

**Individual and coupled effects of future climate and land use
scenarios on water balance components in Australia**

Submitted by

Hong Zhang

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Certificate of Original Authorship

I, Hong Zhang declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Life Sciences/Faculty of Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Contents

Certificate of Original Authorship.....	ii
Acknowledgements.....	iii
Publications arising from this thesis.....	v
Contents.....	vi
List of Figures.....	ix
List of Tables.....	xvi
Glossary.....	xviii
Abstract.....	xx
Chapter 1. Introduction.....	1
1.1 Research aim.....	1
1.2 Research background.....	2
1.2.1 Hydrologic response to climate and land use changes in Australia.....	2
1.2.2 Climate change and variability impacts based on GCMs downscaling data ...	3
1.2.3 Modelling methods of hydrologic response to climate and land use changes..	4
1.3 Significance.....	5
1.4 Proposed thesis outline.....	6
Chapter 2. Literature review.....	7
2.1 Climate change and variability and land use change.....	7
2.1.1 Climate change and variability.....	7
2.1.2 Land use change.....	8
2.2 Downscaling methods.....	9
2.2.1 Change factors (CFs).....	9
2.2.2 Dynamical and statistical downscaling.....	10
2.3 Climate change and variability and land use change impacts on water cycle.....	12
2.4 Research methods of hydrologic response to climate and land use changes.....	14
2.4.1 Research methods of hydrologic response to climate change and variability	15
2.4.2 Research methods of hydrologic response to land use change.....	16
2.5 Watershed potential evapotranspiration models.....	17
2.6 Distributed hydrological models.....	19
Chapter 3. Hydro-meteorological characteristics and climate elasticity of catchments under different climatic conditions.....	22
Abstract.....	22
3.1 Introduction.....	23
3.2 Materials and methods.....	25
3.2.1 Study areas.....	25
3.2.2 Observed data.....	26
3.2.3 Mann-Kendall trend test.....	27
3.2.4 Mann-Kendall abrupt test.....	27
3.2.5 Wavelet analysis.....	28
3.2.6 Climate Elasticity.....	29
3.3 Results.....	30

3.3.1 Trends in hydroclimatic variables	30
3.3.2 Mann-Kendall abrupt test	39
3.3.3 Wavelet analysis	46
3.3.4 Linear regression analyses.....	51
3.3.5 Climate Elasticity	52
3.4 Discussion	54
3.4.1 Trends in hydroclimatic variables	54
3.4.2 Mann-Kendall abrupt test	55
3.4.3 Wavelet analysis.....	56
3.4.4 Linear regression analyses.....	56
3.4.5 Climate Elasticity	57
3.5 Summary and conclusions	58
Chapter 4. Impacts of future climate change and variability on water resource availability of eastern Australia: A case study of the Manning River basin	60
Abstract	60
4.1 Introduction	61
4.2 Materials and methods.....	63
4.2.1 Study area	63
4.2.2 Observed data	65
4.2.3 Statistical downscaling technique.....	65
4.2.4 The XAJ model.....	66
4.2.5 Parameter estimation and performance evaluation.....	68
4.2.6 Regression analyses.....	69
4.3 Results	69
4.3.1 XAJ model calibration and validation	69
4.3.2 Projected changes in temperature and rainfall.....	71
4.3.3 Changes in simulated runoff, actual evapotranspiration and soil moisture	73
4.3.4 Relationships among hydrological responses and climate variables.....	76
4.4 Discussion	77
4.5 Summary and conclusions	80
Chapter 5. Using an improved SWAT model to simulate hydrological responses to land use change: a case study of a catchment in tropical Australia	82
Abstract	82
5.1 Introduction	83
5.2 Materials and methods.....	86
5.2.1 Study area	86
5.2.2 The SWAT model.....	87
5.2.3 Data preparation	88
5.2.4 Model calibration and evaluation approach.....	92
5.2.5 Different land use scenarios	93
5.3 Results	95
5.3.1 SWAT-T LAI calibration	95
5.3.2 Discharge calibration and validation	97
5.3.3 Hydrological responses to land use change scenarios	100

5.4 Discussion	106
5.4.1 Model comparison and evaluation.....	106
5.4.2 Modelled Hydrological responses to different land use change scenarios ...	108
5.4.3 Limitations and uncertainties	110
5.5 Summary and conclusions	111
Chapter 6. Quantifying the impacts of future climate and land use changes on hydrological processes and associated uncertainty in southwestern Australia	114
Abstract	114
6.1 Introduction	115
6.2 Materials and methods.....	117
6.2.1 Study area	117
6.2.2 The SWAT model.....	118
6.2.3 Data preparation	119
6.2.4 Calibration and evaluation methods for the SWAT model	121
6.2.5 Statistical downscaling method	121
6.2.6 Different land use change scenarios	122
6.2.7 Contribution analysis of uncertainty.....	123
6.3 Results	123
6.3.1 Streamflow simulation.....	123
6.3.2 Hydrologic response to land use change	126
6.3.3 Projected changes in climatic variables.....	127
6.3.4 Hydrologic responses to future climate change and variability.....	129
6.3.5 Combined effects of climate and land use changes	131
6.4 Discussion	136
6.4.1 SWAT modelling assessment.....	136
6.4.2 Modelled hydrologic response to land use change scenarios	137
6.4.3 Modelled hydrologic response to future climate change and variability	137
6.4.4 Modelled hydrologic responses to combined effects and uncertainties	139
6.4.5 Caveats and limitations.....	139
6.5 Conclusions	140
Chapter 7. Final conclusions and future research.....	142
7.1 Final conclusions.....	142
7.2 Future research	144
Reference.....	146

List of Figures

- Figure 3-1** The study areas of the 4 catchments and the locations of weather stations and stream gauging stations. 25
- Figure 3-2** The trends and variations of annual hydroclimatic variables anomalies (relative to the average values of 1977-2017) in the Wooroloo Brook catchment from 1977-2017 (1975-2017 for wind). The dashed line shows a linear trend of the 5-year moving average. 31
- Figure 3-3** The trends and variations of annual hydroclimatic variables anomalies (relative to the average values of 1908-2014) in the Murrumbidgee catchment from 1908-2014 (1975-2017 for wind). The dashed line shows a linear trend of the 5-year moving average..... 32
- Figure 3-4** The trends and variations of annual hydroclimatic variables anomalies (relative to the average values of 1991-2016) in the Manning River catchment from 1991-2016. The dashed line shows a linear trend of the 5-year moving average..... 33
- Figure 3-5** The trends and variations of annual hydroclimatic variables anomalies (relative to the average values of 1967-2017) from 1967-2017 (1975-2017 for wind) in the North Johnstone River catchment. The dashed line shows a linear trend of the 5-year moving average. 34
- Figure 3-6** Mann-Kendall abrupt test for annual climatic and hydrologic variables in the Wooroloo Brook catchment with forward trend UF (black line) and backward trend UB (red line). Dotted horizontal lines above (+1.96) and below (-1.96) denote critical values for the 95% confidence interval (Yang and Tian, 2009). 39
- Figure 3-7** Mann-Kendall abrupt test for annual climatic and hydrologic variables in the Murrumbidgee catchment with forward trend UF (black line) and backward trend UB (red line). Dotted horizontal lines above (+1.96) and below (-1.96) denote critical values for the 95% confidence interval (Yang and Tian, 2009). 41
- Figure 3-8** Mann-Kendall abrupt test for annual climatic and hydrologic variables in Manning River catchment with forward trend UF (black line) and backward trend UB (red line). Dotted horizontal lines above (+1.96) and below (-1.96) denote critical values for the 95% confidence interval (Yang and Tian, 2009). 42
- Figure 3-9** Mann-Kendall abrupt test for annual climatic and hydrologic variables in the North Johnstone River catchment with forward trend UF (black line) and backward

trend UB (red line). Dotted horizontal lines above (+1.96) and below (-1.96) denote critical values for the 95% confidence interval (Yang and Tian, 2009). 44

Figure 3-10 Continuous wavelet analysis for annual climatic and hydrologic variables in the Wooroloo Brook catchment. Due to data availability, the period of 1889-2017 (129 years) was used for wavelet analysis, except for wind speed (1975-2017) and runoff (1977-2017). Maximum temperature, minimum temperature, solar radiation, FAO56 PET, relative humidity, and rainfall exhibit similar high frequency cycles (notable but not significant) of about 2-3 years, while wind speed and runoff show similar periodicities of around 4 years (not significant). 46

Figure 3-11 Continuous wavelet analysis for annual climatic and hydrologic variables in the Murrumbidgee catchment. Due to data availability, the period of 1889-2017 (129 years) was used for wavelet analysis, except for wind speed (1975-2017) and runoff (1908-2014). Maximum temperature, minimum temperature, solar radiation, relative humidity, and rainfall exhibit similar interannual cycles of about 2-3 years (notable but not significant). Moreover, maximum temperature, solar radiation, FAO56 PET, and runoff show similar periodicities of around 4 years (notable but not significant), while wind speed has periodicity of 6 years (notable but not significant). 47

Figure 3-12 Continuous wavelet analysis for annual climatic and hydrologic variables in the Manning River catchment. Due to data availability, the period of 1889-2016 (128 years) was used for wavelet analysis, except for wind speed (1975-2017) and runoff (1991-2016). Maximum temperature, solar radiation, and FAO56 potential evapotranspiration exhibit similar interannual cycles of about 4 years (not significant) and 12 years (significant), while rainfall and runoff show similar periodicities of around 4 years (notable but not significant). 48

Figure 3-13 Continuous wavelet analysis for annual climatic and hydrologic variables in the North Johnstone River catchment. Due to data availability, the period of 1889-2017 (129 years) was used for wavelet analysis, except for wind speed (1975-2017) and runoff (1967-2017). Maximum temperature, minimum temperature, relative humidity, rainfall, and runoff exhibit similar interannual cycles of about 2-3 years (notable but not significant). In addition, significant cycles of around 28 years (long period/low frequency) were detected for maximum temperature, solar radiation, and FAO56 PET. 49

Figure 3-14 Correlation analyses between annual hydrological and climatic variables in the (a) Wooroloo Brook catchment (1977-2017), (b) Murrumbidgee catchment

(1975-2014), (c) Manning River catchment (1991-2016), and (d) North Johnstone River catchment (1975-2017). Decimals from -1 to 1 shown in the legend and graph are correlation coefficients “r”.	51
Figure 4-1 The study area of Manning River catchment and location of observation stations including weather stations and gauge station.	65
Figure 4-2 Flow chart for the XAJ model. The inputs to the model are P (rainfall) and PET (potential evapotranspiration), the outputs are Ea (the actual evapotranspiration from the whole catchment, which is the sum of the evapotranspiration from the upper soil layer EU, the lower soil layer EL, and the deepest layer ED) and TQ (the outlet discharge from the whole catchment), and W (area mean tension water storage, namely soil moisture, which is the sum of WU, WL and WD in the upper, lower and deepest layer). The meanings for the state variables and parameters appear inside and outside of the blocks in this figure can be found in Table 4-1 and the reference (Zhao, 1992).....	67
Figure 4-3 The observed and simulated monthly runoff during calibration (1991-2008) and validation periods (2009-2016) in the Manning River catchment.	70
Figure 4-4 Comparison of observed and simulated monthly runoff during (a) calibration and (b) validation periods.	71
Figure 4-5 Projected changes in maximum temperature (T_{max}) (°C), minimum temperature (T_{min}) (°C) and rainfall (%) in the near future (2021–2060, 2040s) and the far future (2061–2100, 2080s) under RCP8.5 based on 28 GCMs compared with baseline at monthly time scale. Data presented are changes in the 40-year mean values for each of the 28 GCMs. Box boundaries indicate the 25th and 75th percentiles; the black lines and crosshairs within the box mark the median and mean, respectively; the lower and upper whiskers indicate the 10th and 90th percentiles.	72
Figure 4-6 Projected changes in maximum temperature (T_{max}) (°C), minimum temperature (T_{min}) (°C) and rainfall (%) in the near future (2021–2060, 2040s) and the far future (2061–2100, 2080s) under RCP8.5 based on 28 GCMs compared with baseline at seasonal and annual time scales. Data presented are changes in the 40-year mean values for each of the 28 GCMs. Box boundaries indicate the 25th and 75th percentiles; the black lines and crosshairs within the box mark the median and mean, respectively; the lower and upper whiskers indicate the 10th and 90th percentiles.	73
Figure 4-7 Projected changes in runoff (%), actual evapotranspiration (%) and soil moisture (%) in the near future (2021–2060, 2040s) and the far future (2061–2100,	

2080s) under RCP8.5 based on 28 GCMs compared with baseline at monthly time scale. Data presented are changes in the 40-year mean values for each of the 28 GCMs. Box boundaries indicate the 25th and 75th percentiles; the black lines and crosshairs within the box mark the median and mean, respectively; the lower and upper whiskers indicate the 10th and 90th percentiles. 75

Figure 4-8 Projected changes in runoff (%), actual evapotranspiration (%) and soil moisture (%) in the near future (2021–2060, 2040s) and the far future (2061–2100, 2080s) under RCP8.5 based on 28 GCMs compared with baseline at seasonal and annual time scales. Data presented are changes in the 40-year mean values for each of the 28 GCMs. Box boundaries indicate the 25th and 75th percentiles; the black lines and crosshairs within the box mark the median and mean, respectively; the lower and upper whiskers indicate the 10th and 90th percentiles. 76

Figure 5-1 The location of the North Johnstone River catchment, Queensland, Australia (divided into 33 sub-basins by the SWAT model), and 11 observation stations (10 weather stations and one hydrologic gauge station (Tung Oil gauge)). 87

Figure 5-2 Mean monthly rainfall and temperature (1967–2017, average over 10 weather stations shown in Figure 5-1) weighted by catchment area using the Thiessen polygon method. 87

Figure 5-3 The land use/cover classification map (a) and soil map (b) for the North Johnstone River catchment, Queensland, Australia. 90

Figure 5-4 The 4-day raw-median LAI and BFAST-smoothed LAI time series for the land use/cover classes of agricultural land-generic (AGRL), wetlands (WETL), forest-evergreen (FRSE), forest-deciduous (FRSD), range-brush (RNGB), and range-grasses (RNGE). 92

Figure 5-5 Land use/cover proportions for scenario 0 (default land use/cover) and four land use/cover change scenarios in the North Johnstone River catchment, Queensland, Australia. Scenario 1: forest-evergreen (FRSE) to range-grasses (RNGE); scenario 2: forest-evergreen (FRSE) to urban (URBN); scenario 3: range-grasses (RNGE) to forest-evergreen (FRSE); and scenario 4: range-grasses (RNGE) to urban (URBN). 94

Figure 5-6 SWAT-T HRU mean LAI compared with smoothed MODIS LAI and default SWAT LAI for (a) agricultural land-generic (AGRL), (b) wetlands (WETL), (c) forest-evergreen (FRSE), (d) forest-deciduous (FRSD), (e) range-brush (RNGB), and (f) range-grasses (RNGE) in calibration (1 January 2008 - 31 December 2017) and

validation (1 January 2003 - 31 December 2007) periods. Calibrated SWAT results were obtained using the Strauch and Volk (2013) modified plant growth model, while default SWAT LAI values were calculated using the default plant growth algorithm. The gray shadings indicate the boundaries of the 25th and 75th percentages from all HRUs simulated by the SWAT-T model. The vertical dashed lines indicate the termination of the calibration period and the start of the validation period. 97

Figure 5-7 The observed and SWAT-T-simulated monthly streamflow for the calibration period (January 2008 to December 2017) and for the validation period (January 2003 to December 2007) in the North Johnstone River catchment, Queensland, Australia. 99

Figure 5-8 Comparison of observed and SWAT-T-modelled monthly runoff in (a) calibration and (b) validation periods in the North Johnstone River catchment, Queensland, Australia..... 100

Figure 5-9 Monthly surface runoff (SURQ), lateral runoff (LATQ), groundwater (GWQ), and actual evapotranspiration (ET) and their monthly changes using SWAT-T under different land use/cover change scenarios in the North Johnstone River catchment, Queensland, Australia..... 103

Figure 5-10 Monthly surface runoff (SURQ), lateral runoff (LATQ), groundwater (GWQ), and actual evapotranspiration (ET) and their monthly changes using default SWAT under different land use/cover change scenarios in the North Johnstone River catchment, Queensland, Australia. 104

Figure 5-11 Spatial distribution of average annual total runoff (mm) under land use/cover Scenario 0 and average annual total runoff change under Scenarios 1 and 3 compared with Scenario 0 using SWAT-T and default SWAT in 33 different sub-basins in the North Johnstone River catchment, Queensland, Australia. 105

Figure 5-12 The annual rainfall and runoff (total runoff, surface runoff (SURQ), lateral runoff (LATQ), and groundwater (GWQ)) relationships for forest-evergreen (FRSE), range-grasses (RNGE), and urban (URBN) land use/cover by using the simulated results of 1967-2017 from selected hydrologic response units (HRU 30 for FRSE, HRU 41 for RNGE, and HRU 52 for URBN in sub-basin #4) with the same slope range (0-10°) and soil type (Ferrosol (Mp19)) using SWAT-T and default SWAT in the North Johnstone River catchment, Queensland, Australia. The reason why sub-basin #4 was selected to analyze the rainfall-runoff relationship for FRSE, RNGE, and URBN was that sub-basin #4 ranked third among the 33 sub-basins in area, and

the area proportions for FRSE, RNGE, and URBN were relatively uniform for sub-basin #4 compared with the other two larger sub-basins (#5 and #10).	105
Figure 6-1 Location map of the Wooroloo Brook catchment (consists of 13 sub-basins).	118
Figure 6-2 The maps of land use/cover classification (left) and soil (right) in the SWAT model for the Wooroloo Brook catchment, SWA.	120
Figure 6-3 The simulated and observed monthly streamflow for calibration (January 1992 to December 2017, data for 2008 are missing) and validation (January 1977 to December 1991) in the Wooroloo Brook catchment, SWA.	125
Figure 6-4 Correlation of monthly simulated and observed runoff in model calibration and validation in the Wooroloo Brook catchment, southwestern Australia.	126
Figure 6-5 Seasonal runoff, ET, and SW in 1977-2016 under land use 0-4 in the Wooroloo Brook catchment, SWA.	127
Figure 6-6 Projected seasonal and annual changes in temperature (°C) and rainfall (%) in 2040s and 2080s under both RCPs based on 34 GCMs compared to the baseline period. Data displayed are changes of 40-year averages for each of the 34 GCMs. The lower and upper whiskers show the 10th and 90th percentiles; box boundaries show the 25th and 75th percentiles; the black line within each box marks the median values.	128
Figure 6-7 Projected seasonal and annual changes in runoff (%) for LU0-LU4 in the 2040s and 2080s under both RCPs estimated from 34 GCMs compared to the baseline period. Data displayed are changes of 40-year averages for each of the 34 GCMs. The lower and upper whiskers show the 10th and 90th percentiles; box boundaries show the 25th and 75th percentiles; the black line within each box marks the median values.	130
Figure 6-8 Projected seasonal and annual changes in ET (%) for LU0-LU4 in the 2040s and 2080s under both RCPs estimated from 34 GCMs compared to the baseline period. Data displayed are changes of 40-year averages for each of the 34 GCMs. The lower and upper whiskers show the 10th and 90th percentiles; box boundaries show the 25th and 75th percentiles; the black line within each box marks the median values.	131
Figure 6-9 Projected seasonal and annual changes in soil water (%) for LU0-LU4 in the 2040s and 2080s under both RCPs estimated from 34 GCMs compared to the baseline	

period. Data displayed are changes of 40-year averages for each of the 34 GCMs. The lower and upper whiskers show the 10th and 90th percentiles; box boundaries show the 25th and 75th percentiles; the black line within each box marks the median values.

..... 131

Figure 6-10 Projected changes in runoff (%) for 34 GCMs (RCP4.5 and RCP8.5) and LU0-4 in 2040s and 2080s compared to the baseline values at annual time scale. Data showed are changes in the 40-year average values for each of the 34 GCMs under different land use/cover scenarios. 133

Figure 6-11 Projected changes in actual evapotranspiration (%) for 34 GCMs (RCP4.5 and RCP8.5) and LU0-4 in 2040s and 2080s compared to the baseline values at annual time scale. Data showed are changes in the 40-year average values for each of the 34 GCMs under different land use/cover scenarios..... 134

Figure 6-12 Projected changes in soil water (%) for 34 GCMs (RCP4.5 and RCP8.5) and LU0-4 in 2040s and 2080s compared to the baseline values at annual time scale. Data showed are changes in the 40-year average values for each of the 34 GCMs under different land use/cover scenarios. 135

Figure 6-13 The contribution of uncertainty sources to the percentage change of annual runoff, ET, and SW using ANOVA. 136

List of Tables

Table 3-1 Mann-Kendall trend test results for climatic and hydrologic variables at annual time scale in the Wooroloo Brook catchment.	36
Table 3-2 Mann-Kendall trend test results for climatic and hydrologic variables at annual time scale in the Murrumbidgee catchment.....	36
Table 3-3 Mann-Kendall trend test results for climatic and hydrologic variables at annual time scale in the Manning River catchment.	36
Table 3-4 Mann-Kendall trend test results for climatic and hydrologic variables at annual time scale in the North Johnstone River catchment.....	37
Table 3-5 Multi-year mean rainfall (P), potential evapotranspiration (E_0), runoff (R), runoff coefficient (RC), and parameter n of land use/cover change in 1991-2014 for the four catchments.....	52
Table 3-6 Climate elasticity for annual hydroclimatic variables in 1991-2014 for the four catchments. εP , εE_0 , εn , εR_n , εT_{max} , εT_{min} , εU_2 , and εRH denote the elasticity of rainfall, potential evapotranspiration, parameter n of land use/cover change, net radiation, maximum temperature, minimum temperature, wind speed, and relative humidity to runoff.....	53
Table 3-7 Comparison between observed runoff change and modeled runoff change due to hydroclimatic variables impacts, i.e., $\Delta R_P + \Delta R_n + \Delta R_{R_n} + \Delta R_{T_{max}} + \Delta R_{T_{min}} + \Delta R_{U_2} + \Delta R_{RH}$ in the four catchments, and the fractional contributions (%) of climate change and variability and human activity to runoff changes.	53
Table 4-1 16 calibrated parameters for the XAJ model in Manning River catchment. ..	70
Table 4-2 Mean values in climatic and simulated hydrological variables in the baseline period (1977-2016) in Manning River catchment.	74
Table 4-3 Regression coefficients of projected changes in hydrological variables (ΔY , %) including runoff, actual evapotranspiration and soil moisture with changes in daily maximum temperature (ΔT_{max} , °C), daily minimum temperature (ΔT_{min} , °C) and rainfall (ΔR , %) in a multiple linear regression model ($\Delta Y = a\Delta T_{max} + b\Delta T_{min} + c\Delta R$); * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$	76
Table 5-1 Data used in this study, data sources, and relevant characteristics.....	88
Table 5-2 Land use/cover change scenarios in the North Johnstone River catchment, Queensland, Australia.....	94

Table 5-3 Description and calibrated values for LAI parameters of each land use/cover type in the SWAT-T model.	96
Table 5-4 The 22 calibrated parameters for the SWAT-T model in the North Johnstone River catchment, Queensland, Australia. The parameters are ranked according to their sensitivities based on global sensitivity analysis.....	98
Table 5-5 Evaluation statistics of monthly streamflow during calibration and validation period. Default SWAT refers to the original SWAT model while SWAT-T refers to the modified SWAT model improved by Strauch and Volk (2013).....	99
Table 5-6 Changes in average annual surface runoff (SURQ), lateral runoff (LATQ), groundwater (GWQ), total runoff, evapotranspiration (ET), and soil water (SW) using SWAT-T and default SWAT (in brackets) under different land use/cover change scenarios in the North Johnstone River catchment, Queensland, Australia in 1967-2017.....	102
Table 6-1 Data input for the SWAT model, data sources, and related characteristics.	119
Table 6-2 The four land use/cover change scenarios based on LU0 (i.e. forest-mixed (50.6%), range-grasses (48.9%) and urban (0.5%)) in the Wooroloo Brook catchment, southwestern Australia.	123
Table 6-3 Land use proportions for LU0-4 in the Wooroloo Brook catchment, western Australia.	123
Table 6-4 The parameters calibrated and ranked in this study for the SWAT model using SWAT-CUP in the Wooroloo Brook catchment, SWA.	124
Table 6-5 Changes in mean annual runoff, actual evapotranspiration, and soil water using the SWAT model under LU0-4 in the Wooroloo Brook catchment, southwestern Australia in 1977-2016.....	126

Glossary

AGRL	<i>agricultural land-generic</i>
ANOVA	<i>analysis of variance</i>
BOM	<i>Bureau of Meteorology</i>
CF	<i>change factor</i>
CMIP5	<i>Coupled Model Intercomparison Project phase 5</i>
CMIP6	<i>Coupled Model Intercomparison Project phase 6</i>
CSIRO	<i>Commonwealth Scientific and Industrial Research Organization</i>
DEM	<i>digital elevation model</i>
ENSO	<i>El Niño Southern Oscillation</i>
ET	<i>evapotranspiration</i>
FAO	<i>Food and Agriculture Organization</i>
FRSD	<i>forest-deciduous</i>
FRSE	<i>forest-evergreen</i>
FRST	<i>forest-mixed</i>
GCM	<i>global climate model</i>
GHG	<i>greenhouse gas</i>
GWQ	<i>groundwater</i>
HRU	<i>hydrologic response unit</i>
IPCC	<i>Intergovernmental Panel on Climate Change</i>
LAI	<i>leaf area index</i>
LAM	<i>limited-area model</i>
LATQ	<i>lateral runoff</i>
LU	<i>land use</i>
LUCC	<i>land use/cover change</i>
MK	<i>Mann-Kendall</i>
MLRM	<i>multiple Liner Regression Model</i>
MODIS	<i>Moderate Resolution Imaging Spectroradiometer</i>
NSE	<i>Nash-Sutcliffe Efficiency</i>
NSW	<i>New South Wales</i>
PBIAS	<i>percent bias</i>
PET	<i>potential evapotranspiration</i>
R ²	<i>coefficient of determination</i>
RC	<i>runoff coefficient</i>
RCM	<i>regional circulation model</i>
RCP	<i>Representative Concentration Pathway</i>
RMSE	<i>root mean square error</i>
RNGB	<i>range-brush</i>
RNGE	<i>range-grasses</i>
SCS CN	<i>Soil Conservation Service Curve Number</i>
SILO	<i>Scientific Information for Land Owners</i>
SURQ	<i>surface runoff</i>
SW	<i>soil water</i>

SWA	<i>south-western Australia</i>
SWAT	<i>Soil and Water Assessment Tool</i>
SWAT-CUP	<i>SWAT Calibration and Uncertainty Programs</i>
SWAT-T	<i>modified SWAT model for tropical areas</i>
SWWA	<i>Southwest Western Australia</i>
T _{max}	<i>maximum land surface temperature</i>
T _{min}	<i>minimum land surface temperature</i>
UB	<i>backward trend</i>
UF	<i>forward trend</i>
URBN	<i>urban</i>
WETL	<i>wetlands</i>
XAJ	<i>Xinjiang</i>

Abstract

The hydrological cycle is influenced by both the climate change and variability and land use/cover change. Assessing the impacts of both climate change and variability and land use/cover change on hydrological variables is crucial for sustainable development of water resources and natural ecosystems. This thesis mainly assessed the effects of land use/cover change and future climate change and variability, both separately and in combination, on water resource availability in Australia. In specific, four inter-related studies were carried out based on statistical methods (Mann-Kendall trend test, Mann-Kendall abrupt test, wavelet analysis, linear regression, and climate elasticity), hydrological models, global climate models (GCMs), different land use/cover scenarios, and analysis of variance method.

The main findings of this thesis are: (1) As expected, rainfall is the factor that most affects runoff, and an increase of 10% in rainfall caused an increase of 24.4% in runoff according to the average of the four catchments. (2) Annual rainfall and runoff were projected to decrease slightly in 2021-2060 and increase in 2061-2100. A slight increase was predicted in annual actual evapotranspiration, while a decrease was projected in annual soil water in the future. (3) Urbanization increased surface runoff while decreased lateral runoff and groundwater, but produced no clear change in total runoff, actual evapotranspiration, and soil water. Additionally, afforestation decreased surface runoff and caused slight changes in other hydrologic variables. (4) For the combined impacts of climate and land use/cover changes, the results of different land use/cover change scenarios were only slightly different from the response of the original land use/cover. An uncertainty analysis shows that GCMs had the greatest contribution to hydrologic variables, followed by RCPs and land use/cover scenarios.

Overall, this thesis offers an improved understanding of the individual and coupled impacts of future climate and land use/cover scenarios on water balance components in Australian catchments. It is advisable for impacts analysis (non-extreme dry or wet studies) to use an ensemble of GCMs under different RCPs as this study or select “good” GCMs that can capture regional atmosphere physical processes as some other studies, to minimize the uncertainty of projected future hydrologic variables. This thesis can provide crucial information for the development of efficient adaptation strategies and future policy plans for sustainable land and water management in Australia.

Keywords: Climate elasticity; climate change and variability; land use/cover change; GCMs; MODIS LAI; XAJ model; SWAT model; SWAT-T model; Australia; runoff