Biophysical modelling in support of an assessment of the potential economic impacts of climate change for South Africa

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Integrated Assessment Modelling Framework

To assist National Treasury and the National Planning Commission (NPC) in evaluating the potential economic impacts of climate change in South Africa, the United Nations University – World Institute for Development Economic Research (UNU-WIDER), in collaboration with external partners, evaluated the potential the future climate change risks under two global mitigation scenarios on four key impacts channels (water, agriculture, roads and sea level rise) using an integrated assessment model shown in Figure 1 (Cullis et al, 2015). The model results were then passed to an economic model used to evaluate the economic risks for South Africa. Where possible existing South Africa models were used such as the Pitman rainfall-runoff model and the Water Resources Yield Model (WRYM). For the road impact model (IPSS), local South Africa cost factors were applied.

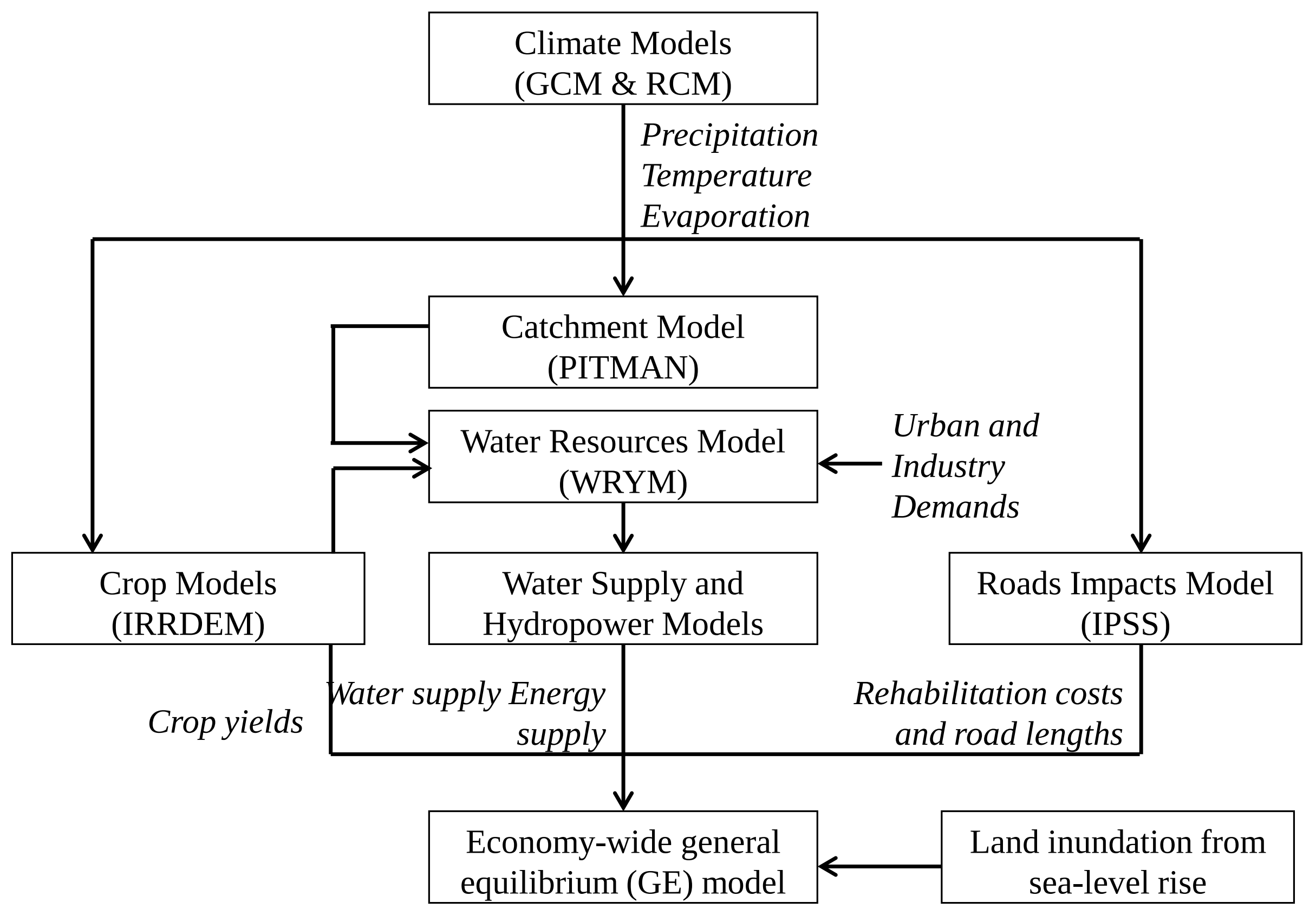


Figure 1: Integrated assessment modelling framework used to evaluate the economic risks for climate change in South Africa through key impact channels.

Hybrid Frequency Distribution of Possible Climate Futures

The climate change scenarios used in this study result from consideration of a hybrid frequency distribution (HFD) of the range of possible climate futures for the globe (Schlosser et al, 2012). These HFDs are generated through the numerical hybridization of zonal trends derived from the MIT Integrated Global System Model (IGSM) (Sokolov et al., 2009) with a set of pattern kernels of regional climate change from the IPCC AR4. The advantage of the HFD approach over traditional top-down approaches to investigating climate change impacts is that it looks at a much wider range of potential impacts and provides the basis for risk based decision making. The HFD approach allows for the consideration of over 6000 possible climate futures resulting from the consideration of 400 iterations of the IGSM zonal band model outputs and mapped using the pattern kernels for 17 of the available 22 AR4 global climate models. The benefits of global mitigation were investigated by considering results from both the IGSM Unconstrained Emission (UCE) scenario and a best case greenhouse gas stabilization scenario in which an equivalent CO^2 concentration of ~480 ppm is achieved by the end of the century – and is referred to as the "Level 1 stabilization" (L1S) policy (Webster *et al*., 2011).

Impacts on Catchment Runoff and Average Water Supply

The HFD derived climate change risk on surface water runoff as compared to the impact on the average annual water supply to the country by 2050 are shown below. The results show a wide range of potential impacts on surface water runoff, with a slight increase in the median, while the potential impact on the average annual water supply is less wide ranging. This suggests that the highly integrated bulk water distribution system for South Africa provides some resilience to future climate change impacts and risks.

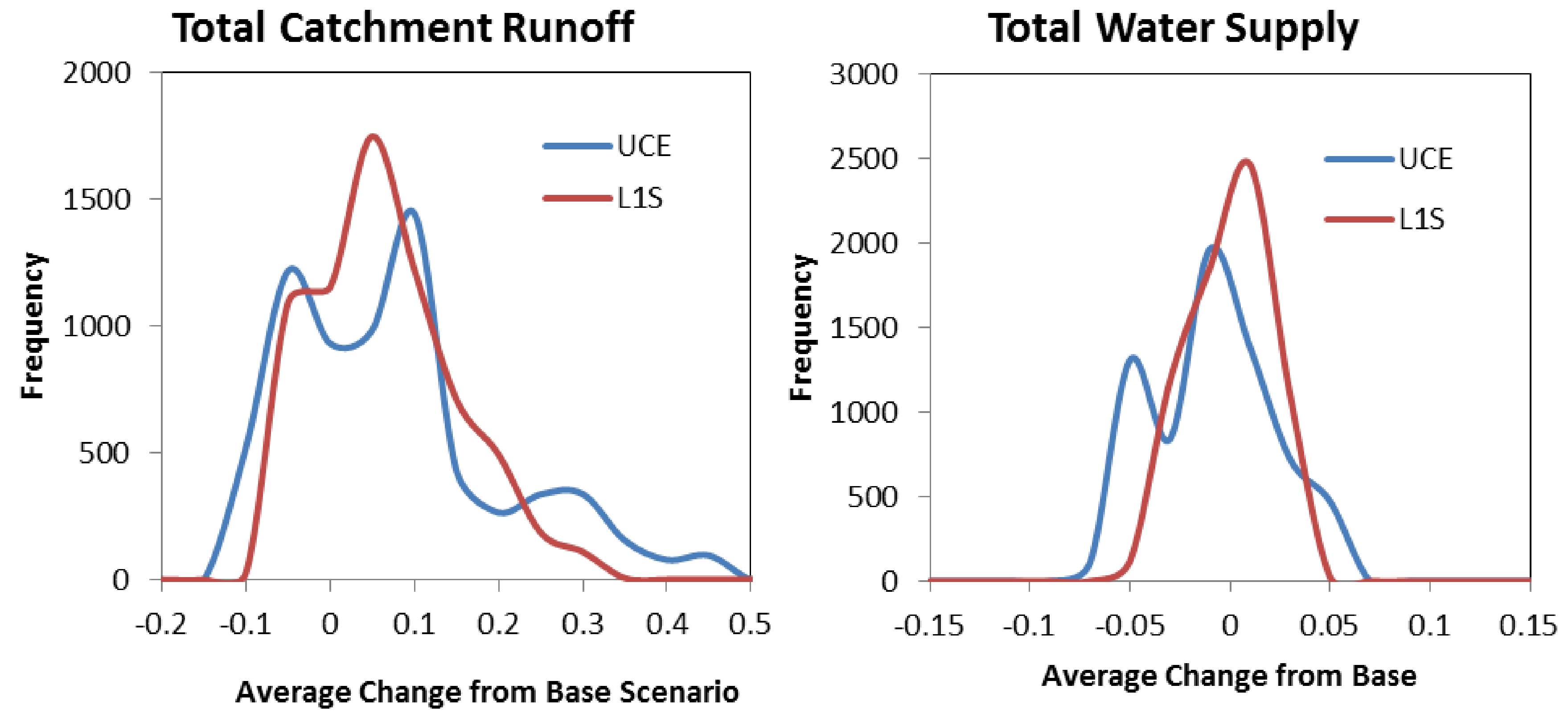


Figure 2: Comparison of the potential impacts of climate change under the UCE and L1S scenarios in terms of total catchment runoff for the country and the change in the ability to meet the total national average annual water supply demands for the period 2040 to 2050. (Cullis et al, 2015)

Water Resources System Model and Regional Impacts on Supply

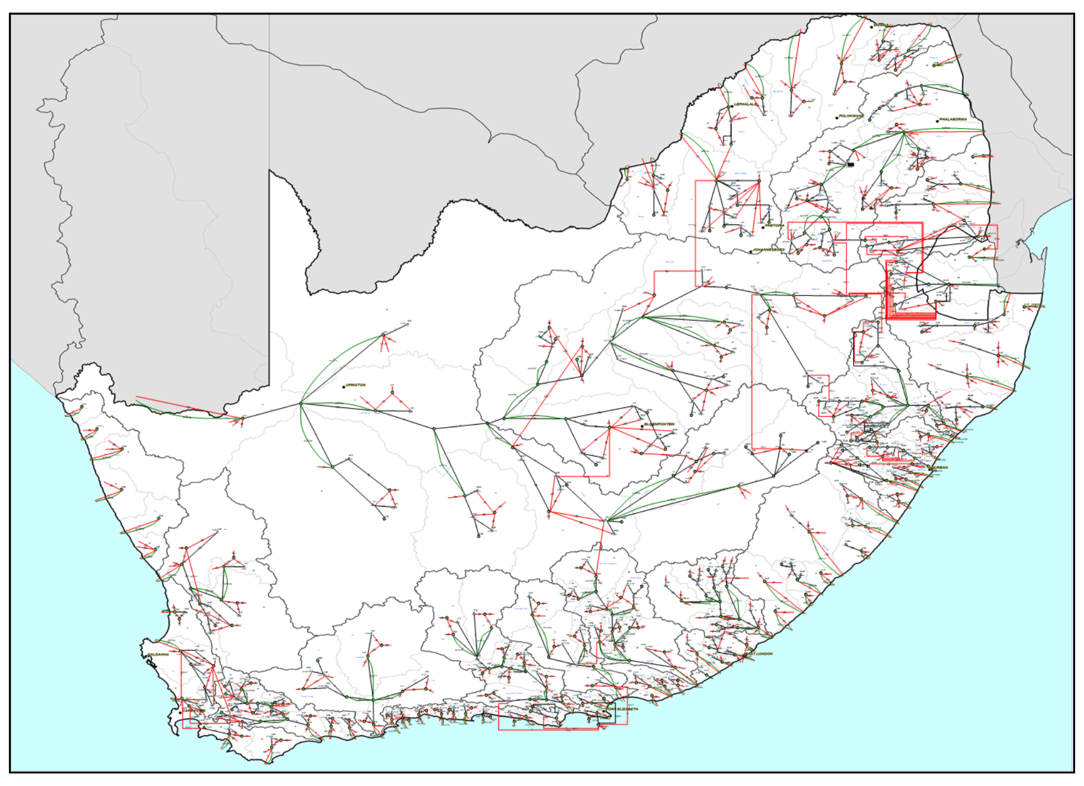


Figure 2: Schematic diagram of the national configuration of the Water Resources Yield Model (WRYM) used for evaluating the potential impacts in terms of water supply.

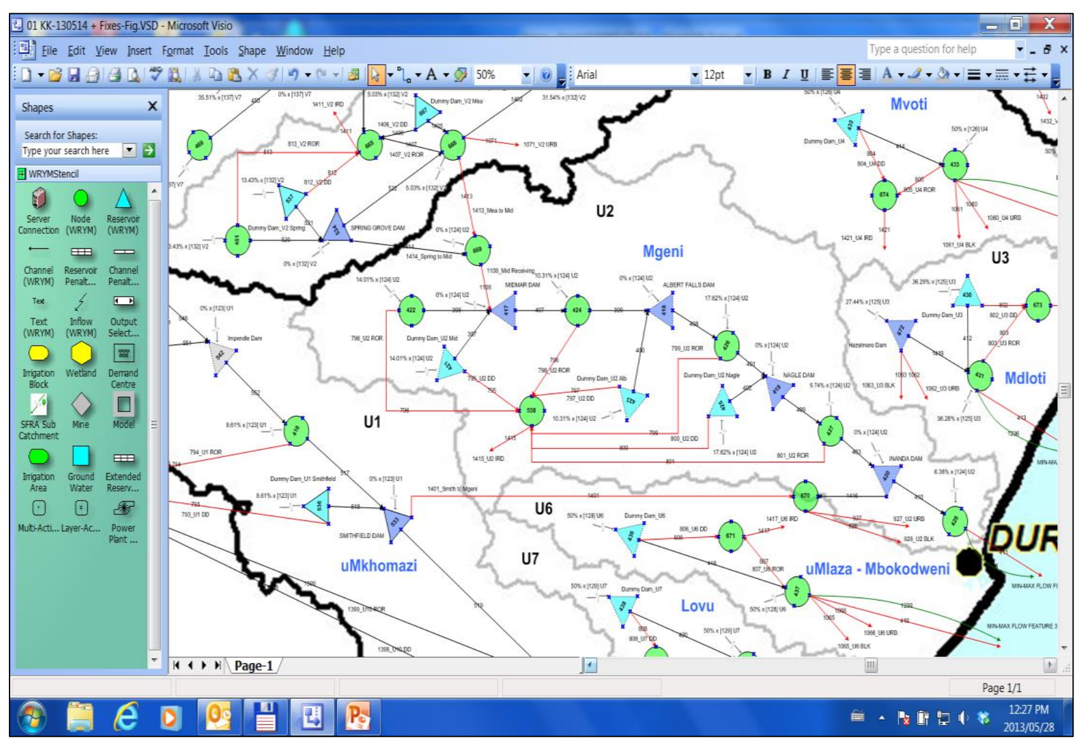


Figure 3: Detail of one section of the national WRYM system model used for analysis (Mooi-Mgeni River System)

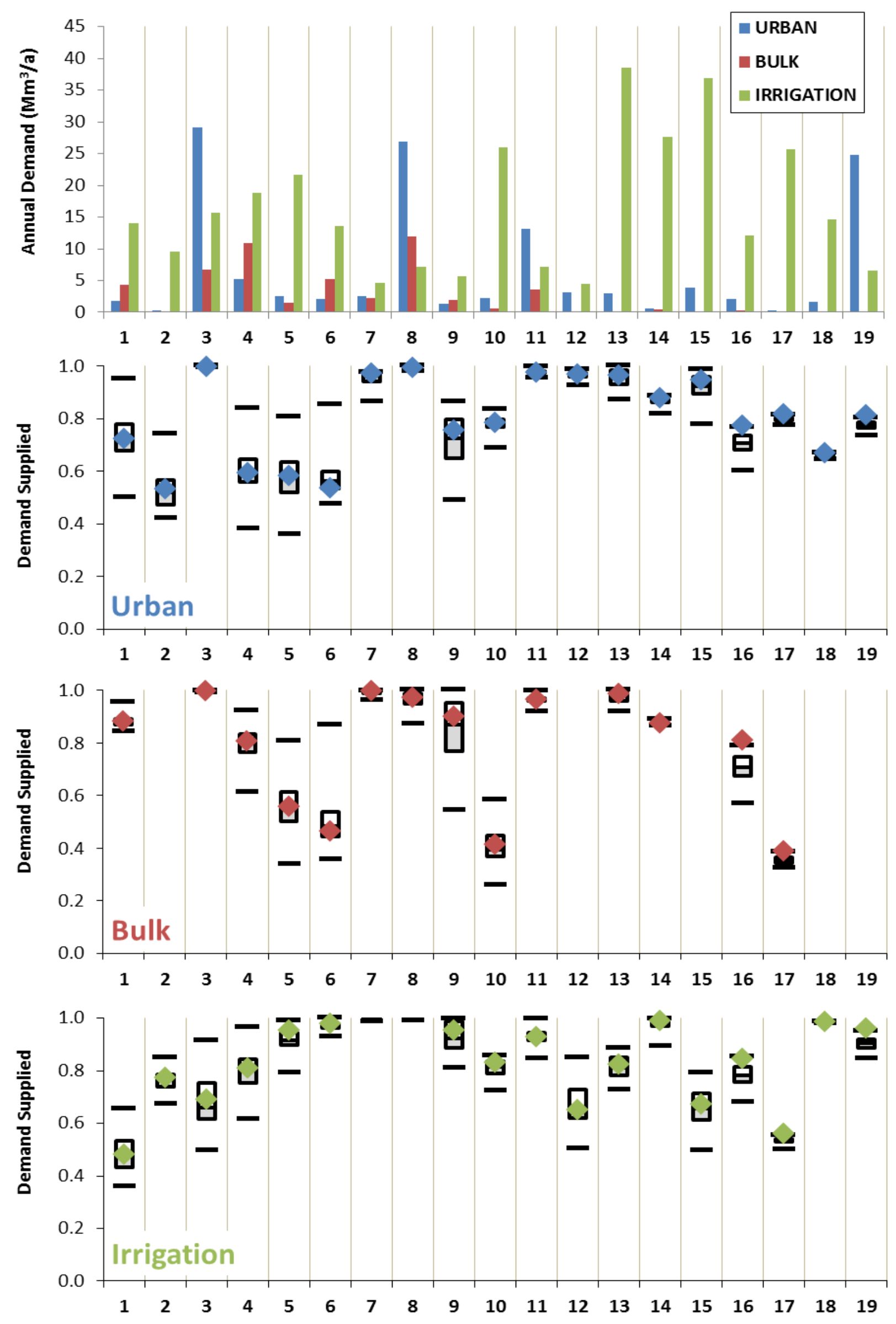
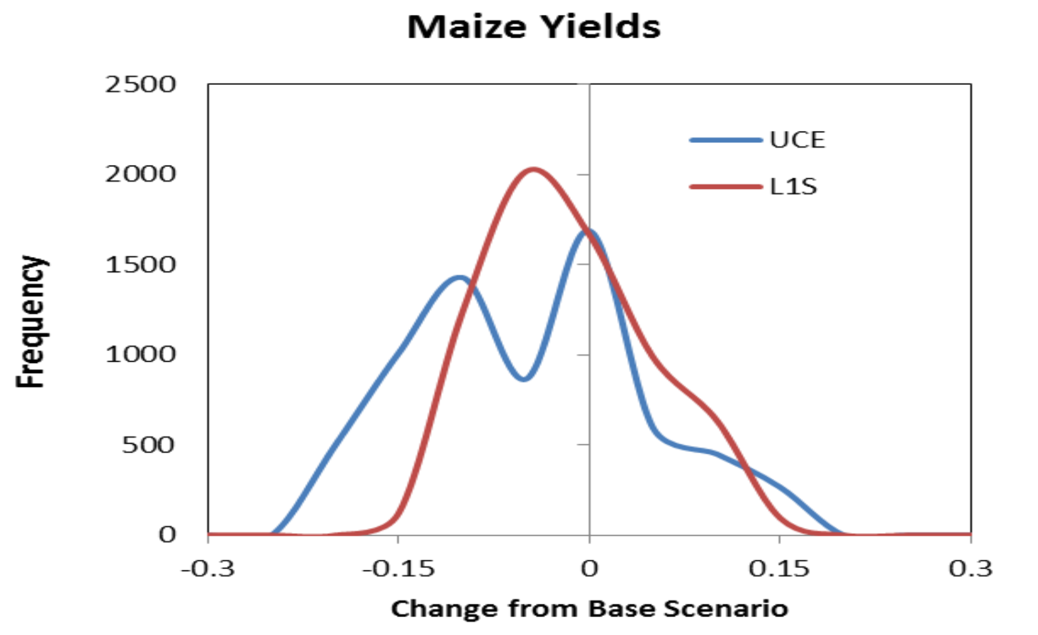
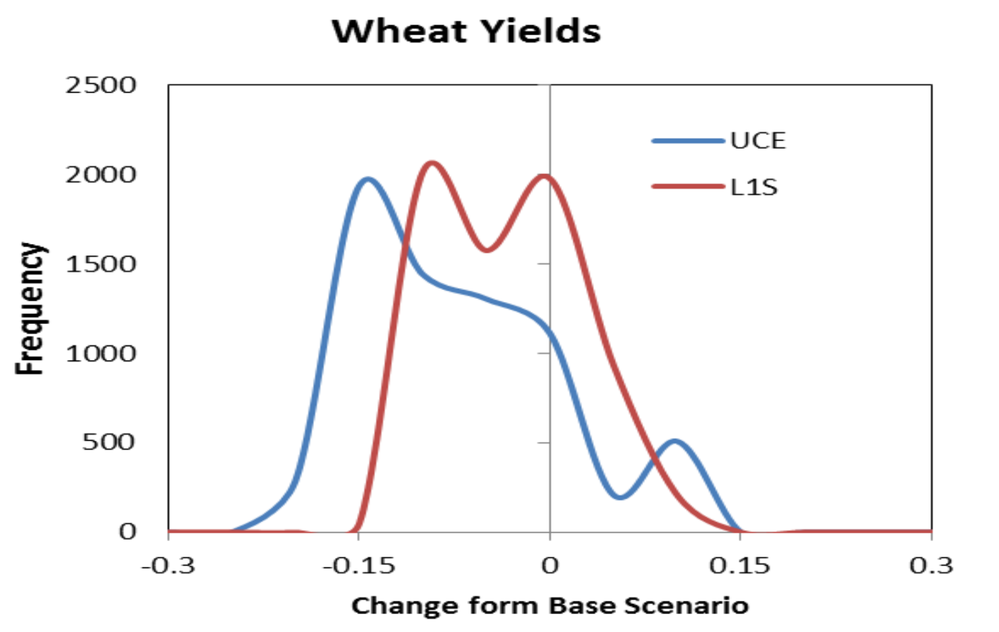


Figure 4: The average annual demand (top) for the 19 WMAs for the period 2040 to 2050 and the estimated proportion of the demand that can be supplied under the base scenario (symbols) and specific models representing the minimum, 25th percentile, median, 75th percentile and maximum impact under the UCE scenario for different water use sectors.

Impacts on Yields from Dry-land crops and Irrigation Demand

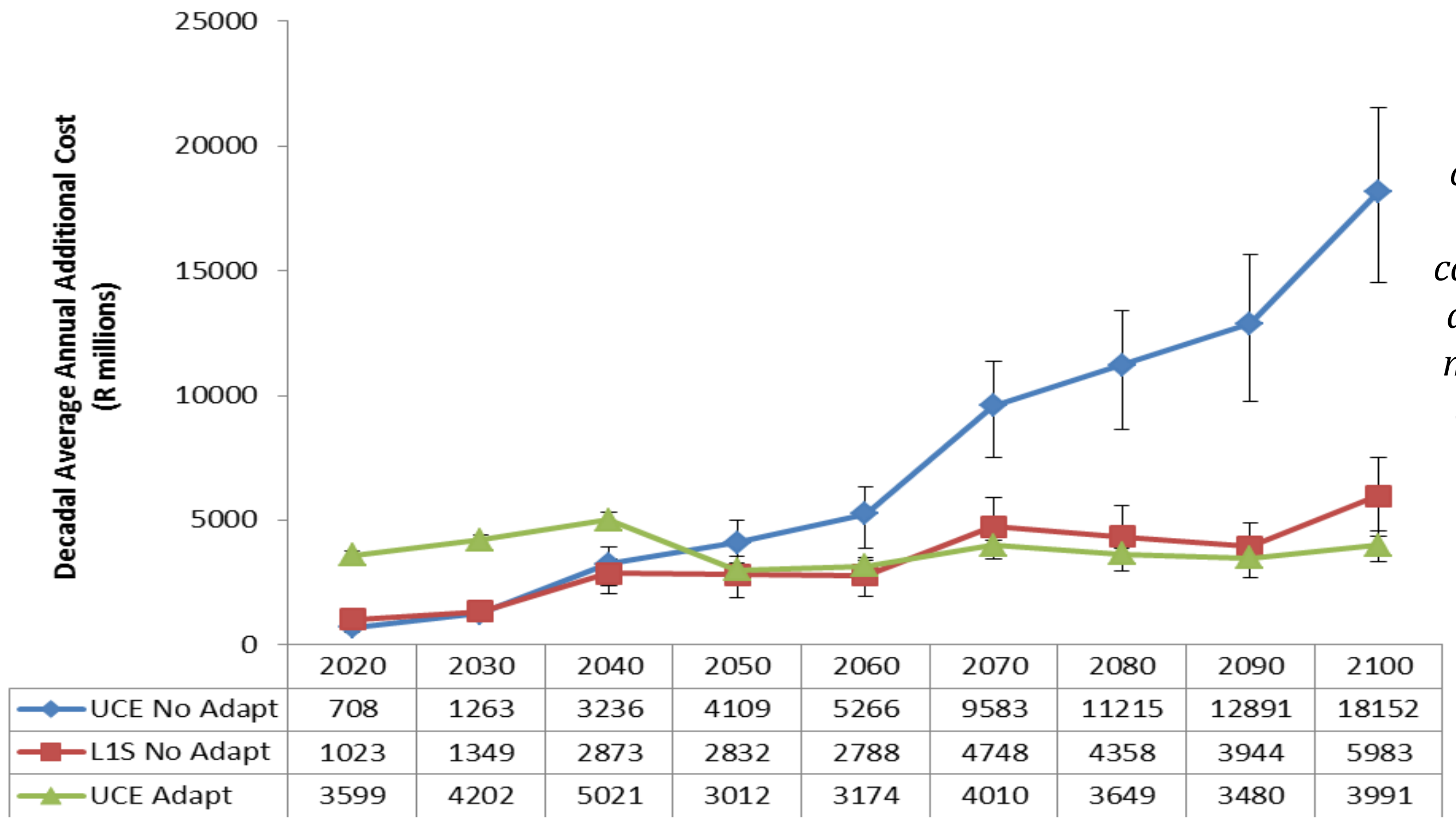
All future climate scenarios show an increase in the mean annual temperature and this is consistent across the country. As a result there is a consistent increase in irrigation demands of 6% (range X% to Y%). There is a wide range of impacts on the yields from dry land agriculture due to increasing evaporative demand, but increased variability in future precipitation impacts. A decline in the median impact on staple crops such as maize and wheat is particularly concerning, with some scenarios showing greater than 15% reduction in the average annual yield for the country. Global mitigation scenarios (L1S) show a significant reduction in risk.





Impacts on Roads Infrastructure Costs

The results of the analysis of possible future increases in the cost of road maintenance and repair due to climate change are shown below and clearly demonstrate the benefits, particularly in the second half of the century for taking a pro-active adaptation approach as well as the long term benefits of global mitigation efforts. Pro-active adaptation does require some up front costs, but this results in significantly reduced rehabilitation costs after about 2050. It is important to note however that it will take at least 30 years to roll-over the existing roads infrastructure and so pro-active adaptation needs to start sooner rather than later.



	2020	2030	2040	2050	2060	2070	2080	2090	2100
UCE No Adapt	708	1263	3236	4109	5266	9583	11215	12891	18152
L1S No Adapt	1023	1349	2873	2832	2788	4748	4358	3944	5983
UCE Adapt	3599	4202	5021	3012	3174	4010	3649	3480	3991

Figure 2: Comparison of the potential impacts of climate change under the UCE and L1S scenarios in terms of total catchment runoff for the country and the change in the ability to meet the total national average annual water supply demands for the period 2040 to 2050. (Cullis et al, 2015)

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