NSSN
NSW Smart Sensing Network

Smart Sensing for Flooding Codesign Workshop

Summary Report

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On 23 August 2022, the NSW Smart Sensing Network (NSSN) hosted the *Smart Sensing for Flooding Co-design Workshop* at the Hawkesbury Institute for the Environment, Western Sydney University. The purpose of the event was to mobilise experts across academia, industry, and government to explore smart sensing opportunities for **flood prediction, response, and recovery.** The ideas gathered from the wide range of stakeholders will be pursued for realisation into collaborative projects, alongside the recommendations put forward by the 2022 NSW Flood Inquiry report.

A total of 75 people registered for the event with various backgrounds – including relevant stakeholders who are directly involved with flood response. Good representation was seen across the attendees in the broad categories of industry, government, academic and the NSSN team. The fact that many had gathered from various locations including Lismore, Brisbane, Canberra, and Sydney demonstrated the overall support towards resolving the challenges posed by floods.

The workshop was opened by the Member for Hawkesbury and Parliamentary Secretary for Science, Innovation and Technology, **Ms Robyn Preston MP.** A range of challenges were put forward from the recent flood events around; improving real-time alerts, better communication on evacuation routes, and ensuring network connectivity for people. A call was made for what new technologies can offer to deliver more accurate information to those who need it.

The opening addresses were followed by keynote speakers and panel discussions:

- **Associate Professor Damien Maher**, Southern Cross University
- **Mr Stephen McRobert**, Chief Information Officer, NSW State Emergency Service
- **Ms Anna Nelson & Mr Dean Betts**, Resilience NSW

- **Panel 1**: Moderated by Peter Runcie, NSSN Smart Cities Theme Lead
    - Ms Robyn Preston MP, Member for Hawkesbury
    - A/Professor Damien Maher, Southern Cross University
    - Mr Peter Cinque, Senior Manager - Emergency Risk Management, NSW State Emergency Service
    - Mr Andrew Dyer, Principal Peril and Climate Risk Analyst, IAG Australia

- **Panel 2**: Moderated by Dr Diana Day, NSSN Board Member
    - Mr David Witherdin, Deputy Secretary - Commercial & Corporate Services, Department of Regional NSW
    - Mr Angus Ferguson, Senior Environmental Scientist, Commonwealth Department of Environment and Climate Change
    - Ms Nichol Bichel, Principal Flood Engineer, Floodmapp
    - Mr Steven Molino, Founding Principal and Director of Water Technology, Molino Stewart

Workshop summary and general overview:

Overall, 45 out of 70 registrants attended the event (not including NSSN representatives), forming an almost equal split between government, academia, and industry.

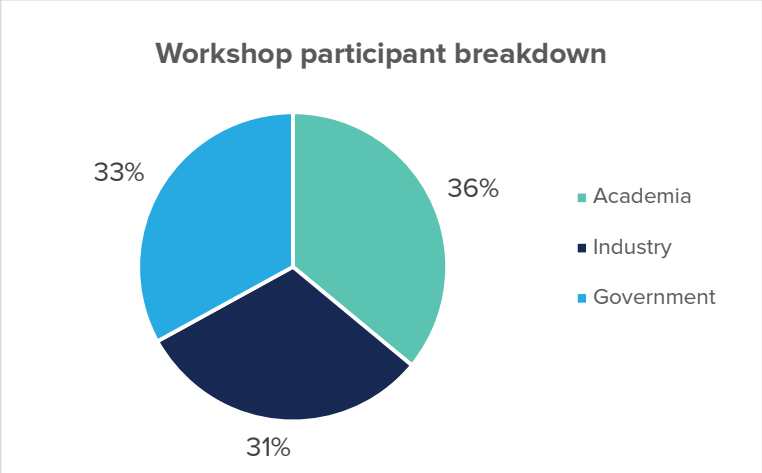


Figure 1: Breakdown of the participants attending the NSSN Smart Sensing for Floods workshop - showing a good representation across academia, industry, and government.

Some key insights from the opening speeches and panels were:

- Many people were contacting their local MP through Facebook to determine if they needed to evacuate or not.
- There are no gauge systems in the Yarramundi
- There should be more consideration on the indirect impacts of floods such as logistical issues in transporting and delivering supplies to affected members of the community
- The drainage system is largely unmapped, and its functionality is likely compromised due to a lack of maintenance
- In the recent floods, there was significant rainfall all at once, all over the catchments, not in specific locations as usual. Modelling struggles to cope with such events
- Warning messages lagged actual flood levels; the language used lacked any call to action
- Several gauges failed during peak floods
- During moderate flood levels, SES warnings were accurate but lost touch with reality as the flood worsened
- The SES deals with a deluge of data from various sources, which are not always accurate
- Decision chain for assets in the flood plain comes from gauge data and modelling, high premiums are due to failures in the chain. Investment in the health of the network is required
- The community knows what to do during a flood, but the messaging gave the wrong impression that the floods would subside the next day. There is no understanding of the impact and duration of such events, as such the best decisions cannot be made

- Harnessing people's sense of agency is key; even if the technology is perfect, the delivery of that information and translation into action is crucial
- Community/locally based ground observations of river heights need to be integrated into decision making
- There is a gap in monitoring the entire water ecosystem. The entire monitoring chain needs to be strengthened
- There are no official communication pathways between emergency services and the community. There is still a lack of telecommunications service to remote communities
- The after-effects of the floods left a swath of rotting vegetation affecting oxygen content of the rivers, leading to massive fish kills

To address these items in more detail the co-design session allowed for attendees to take a deep dive into these issues and see where smart sensing could address them.

Co-design session outputs

1. Stakeholder map

The second part of the workshop involved all attendees brainstorming ideas to put forward to address these broad themes. The first activity involved all participants building up their own map of relevant stakeholders – describing how they see information flowing between different organisations and themselves. The purpose of this exercise was to understand the underlying relationships between different entities in the flood scene and to get a broad understanding on the workflow from each end of the decision chain. Multiple groups established their own stakeholder maps - each with slightly different angles. Rather than showing the results of each, Figure 2 below shows a map that combines the key pieces of information gathered across all groups. It is important to note that this is only an aggregate of everyone's perception of what the process flow looks like from a generic, high-level standpoint, and may not truly represent the reality of the flood response ecosystem. (It appeared that attendees focused mostly on the entities related to the immediate response to a flood event, rather those involved with the prediction and recovery stages.)

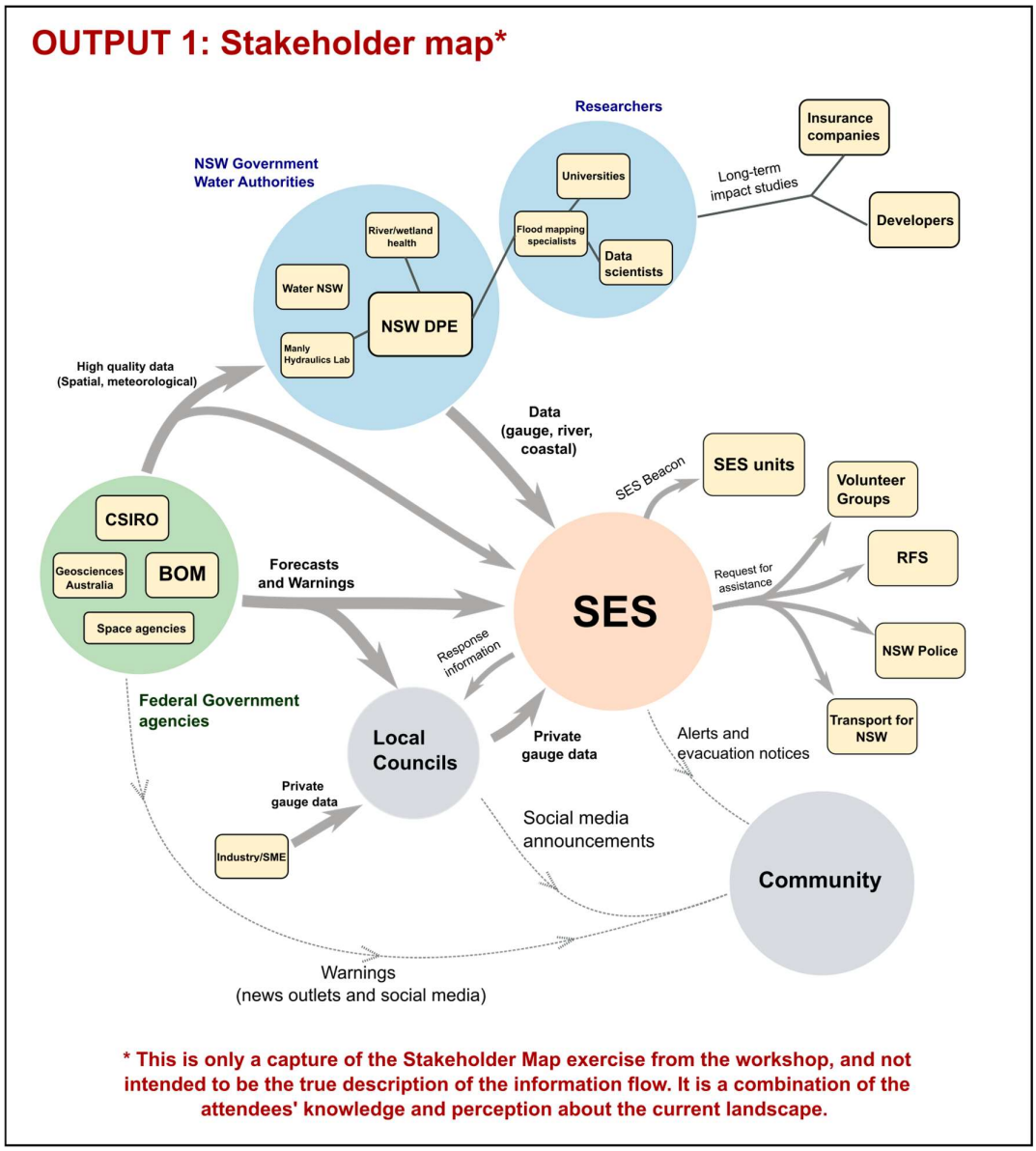


Figure 2: Stakeholder map developed from the first exercise in the Co-design session.

Observations gathered from this exercise are:

- There are many stakeholders, with more to be uncovered, with complex relationships. In some cases, the flow of information is unclear, and entities downstream are confused where to get relevant information.
- Due to the sprawling web of relationships, caution should be taken in developing solutions as they will affect multiple entities in the web. Their relationships and how they interact with one another must be fully evaluated to ensure that all user needs are considered.
- There is a general flow of information from federal government agencies (e.g., the BOM) to those who interpret this into actions/responses with no obvious hierarchy
- Flood data comes from multiple agencies at all levels of government (federal, state, and local) and industry

- Some local councils have worked independently with local SMEs to set up their own gauges. More can be done to understand how to connect this information with the broader group, and ensure the data is consistent.

In line with the 2022 Flood Inquiry report, the SES is the pinch point in the process flow, overburdened with making sense of the all the data from various sources and translating them into actionable decisions at a timely and efficient rate. The BoM is a critical source for this information, as the primary reliable source of information through which future decisions are reliant.

2. Problem statement generation

The second activity called upon individual groups to construct a number of problem statements relevant to their line of work in the flood response ecosystem. This was a high-speed, high-volume exercise with the intention of retaining these entity-specific problem statements for further pursuit after the workshop. Following this, each table was asked to decide on a single problem statement for detailed evaluation, to which all members could contribute. This involved considering the problem from an external user interface and economic/technical feasibility perspective.

There were 123 problem statements written down in the workshop, which were recorded and categorised. A significant overlap of key themes was identified. The following chart presents a breakdown on the key categories addressed. Rather than list each individual statement, a general description of what each category entails are below.

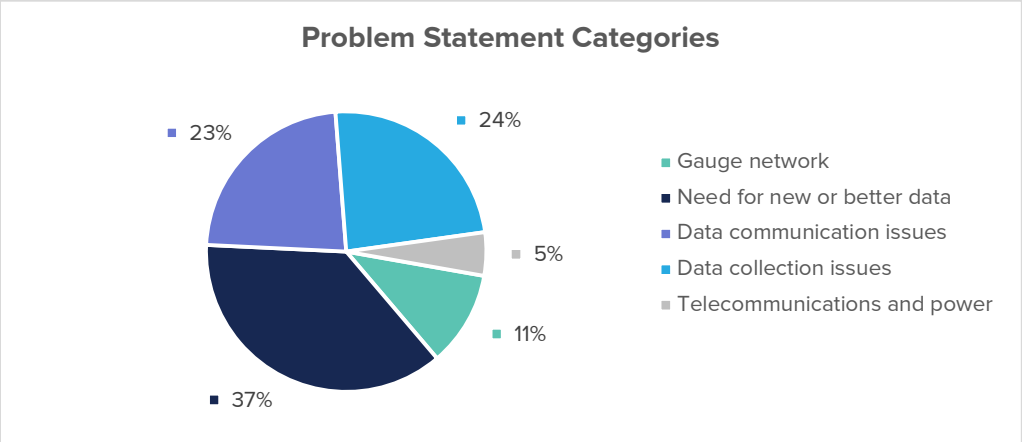


Figure 3: Breakdown of generated project statements by topic.

Gauge network: Various issues compromise the integrity of the current rain and river gauge network. They include unreliable data during peak and flash flooding, lack of spatial resolution in key areas of interest, unmapped parts of the river system, no visibility on knock-on effects from flooding upstream or downstream, the encroaching issue of maintainability and longevity of the network, and lack of a centralised monitoring system across entities raised as key issues.

Need for new or better data: A considerable number of statements showed the need for additional sensor data to complement the current network, as well as general requirements for what a new system would require. Scalability, real time measurements, strategic sensor placement according to risk, and ease of maintainability were listed as ideal improvements. Using sensors to get a better understanding of the land, effects of vegetation, topographical variations where evacuation routes and critical infrastructure are affected by landslips and flooding was also a shared notion across groups.

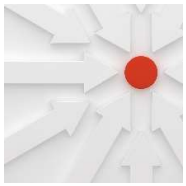
Data communication and data collection issues: Although not directly related to sensors, a great portion of problem statements were dedicated to the problem of integration of various sources of data, and the synthesis and translation of that information into clear, actionable decisions on behalf of emergency services and the community. Future projects should keep in mind the intended use, and corresponding impact, of new data gathered. The way in which data are both gathered and delivered should ultimately be for the purpose of making quicker, more educated decisions for all stakeholders involved. A balance must be struck between obtaining enough data to fill in information gaps, whilst making sure it is not unwieldy. This may be a case where less is more.

Telecommunications and power: A small amount of problem statements referenced the power outages and network communications shutdowns during floods.

Each group was asked to select one problem statement for further exploration to be presented to their adjacent table for constructive feedback. Each group's problem statement is outlined below with its corresponding feedback. (Note: There was no Group 4 in this workshop due to specific arrangement of the room).

	Selected Problem statements
	**Group 1: Lack of accurate and integrated information.** There needs to be a more accurate, abundant, and real time source of data that can be accessed from a centralised system to facilitate situational awareness. A new-generation sensor network that allows for additional metrics such as river rate-of-flow, upper catchment measurements, confidence bounds, historical levels and their respective metadata will be stored and serviced in an open access network. Telecommunications service providers will need to be involved to maintain serviceability, and a consolidated government approach will be required for a standardised implementation and to ensure robustness of the system throughout time. Challenges: • Ensuring the data is open access, and maintained overtime with a dedicated budget • Consolidating the data in such a way that creates impact • Interfacing with the current gauge network and relevant stakeholders
	**Group 2: Poor understanding of river dynamics and stability** Local governments need more information about river dynamics to make decisions around land-use, infrastructure planning, and evacuation route risk assessments. Better river gauges (real-time), the incorporation of remote sensing techniques, and historical data (e.g., soil erosion, paleo floods) can provide this information. Specific local areas have performed these studies, the next step is to do this at scale and integrate all studies together to complete the picture. This would require collaboration between land holders, farmers, environmental flow managers and government to get a better picture of river catchments and how they will hold up in flood events.
	**Group 3: Latency in forecasts: Rainfall and flooding** Councils and SES need access to more real-time rainfall data to help them to respond faster to flood events. SES needs minimum latency on the information to better plan evacuations. “Rainfields data” (a quantitative radar-based rainfall estimate) is available at cost from the BOM, and there is avenue to explore using this for hydrological forecasting. New models that fuse this radar and gauge information could be explored, along with a study on the scaling up of this technology. How can this system be made accessible to all councils?

	**Group 5: Existing network does not have enough geographic coverage - utilise low-cost sensors.** Central agencies need more water level and rainfall data. The key is achieving near real-time (5-minute sampling rate) data to provide rapid warnings and decision-making. Low-cost widely distributed sensors across the catchment are required to achieve this. The data will be transmitted via radio networks to access points, and then via cellular or satellite comms to an IoT platform to be visualised online.
	**Group 6: Personalised Evacuation Planner - Building community knowledge of appropriate water levels and risk into evacuation route planning.** Evacuation advice to communities is generic in the sense that the same advice is given to people in a vicinity even though individuals have different needs (e.g., have young children or elderly family members, mobility impairments, need to move livestock, lack private transport). Individuals also have different risk appetite – some wishing to leave well in advance while others willing to wait longer before leaving. Evacuation plans and advice should be dynamic and consider changing conditions as well as individual circumstances. At least, the following information should be used: flood models, live traffic feeds, current and predicted condition and availability of transport infrastructure, implicit community knowledge about evacuation routes, actual conditions on the ground and personal circumstances. An evacuation planning and alerting system should have a simple user interface to allow community members to build personal “evacuation profiles and an information platform that generates personalised evacuation advice for individuals. Similar functionality could be provided to organisations such as aged care facilities and integrated with community transport providers. Challenges are likely to include data privacy and ensuring the models remain accurate on-the-fly. Multiple stakeholders will be required to support the system.
	**Group 7: How to turn different sources of data into actionable items?** Community and businesses need existing data to be converted into real-time information to plan for evacuation. Data such as rainfall, river gauge and river levels exist in separate locations but do not advise the impact on the catchment and the community. The idea is to develop an app to pull data from multiple agencies (e.g., stream gauges & BOM rain forecasts) and provide targeted, location specific, warnings and recommendations to the user.

	[Note: Given the overlap – Group 6 & 7 combined their problem statement]
	**Group 8: Multi-user interface for data source integration** All data, of all scales, are required in one centralised location (satellite, land-use, gauge, vegetation cover, water quality, air quality…) for councils, government, and research organisations. This platform will aid future modelling, mapping, and localised warnings for certain areas. The goal is to have an open data platform that inspires innovation. Other sources such as First Nations' traditional knowledge should also be considered. Challenges foreseen on data sharing and finding a common data structure that is suitable for multiple agencies.
	**Group 9: Sense and observe impact of events – to better predict the next event.** Future floods are inevitable and more needs to be done to build back better – by sensing and collecting data from the recent events. This involves collating impact data (ecological and infrastructure), insurance claims, remote sensing data, and citizen science inputs. The proposed solution is to construct an interdisciplinary pilot of a flood impact model that evaluates the efficacy of flood response measures.

Next steps:

The problems above, combined with those revealed from NSSN's internal literature reviews, will be subject to further pursuit to determine their technical feasibility, cost-to-benefit ratio, and their implementation road map. This will be done through interviews with relevant stakeholders (both workshop attendees and newly identified ones) and additional literature reviews.

The anticipated timeline for completion of the initial proposals will be 2-3 months with funding opportunities to be sourced from government bodies and interested industry partners. At this point, the NSSN will call upon interested members to be part of the solutions moving forward.

List of workshop registrants

Name	Organisation	Codesign group number
Adam Murphy	Bureau of Meteorology	-
Aditi Phansalkar	University of Technology Sydney	-
Alex Clifton	Bureau of Meteorology	-
Andrew Dyer	IAG	7
Angus Ferguson	NSW Department of Planning and Environment	2
Ashok Rant	Water NSW	7
Basant Maheshwari	Western Sydney University	-
Ben Smith	Western Sydney University	8
Ben Eggleton	University of Sydney	3
Beth Mitchell	NSW Department of Education	6
Bronson McPherson	Manly Hydraulics Laboratory	1
Cameron Churches	Taggle	5
Carmela Brion	Resilience NSW	-
Carolyne Huber	Schematic Intel	7
Chintan Gatecha	Senstra	-
Cormac Purcell	Trillium	6
Damien Maher	Southern Cross University	2
David Kennewell	Hydrata	2
Diana Day	NSSN	2
Fiona Johnson	University of New South Wales	8
Habib Rehman	Iconics	1
Jackie Carr	Hawkesbury Council	1
James Ball	University of Technology Sydney	3
James Melsom	University of Technology Sydney	-
Jeff Loughan	Lixia	6
Jo White	NSSN	5
Joanna Kraatz	Wollondilly Council	9
Jodie Hatfield	Macquarie University	5
Joe Leech	Aquamonix	-
John Close	Australian National University	-
John Jones	Taggle	-
Jose Rodriguez	University of Newcastle	7
Julien Epps	University of New South Wales	5
Juliette Murphy	Floodmapp	-
Katherine Dafforn	Macquarie University	9
Kenneth Iam	Senstra	8
Kirstie Fryirs	Macquarie University	8
Lucy Marshall	University of New South Wales	1
Luke Kavanagh	Madison Group	-
Martin Andersen	University of New South Wales	-
Martin Bryant	University of Technology Sydney	-

Meighan Heard	Mitsubishi Electric Australia	1
Michael Chang	Macquarie University	6
Moe Mojtahedi	University of New South Wales	-
Myl Senthilvasan	Penrith City Council	7
Nick Haskins	NSSN	9
Nick Long	Bureau of Meteorology	-
Nicolas Lyons	NSW Department of Primary Industries	9
Nicole Bichel	Floodmapp	1
Patricia Saco	University of Newcastle	8
Peter Cinque	NSW State Emergency Service	3
Peter Runcie	NSSN	6
Philip McAteer	Blacktown Council	7
Robert Salama	Western Sydney University	9
Romeo Gaubert	Schematic Intel	3
Sarah Barns	Sitelines Media	-
Sathaa Sathasivan	Western Sydney University	7
Sean van der Walt	Walt Technologies	-
Shin-Chan Han	University of Newcastle	6
Shivanesh Rao	NSW Department of Planning and Environment	8
Simon Igloi	Lixia	5
Stephen McRobert	NSW State Emergency Service	3
Steven Molino	Molino Stewart	9
Steven Sandi	University of Newcastle	5
Stuart Khan	University of New South Wales	-
Tim Ralph	Macquarie University	2
Valerie Tulk	Northern Beaches Council	3
Will Barton	Hawkesbury Council	2
Willem Vervoort	University of Sydney	9
Yuuta Van Hamond	Senstra	8