Climate Risk Management 6 (2014) 6–17

Contents lists available at ScienceDirect

Climate Risk Management

journal homepage: www.elsevier.com/locate/crm

Estimating future changes in flood risk: Case study of the Brisbane River, Australia

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ARTICLE INFO

Article history:
Available online 4 December 2014

Keywords:
Flood risk
Rainfall projections
Brisbane River
Wivenhoe Dam

ABSTRACT

Estimates of potential changes to flood risk due to climate change can be of great value but are difficult to estimate for various reasons including uncertain rainfall projections and problems associated with transforming model rainfall values into runoff and inflows at relevant catchment scales. Here we attempt to estimate changes to flood risk for the Brisbane River region of south-east Queensland which has a long history of serious flood events but which now benefits from the mitigating effect of the upstream Wivenhoe Dam. In this specific case study, the existence of good quality long-term records of rainfall, a relatively large number of climate model projections and the fact that the storage levels within the dam can be reasonably simulated as a function of annual rainfall totals provides a basis for estimating possible changes to flood risk. Changes to the risk of more serious floods is assumed to depend on changes to either the magnitude or frequency of extreme rainfall events combined with changes to the amount of water actually stored in the dam. An increase in extreme rainfall events could be offset by lower annual rainfall totals that effectively increase the mitigation capacity of the Dam. We analyse the results from climate models which simulate the effect of increased greenhouse gas emissions and note that they tend to favour an increase in the former and a decrease in the latter. As a consequence, the model results indicate a range of possible outcomes with no clear tendency one way or another. This outcome reflects the fundamental nature of the climate model results for rainfall for this region and will, most likely, dominate all attempts to reduce uncertainty.

Introduction

Information about potential changes to flood risk is valuable to a range of decision makers confronted with mitigation and/or adaptation options. At the catchment scale, it is crucial to dam managers who may be responsible for conserving water resources while mitigating the effects of heavy rainfall events. At the metropolitan scale, information about flood risks is crucial to local planners who must consider the vulnerability of increased population and assets located in flood-prone areas (Dumas et al., 2013). It also is obviously important to the insurance industry, which is why large the world's largest reinsurance company pays close attention to the statistics of global weather-related disasters and the results from climate models (Munich Re, 2013).

Estimating potential changes to flood risk can be achieved by combining the evidence for recent trends in extreme weather events with the projections of climate models (Huber and Gulledge, 2011). While increases in heavy precipitation

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http://dx.doi.org/10.1016/j.crm.2014.11.002
2212-0963/© 2014 Published by Elsevier B.V.

events have been observed over recent decades for some regions (Karl et al., 2009) this is not the case generally. The present-day consensus is that "*there are likely more land regions where the number of heavy precipitation events has increased than where it has decreased*" (IPCC, 2013). For Australia, there is evidence (Alexander and Arblaster, 2009) for longer dry spells but more intense heavy rainfall events. However, a report by the Bureau of Meteorology concluded that it was not possible to be definite about detecting increases in the frequency of extreme precipitation events (Jakob et al., 2009).

While significant trends may or may not always be apparent, both theory and climate modelling experiments suggest that extreme rainfall events are likely to become more frequent in response to increases in greenhouse gas concentrations (Bates et al., 2008; Min et al., 2011). The consensus is that "*Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions will very likely become more intense and more frequent by the end of this century, as global mean surface temperature increases*" (IPCC, 2013). For Australia, analyses of climate model projections indicate relatively robust signals for both increased and decreased flood risk over many regions including an increased risk for 1-in-100-year flood events for much of south-east Australia (Hirabayashi et al., 2008).

Studies dealing specifically with flood projections include Hirabayashi et al. (2008) (global river basins), Wobus et al. (2013) (United States), Dumas et al. (2013) (France), Lawrence et al. (2013) (New Zealand), Hochrainer-Stigler et al. (2013) (Hungary) and Prudholme and Davies (2009) (United Kingdom) but all face a number of challenges. First, observations can be sparse, making it difficult to apply statistical methods. Secondly, significant uncertainties can arise due to a wide range of climate model projections at regional scales (Prudholme and Davies, 2009). This range typically reflects the uncertainties associated with different emissions scenarios, and the individual model sensitivities. Thirdly, there are additional uncertainties associated with downscaling techniques that are used to transform the model outputs into usable information at smaller (i.e. catchment) scales (Lawrence et al., 2013). Finally, the hydrological models that are used to transform rainfall estimates into flow estimates are imperfect, and therefore increase the level of uncertainty. In a study of potential impacts for France it was concluded that it was impossible to provide a reliable projection of flood losses (Dumas et al., 2013) and, as noted in a recent United Kingdom Government report, "*. . .projections of extreme rainfall and future flooding are one of the most challenging areas of climate change science and the spread of possible outcomes is large*" (DEFRA, 2012).

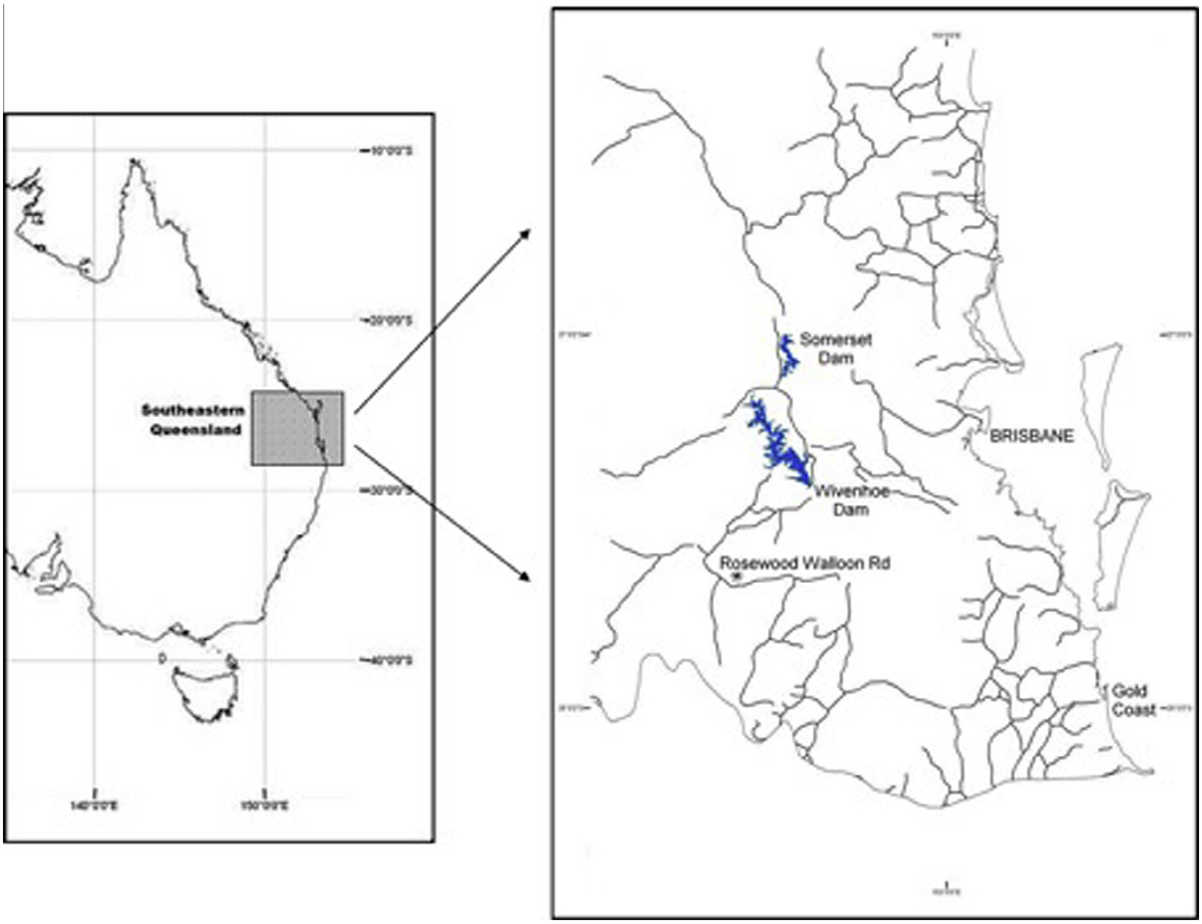

Fig. 1. The south-east Queensland study area and the locations of Brisbane and the Wivenhoe Dam.