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# Assessing stakeholder receptivity to flood mitigation adaptation pathways.

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**Abstract:** The combination of rapid urbanisation and anthropogenically induced climate change contributes towards urban cities facing increasing levels of flood risk. It is hypothesized that the visual presentation of various adaptation pathways given uncertain future scenarios will aid in identifying potential barriers towards the implementation of the proposed adaptation pathways. This research models the 1D/2D flood dynamics in an urban catchment that is subject to uncertain future scenarios of varying rainfall events, sea level rise, and urbanisation due to population growth. Adaptation pathways which include land use controls, rainwater harvesting, and drainage maintenance are evaluated for their ability to mitigate floods under uncertain future scenarios. A visual presentation of various adaptation pathways given uncertain scenarios is presented to stakeholders to aid in the assessment of stakeholder receptivity towards proposed adaptation pathways. Stakeholder receptivity will be assessed using surveys with which the results will be used to develop an understanding of the requirements for adaptation pathways to be implemented.

**Keywords:** Urban flooding; adaptation pathways; receptivity

## 1. INTRODUCTION

Floods impede the ability of developing countries and countries with climate reliant industries to grow socioeconomically. Climate change, and urbanisation place increasing stresses on flood resisting communities, rendering flood resistance measures unsustainable (Liao, 2012).

For centuries civilizations have primarily dealt with floods by resisting measures such as dams and dikes (Kundzewicz, 2002). When a community relies primariliy on structural flood protection measures, the impacts of floods as well as the ability to respond effectively to a flood event are often forgotten (Bosschaart et al., 2016). Further, the failure of a resisting systems is often catastrophic (Liao, 2012). Resilient communities rely on a balanced combination of structural and non-structural flood mitigation measures. A resilient system that is subject to shocks will respond by adapting to a new acceptable state.

Non-structural measures that contribute towards a communities flood resilience include; policy, laws, regulations, zoning, economic instruments, private mitigation measures, evacuation planning, flood forecast and warning systems, flood databases, flood risk assessments, maintenance of drainage infrastructure, and flood education programs (Kundzewicz, 2002).

The understanding of a communities flood risk is an essential step towards resilience. Flood risk is defined as a function of; hazard, exposure, and vulnerability (Allen et al., 2011). For resilient flood mitigation measures to be implemented it is necessary that flood risks for alternative adaptation pathways given uncertain future scenarios be conveyed to stakeholders. Model visualisations are a powerful tool that can be used to enhance communication and learning (Voinov et al., 2016).

Educational attempts focused on flood risk have targeted flood risk awareness and flood risk perception. A review of the literature (Wachinger et al., 2013) has demonstrated that an increased risk awareness or risk perception does not necessarily correlate with increased protective actions. For flood risk mitigation measures to be adopted it is essential that the receptivity (Jeffrey & Seaton, 2004) of stakeholders be assessed. (Farrelly & Brown, 2014) used the receptivity model to assess and contrast a communities expected receptivity towards resilient alternative water supply options for uncertain climates with the actual receptivity of the community. Thus allowing the identification of potential barrier towards the adoption of resilient water supply policy. There are no current studies in the urban drainage modelling literature that use visually based flood assessments of flood adaptation pathways to aid in the assessment of receptivity in stakeholders. This study will aid in the identification of potential barriers towards the adoption of flood resilient policies.

## 2. MATERIALS AND METHODS

To assess the uncertain future scenarios and adaptation pathways a flood model for the Elster creek catchment of Victoria Australia is developed. Scenarios and adaptation pathways are simulated using the Two dimensional Unsteady FLOW (TUFLOW) Heavily Parallelised Compute (HPC) module. To provide a baseline initial receptivity is assessed. Model visualisations are used to educate stakeholders on the effectiveness of flood mitigation adaptation pathways given uncertain future scenarios. Receptivity is retested to determine remaining barriers towards implementation of flood resilient adaptation pathways.

### 2.1 Description of study sites

*Elster creek*. The Elster creek catchment is an urbanized catchment of 39 $km^2$. The Elster creek catchment is built primarily on swamp land and is subject to pluvial and tidal flooding events. The provision of 1m resolution lidar data, detailed topography and drainage network make the Elster creek catchment an ideal catchment to explore and visualise adaptation pathways under the influence of uncertain climate and population scenarios.

*Cibinong*. Cibinong, the capital of Bogor Regency, Indonesia is currently undergoing rapid urbanisation and similar to the Elster creek catchment is predominantly built upon swamp land. There is currently insufficient high resolution data to model the impact various adaptation pathways have on floods given uncertain climate and population scenarios. It is hypothesized that visualizations of adaptation pathways from the Elster creek catchment will either improve receptivity towards adaptation pathways or aid in the identification of potential barriers towards the implementation of adaptation pathways.

### 2.2 TUFLOW
The TUFLOW HPC module is used to model the coupling of the 1D creek network with the 1D pipe network and 2D surface drainage network for numerous adaptation pathways under the influence of uncertain scenarios. The model is forced by rainfall on grid and has a downstream tidal boundary condition. To maintain speed and efficiency when assessing the adaptation pathways under uncertain scenarios a 5m cell resolution is used.

### 2.3 Scenarios
If sustainable and resilient flood mitigation strategies are to be proposed, it is essential that flood models consider the uncertainty associated with future scenarios. The current flood model is used as a benchmark for scenarios based on projections for 2030, and 2045.

*Climate induced rainfall changes*. Given the trajectory of projected Representative Concentration Pathways (RCPs) there is considerable uncertainty in the Intensity Frequency and Duration (IFD) of future rainfall events. Using RCP 2.6 and 8.5, rainfall intensities for events with Average Exceedance Probability (AEP) of 0.181 and 0.049 are used.

*Climate induced sea level rise*. A number of urban catchments are connected to the sea and are susceptible to increased flooding as a result of rising sea levels. Consequently, high, and low sea level rise scenarios are used as the downstream boundary condition.

*Population growth*. Urban development is highly dependent on population growth and economic development. To adequately assess flood mitigation strategies it is necessary to consider a range of population growth scenarios.

### 2.4 Adaptation pathways
To determine appropriate solutions that are resilient under the uncertain future scenarios adaptation pathways that include the use of rainwater tanks as flood storage measures, land zoning in undeveloped regions, and maintenance of drainage infrastructure will be assessed.

*Rainwater harvesting*. Rainwater tanks provide multiple benefits. Their use as a distributed smart flood storage network is currently underexplored in the urban drainage modelling literature. Adaptation pathways in which two different uptakes of 3kL rain tanks are modelled.

*Land zoning*. The prevention of development in currently undeveloped flood prone areas and restriction of further development in currently developed areas will be contrasted with the unrestricted development in flood prone areas.

*Maintenance of drainage infrastructure*. Without the provision of adequate maintenance schedules, solid wastes impede drainage networks and increase flood risk (Bankoff, 2003). Models of unblocked and partially blocked drainage networks will be used to assess the extent a partially blocked drainage network can exacerbate flood risk in an urban environment.

### 2.5 Receptivity model
The receptivity model described by (Jeffrey & Seaton, 2004) comprised of four components that is be used to identify the capacity of different stakeholders to absorb, accept and utilize innovation options. The four components are:

- Awareness – Prior knowledge of an issue or problem.
- Association – Recognition of the potential value of a proposed solution.
- Acquisition – Ability to acquire technologies or exploit new knowledge.
- Application – Ability and motivation to obtain long term benefit from proposed solutions.

Receptivity of the stakeholders to the proposed adaptation pathways will be assessed in Cibinong through surveys before and after the presentation of study results.

### 2.6 Workshops

Workshops are currently planned to be conducted in Cibinong. To assess receptivity the workshops will consist of an introductory receptivity survey, visual presentation of adaptation pathways for uncertain scenarios and then conclude with a survey that assess receptivity.

## 3. RESULTS AND DISCUSSION

No results are currently available. The modelling of adaptation pathways for uncertain scenarios will provide visual results that demonstrate the combined utility of drainage maintenance programs, land use controls and rain water harvesting. Surveys of receptivity will highlight potential barriers towards the effective implementation of adaptation pathways.

## CONCLUSIONS

Visualisations of flood impacts are provided for varying rainfall, sea level, and urbanisation scenarios. Land use controls, rainwater harvesting, and drainage maintenance adaptation pathways are assessed. Visual presentations of these adaptation pathways are presented to stakeholders in Cibinong to aid in the assessment of stakeholder receptivity towards these adaptation pathways. This methodology will contribute towards the identification of potential barriers that the implementation of adaptation pathways faces.

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