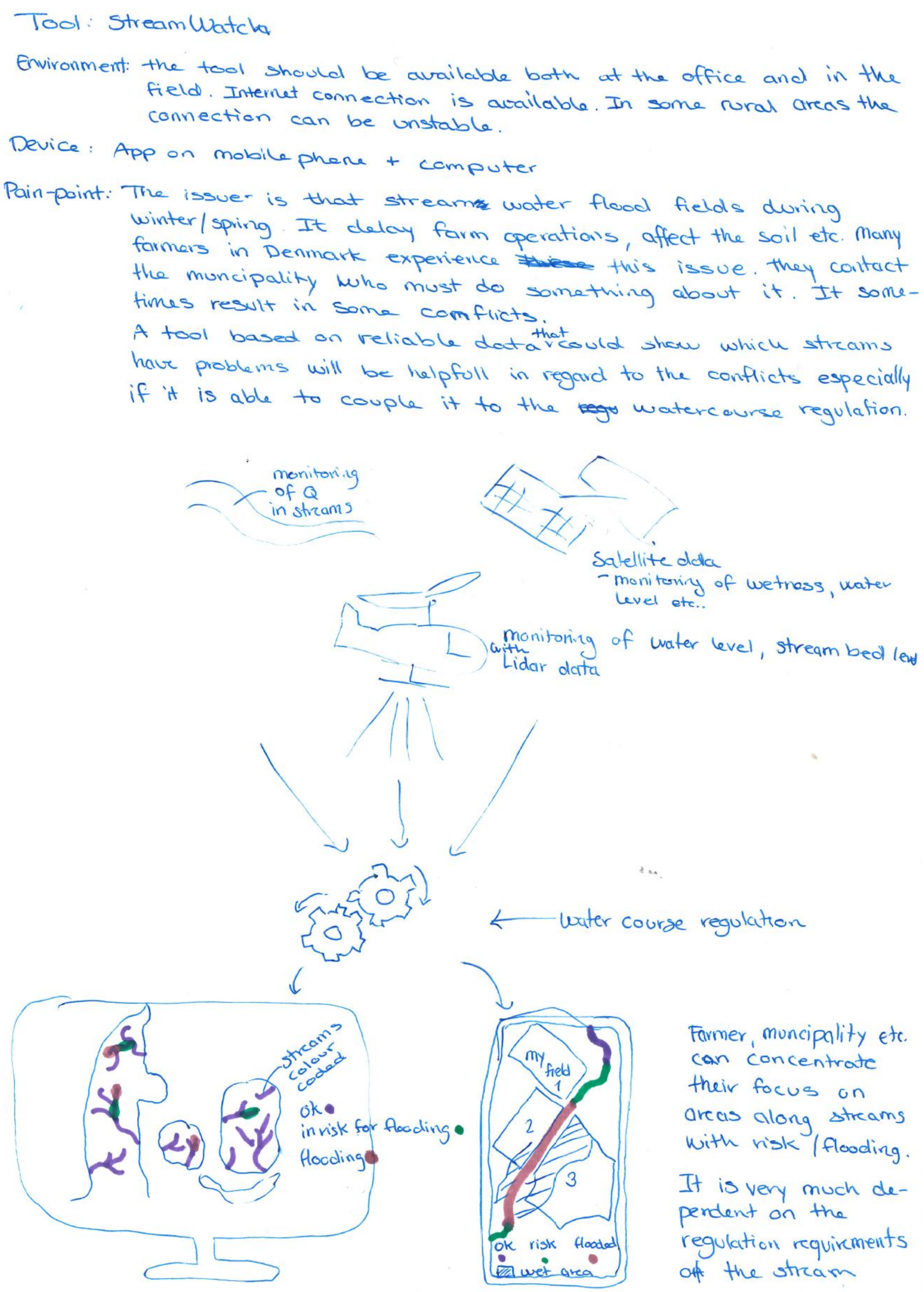

Figure 1. Example Pen-and-Paper Prototype for Desired Solution

The following examples illustrate how selected mandatory requirements are operationalized within the framework and translated into concrete system functionalities:

- Data Handling: Integration of Copernicus Sentinel imagery and ECMWF ERA5 [1]datasets; provision of WMS/WFS services for external GIS interoperability; export of harmonized risk indicators in NetCDF

[1] https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5

format.

- Analysis and Intelligence: Plug-in integration of user-defined drought or flood models without modifying the system core.
- Interfaces and Interoperability: Web-based interactive GIS viewer with multi-layer visualization and secure role-based API access.
- Governance and Security: Role-based access control (RBAC) with fine-grained permissions and GDPR-compliant secure authentication.
- Operational Support: Training sandbox with dummy datasets and executable installation package for standardized deployment.

In addition to its role as a technical specification baseline, the framework also serves as governance instrument, aligning procurement evaluation criteria, interoperability constraints, and operational validation benchmarks into a coherent structure that supports both the PCP tender process and subsequent monitoring of solution performance.

The desired solution will use of earth observation data to provide real time information of water-soil-vegetation relevant to crisis anticipation and preparedness.

DISCUSSION

The results have several implications for ISCRAM and the broader crisis management community.

First, the framework demonstrates how Pre-Commercial Procurement technical harmonization reduces downstream integration risk and shortens time-to-operations. By translating operational narratives into structured requirement clusters before tender publication, procurers avoid fragmented solution landscapes and incompatible architectures. This pre-tender alignment is particularly valuable in multi-agency, cross-border contexts where integration complexity is high.

Second, cross-border interoperability is substantially strengthened through mandatory compliance with open standards and FAIR data principles. In multi-country crisis contexts, this reduces data silos and facilitates coordinated situational awareness. The required information standards in the water management domain establish a new common water-crisis taxonomy, which improves collaboration between cross-administrative and cross-border crisis organizations and provides a sound basis for future scaling to larger regions.

Third, the structured traceability from User Story Lines to evaluation criteria enhances transparency and accountability in public innovation procurement. This is particularly relevant when justifying R&D investment under EU funding schemes, as it provides an auditable chain from operational need to procurement decision.

Fourth, the open-source preference combined with modular plug-in architectures supports long-term sustainability and mitigates vendor lock-in. However, the sustainability of open-source software ecosystems is contingent on active communities and sufficient maintenance resources—a risk that procurers and project coordinators must actively monitor and mitigate throughout and beyond the PCP lifecycle.

Fifth, the framework is transferable beyond water resilience to adjacent crisis management domains. The underlying methodology, consisting of co-designed USLs, structured SOTA analysis, open standards compliance, and phased competitive R&D procurement, is applicable to wildfire management, heatwave response, coastal risk monitoring, and multi-hazard early warning systems, among others.

Several risks warrant attention in applying this framework. Data licensing constraints may limit access to key EO datasets in certain operational contexts. Cybersecurity requirements must be integrated from the design phase rather than retrofitted. Surge performance under real-crisis conditions requires explicit stress-testing protocols. Finally, the long-term sustainability of recommended open-source components depends on community vitality, which can be difficult to assess at procurement time.

LIMITATIONS AND FUTURE WORK

Several limitations of the current work should be acknowledged. The results reflect an initial and evolving inventory and evaluation, and the candidate shortlists will require further refinement as the PCP process progresses. Geographic and sectoral coverage of end-user engagement is not yet exhaustive; continued involvement of additional regions, agencies, and private sector providers will be necessary to capture the full range of operational requirements.

The next phase will translate the evaluation into comprehensive guidance documentation, including component rationale, deployment alternatives, API profiles, scalability considerations, quality assurance practices, and alignment with OGC and INSPIRE standards. Configuration baselines, sample workflows, and key performance indicators will also be developed to support tenderer onboarding.

A subsequent monitoring phase will track adoption of recommended tools and standards, gather feedback from project teams and end-users, observe additional technologies introduced by suppliers during the PCP phases, and identify candidates for wider adoption or new standardization. Adoption monitoring will draw on usage metrics, interoperability test outcomes, exercise and incident feedback, and periodic reviews with change control.

Standardization efforts will focus on identifying gaps in existing OGC and INSPIRE profiles and proposing extensions or new profiles where necessary, with findings fed back to relevant standards bodies and communities of practice. An emerging technology watch will track developments in EO processing frameworks such as openEO, edge and 5G computing, and AI-assisted anomaly detection, with defined criteria for inclusion and minimum maturity thresholds.

Broader conformance testing and field validation activities are planned for the later PCP phases, which will provide empirical evidence on the operational performance and interoperability of procured solutions in real-world crisis management scenarios.

CONCLUSION

The project delivers a validated, stakeholder-driven set of five representative use case clusters that span urban and rural contexts and key climate resilience challenges (groundwater depletion, excess surface water, vegetation stress). Through structured scoping, USLs, and prototype-based validation, it translates operational needs into clear technical and non-technical requirements with defined test sites and acceptance criteria. Complementary SOTA/market, IPR/standards, and economic analyses de-risk procurement by clarifying maturity, gaps, constraints, and value.

By combining operational co-design, standards-based harmonization, and phased competitive R&D procurement, the PCP-WISE approach provides a replicable model for cross-border resilience innovation. Together, these outputs provide a robust foundation for the PCP-WISE tender, ensuring that forthcoming R&D targets fit-for-purpose, interoperable solutions capable of improving local and regional climate resilience in the short, medium, and long term. Looking ahead, this framework has the potential to provide a sound basis for near-future pan-European water and water-crisis management information services that can be scaled across administrative and national boundaries to strengthen societal resilience to climate-related extremes.

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