CSIRO Submission 11/407

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Introduction

CSIRO is an internationally recognised research and development organisation with extensive expertise in the fields of hydrology, materials science, river management and climate change and climate variability. This submission has been prepared by a team of scientists from CSIRO with experience and international recognition in these fields.
This submission is structured according to the Terms of Reference (ToR) of the Commission of Inquiry.

Response to the Terms of Reference

a) The preparation and planning by federal, state and local governments; emergency services and the community for the 2010/2011 floods in Queensland

CSIRO has no comment to make directly on this ToR. However there is strong agreement in the international climate change research community that severe weather events are likely to become more frequent and intense under climate change (see http://www.csiro.au/science/adapt-extreme-weather.html). This is an important factor to consider when evaluating future preparations and plans for severe weather events.

b) The performance of private insurers in meeting their claims responsibilities

CSIRO has no comment to make on this ToR.

c) All aspects of the response to the 2010/2011 flood events, particularly measures taken to inform the community and measures to protect life and private and public property

CSIRO has no comment to make on this ToR.

d) The measures to manage the supply of essential services such as power, water and communications during the 2010/2011 flood events

CSIRO has no comment to make on this ToR.

e) The adequacy of forecasts and early warning systems particularly as they related to the flooding events in Toowoomba, and the Lockyer and Brisbane Valleys

CSIRO considers that the forecasts used for the flooding events in Toowoomba, the Lockyer and Brisbane Valleys were the best available for the region at the time. Significant research is in progress to improve the skill of future flood forecasts.

To address current knowledge gaps CSIRO's research and development concerning flash flood forecasting is aimed at incorporating the effect of initial catchment wetness and other physical characteristics while modeling streamflow. Currently, warnings are mainly based on expected rainfall intensity (i.e. how much rainfall is expected over the next few minutes to hours) with little consideration of what type of soil the rain is falling on or how much more water the soils can hold. Flash flooding prediction may be best done using a special class of spatially distributed models because such flooding can occur anywhere, not just in the main river channels.

CSIRO is also developing software that produces probabilistic predictions of river flows with a lead-time of up to two weeks. The aim is to improve the ability to predict river flows by simulating catchment water balance and river flows using rainfall forecasts as well as real-time observations of rainfall and river flow as inputs, which would improve future forecasting abilities.

Measurement of rainfall and soil moisture

The measurement of the rate of rainfall and soil moisture is a fundamental limitation to the prediction of all forms of flooding. Traditionally rainfall measurement has been limited to a sparse network of ground based rain gauges that are either manual rain gauges (read once or twice a day) or automated rainfall rate sensors (pluviometers).

Other forms of rainfall measurement are now available or are in various stages of the research and development process (Renzullo et al., 2011). For example, much of the densely populated parts of Australia are now instrumented with a network of rainfall radar facilities that measure the electromagnetic energy reflected from raindrops, which is converted to an approximation of rainfall rates distributed across a ~200 kilometre radius from the instrument. Also, there are satellite-mounted sensors that provide estimates of the rate of rainfall across the continent (Li and Shao, 2010).

CSIRO is evaluating the use of blended ground-based and satellite-based approaches to rainfall measurement. This work focuses on whole-of-continent daily rainfall estimation, so that, if successful, the amount of daily rainfall for every part of Australia could be assessed. This would be especially useful in locations that are remote from the rain gauge and rainfall radar network, or where a sparse rain gauge network can be used to locally calibrate the satellite mounted sensor. These data may also be useful for predicting local flooding including flash flooding if the current technical limitations can be overcome.

Recent technologies for assessment of soil moisture across catchments may offer significant future improvement in flood forecasts. Soil moisture is now measured for large portions of the world's land surface using passive microwave sensors mounted on orbiting satellites (Liu et al., 2009). Prior knowledge of soil moisture across a catchment enables predictions of runoff to be adjusted accordingly. When soils are saturated, all rainfall becomes runoff. The degree and spatial extent of this effect has been largely unknown outside small experimental catchments until the advent of microwave sensor technologies.

Monitoring inundation by remote sensing

Forecasting of river flows including floods is generally informed by stream gauges that measure the height of river flow and convert this to the volume of river flow.

Measuring stream flow in this way has a number of limitations:

- Stream gauges can be damaged during floods by debris
- The relationship between river height and river flow rate is uncertain and non-linear, particularly when the river flow is above the banks of the river. This effect is especially common and important in environments of low topographical relief including the flatter inland parts of Australia.
- Stream gauges are frequently sparse in low population environments including many non-coastal parts of Australia.

One or more of these three limitations are likely to apply for flood events. All three are likely to apply in low terrain, semi-arid and arid parts of Australia including the western Darling Downs and Maranoa.

To address these limitations CSIRO has recently undertaken research using satellite-mounted instruments to sense inundation where floods take many days to many months to travel along a river network. This work was piloted in the Condamine-Balonne River network of south west Queensland and north west New South Wales, more specifically the Balonne floodplain, downstream of the St. George township. Using a combination of satellite images and high resolution land surface elevation data for the area being measured, this method allows assessment of the volume of water inundating low terrain areas, including those with multiple channels and extensive flooded floodplains (Gouweleeuw et al. 2011). This provides an instantaneous estimate of the volume of flood water for a large area. This estimate can be used as an input to prediction of the downstream flooding that is independent of the conventional flood monitoring network and therefore is likely to improve flood forecasts. It is anticipated that these techniques may become operationally available in ~5 years time and complement existing methods in inland low terrain catchments.

For short duration events such as flash floods, Australian satellite availability is limited because the satellite overpass may not coincide with the time and location of the flood event. This limitation is of greatest significance for short duration events such as those experienced in the Lockyer Valley (where there is hours or one or two days between rainfall and downstream flooding) and is of much less consequence in applications where floods take many days to months to move down major rivers, like the Condamine-Balonne river system in south west Queensland, or the Fitzroy River in central Queensland.

The use of satellite-mounted instruments in Australia is hampered by reliance on satellites owned and operated by other countries. The satellites currently used by researchers are in non-geostationary orbits around the earth, so that the measurement of Australian rivers and catchments is subject to the coincidence of events on the ground and the timing of the overpass of the satellites and their sensors. This leads to delayed measurement and transmission of the data for use in Australia.

Geostationary satellites, that orbit the earth in a way so that they are constantly directly above the land and water to be measured, are used by many nations. These satellites are often referred to as weather satellites as they provide near continuous monitoring of key weather-related quantities. Australia does not have such a satellite platform. If it did, the satellite-based data described in this submission could be measured near continuously and made available within minutes of measurement.

f) The implementation of the systems operation plans for dams across the state and in particular the Wivenhoe and Somerset release strategy and an assessment of compliance with, and the suitability of the operational procedures relating to flood mitigation and dam safety

CSIRO has no comment to make directly on this ToR. However, the operation of reservoirs usually involves tradeoffs between the different roles that the reservoir performs which may include flood mitigation, hydroelectricity generation and security of future water supplies. This submission does not critique current operational procedures, but describes a development that could be incorporated into future reservoir operation procedures.

Forecasting climate and stream flows for the coming season (~3 months ahead) has many potential advantages for land and water managers. Such forecasts are presented as probabilities (see Wang et al., 2009; Robertson and Wang, 2009 and Wang and Robertson, 2011). As such these forecasts do not predict conditions on a specific day However they can inform risk management of outcomes influenced by climate and stream flow in the coming three months (like those concerning the balance between water supply and flood mitigation for reservoirs). Operational stream flow forecasts only became available from the Bureau of Meteorology in late 2010 for a limited number of catchments in south-east Australia, so it is likely that many related operational systems, including reservoir management procedures, are yet to be adapted to take advantage of this information. CSIRO understands that the Bureau of Meteorology seasonal stream flow forecast service will gradually be extended to include rivers in other parts of Australia including Queensland.

While any review of operational procedures requires consideration of local factors, in principle reservoir operators should have improved confidence in their predictions of coming stream flows once seasonal stream flow forecasts are available. Operators could use this information as an input to balance the flood mitigation and water storage roles of reservoirs such as Wivenhoe Dam.

g) All aspects of land use planning through local and regional planning systems to minimise infrastructure and property impacts from floods

Broadly there are three types of non-coastal terrain where forecasts of flooding in Queensland are applied: high relief landscapes such as the upper parts of the Lockyer Valley, the flood plains of major coastal rivers such as the Brisbane River and very low terrain landscapes of inland Australia where multiple river channels are common, such as the environment surrounding the Balonne River. There are a number of software tools and new approaches to monitoring which may assist in future risk assessment and planning for floods. The monitoring techniques described above would be greatly enhanced through the deployment of an Australian weather satellite and sensors currently under development.

Understanding flows across the Landscape

For high relief landscapes where flow speeds are relatively high and the dynamics of flow paths and flow speeds are especially important, CSIRO is developing software tools which could be used to enhance future land use planning. These models provide simulations of rapid changes that occur as floods develop and explicitly include the interaction of flows with the highly variable land and vegetation surfaces that the flood encounters as it moves down watercourses and across floodplains (Cleary and Prakash, 2004). CSIRO has experimentally applied this approach to several case studies worldwide (Cleary and Prakash, 2004). The CSIRO simulation model calculates the height and speed of water as it varies through time using a digital elevation model of the land and streams. The widespread operationalisation of such models depends on evaluation across a range of environments. Surveying the extent of the 2010-2011 Queensland floods provides an opportunity for the evaluation and calibration of these predictive tools.

Vulnerability of communities and adaptation options

CSIRO's South East Queensland Climate Adaptation Research Initiative (SEQCARI) is a three year research initiative examining South East Queensland's vulnerability to climate change and developing practical and cost-effective adaptation strategies to assist decision-makers in government, industry and the community. It is a collaborative project that involves over 40 scientists from the CSIRO Climate Adaptation National Research Flagship, Griffith University, The University of the Sunshine Coast and The University of Queensland.

SEQCARI's interdisciplinary and integrated research will be able to inform the response to the floods across a number of sectors, particularly in terms of having an improved understanding of the systematic and cross-sectoral drivers that facilitate and constrain preparedness for, and response to, such extreme events.

By using a statistical approach to examine the impact of flooding levels on the value of private residences, the benefits of different inundation adaptation measures are being assessed.

There are a number of other activities within SEQCARI which can inform planning to reduce community vulnerability:

- Field work to monitor mangrove responses to climate stresses, particularly sea-level rise. Mangrove communities have received large sediment loads during the recent floods, and hence have risen at a faster rate than current sea-level increases.
- Work with beef and horticulture producers to explore existing and future adaptation. Many producers have measures in place to retain sediment in extreme weather. Recent floods have tested many such adaptation measures and will provide insights into their effectiveness.
- Exploring how planning models can be modified in order to incorporate climate change uncertainties.
- Examining the social, economic and environmental determinants of adaptive capacity to climate change. Integrated models are being developed via participatory workshops focusing on different settlement types (Gold Coast, Sunshine Coast, Moreton Bay and Ipswich) and sectors (Biodiversity, Energy) across south east Queensland.
- Using a scenario planning approach in partnership with major regional stakeholders to explore what adaptations are needed for emergency responses in extreme weather, as well as the appropriateness of the current arrangements for cross-sectoral coordination for facilitating adaptation. Additionally, CSIRO examines the linkages between emergency management and critical infrastructure (such as roads) and explores the suitability of the disaster management arrangements in south east Queensland to handle the increasing demands due to climate change and the efficacy of hazard awareness and preparedness strategies. CSIRO has developed design and materials selection recommendations for the construction of housing subjected to severe weather events. In particular, CSIRO, in conjunction with the NSW Government and the Gold Coast City Council, has produced strategies and design documents to minimise flood damage to housing, and the application of these strategies has the potential to reduce damage by 50–80% depending on flood depth and speed.

There are two ways to protect housing from floods:

- Wet-proofing—allows flood water to enter a dwelling, but minimises its effects through design, structural strengthening and materials selection.
- Dry-proofing—impermeable barriers within the house fabric prevent water ingress; only suitable for houses subject to shallow flooding (<0.5 m), as hydrostatic pressure can cause structural failure for deep floods.

CSIRO/NSW Government research into wet-proofing is summarised in the report *Reducing Vulnerability of Buildings to Flood Damage.* http://www.ses.nsw.gov.au/multiattachments/9022/DocumentName/Building_Guidelines.pdf.The document (based on NSW housing types) not only looks at design changes and materials selection to reduce flood damage, but also compares and costs the damage likely to be incurred by different house types, both with and without minimisation strategies. For example, in shallow floods in which water rises just above the floorboards, wet-proofing can reduce damage by up to 80%. Appropriate selection of housing type (house on suspended floors versus slab on ground) can lead to major damage reduction in deeper floods. On the basis of this work, a user friendly software tool to predict damage to housing on a city-wide basis has been developed.

Dry-proofing is widely used in the UK and the USA, and CSIRO/Gold Coast City Council research into dry-proofing has demonstrated that the technique is feasible for Australian building designs, although additional research is required to produce codes and guidelines.

In addition, CSIRO has produced guidelines on immediate post-flood repair (available at http://www.csiro.au/org/Repairing-Flood-Damage.html), which were developed following surveys of floods in the Benalla, Geelong (Victoria) and Wollongong regions (NSW). These guidelines are being referred to and linked to by the Queensland and Victorian Building Commissions in the recent emergency recovery. Early drainage and drying of buildings is vital as the high moisture contents in materials and the building fabric can promote long term decay.

Summary

As an independent research agency CSIRO has limited comment to make directly on the ToR for this inquiry, in particular those which relate to operational issues and the response by policy makers and government agencies. However there are number of areas where research can inform the recovery process in terms of reconstruction and planning. Developments in forecasting rainfall, streamflow and flooding patterns could contribute to improved forecasting, prediction and warning for extreme events in the future.

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