# Response to comments from reviewer 2

| 0 | Response to general comments |
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| | The issue of the general comments are addressed as below:<br><br>The Introduction section has been rewritten following suggestions provided by the reviewer. We had tried to present current status of research on climate change impact on water resources, particularly change in rainfall and runoff. The authors tried to draw a global trend and then focused on studies relevant to Western Australia, more specifically to SWWA, the region under which the study area is located. We acknowledge that many researches on climate change impact have been carried out in eastern states catchment of Australia, particularly in Australia's key water resources basin, the Murray Darling Basin. The web link for accessing the conference paper presented with some findings of this research work has been provided under specific comments part. Also, the Fig. 2 is modified from the published paper and it is referred appropriately.<br><br>Catchment description has been rewritten following suggestions of the reviewer. Geology, soil characteristics and vegetation and land use relevant to hydrologic modelling has been described as suggested.<br><br>Key information on A2 and B1 scenarios has been presented in early part of the introduction.<br><br>Rationale in selection of observed and projected rainfall and runoff period has been presented under specific comments section below.<br><br>It was true that there were some inconsistencies in units for presenting runoff results and changes in runoff during observed and projected period. The selection of unit for rainfall and runoff has been made keeping in mind the scientific basis as well as the objective of using the results in water resources planning. All rainfall analysis has been presented in mm and rainfall changes are presented in %. We intended to present all runoff analysis in Giga Litre (GL) when the flow is measured at gauging stations. But for spatial distribution of runoff we have used the unit mm which we thought more appropriate. Changes in runoff have been presented in %. The figures and Table 4 relevant to rainfall are described jointly as they complement each other. Also the figures and Table 5 has relevant to runoff has been described jointly for better understanding.<br><br>Critical discussion explaining the causes of reduction of runoff and changes in runoff generation process in a drying climate are added in the discussion (section 4.4.3) as follows:<br><br>Throughout the catchment at the gauging stations a reduction of rainfall has resulted into 3-4 times higher reduction of runoff during mid and late this century. This can be explained through water balance components of the LUCICAT model. The components of catchment water balance as captured in the model are rainfall, soil evaporation, transpiration, interception, storage change and stream flow where stream flow consists of surface runoff, interflow and baseflow. Analysis of LUCICAT water balance components (inputs and outputs) shows that interflow comprises the majority of stream flow (70-80 %) followed by surface runoff (around 20%) and baseflow (3-20%) in SWWA (Kitsios, 2009, Bari et al., 2005). LUCICAT water balance results of the previous study (Kitsios, 2009, Bari et al., 2005) and the projected runoff changes found in this study confirms that each of the water balance |

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| | components of stream flow would decrease in the future resulting into decreasing ground water storage with interflow still would be the largest contributor of the future stream flow. Significant decline of interflow (from 43% to 72%) and surface runoff is main contributor of lower stream flow in the future. Reduction of baseflow (up to 43%) would be linked to a decline in conceptual groundwater levels, changes in groundwater storage and soil moisture across the catchment under a future climate regime (Bari et al.,2005) which subsequently may leads to a reduction in baseflow, stream zone saturated areas and surface runoff.<br><br>Further discussion on limitations and assumptions of the study has been added under "uncertainty" section 4.6. |
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| SL No. | Response to Specific comments |
| 1 | Introduction: Page 12028, Lines 12-13: Arbitrary past climate scenario selection (1961-<br>1980Â˘ n), Why? |
| | The following section describing guideline for selecting baseline period for climate change impact study has been extracted from the report by IPCC (1999):<br><br>2.1.2 Baseline period<br>The baseline period is usually selected according to the following criteria (IPCC, 1994):<br>· representative of the present-day or recent average climate in the study region;<br>· of a sufficient duration to encompass a range of climatic variations, including a number of significant weather anomalies (e.g. severe droughts or cool seasons);<br>· covering a period for which data on all major climatological variables are abundant, adequately distributed over space and readily available;<br>· including data of sufficiently high quality for use in evaluating impacts;<br>· consistent or readily comparable with baseline climatologies used in other impact assessments.<br>A popular climatological baseline period is a 30-year "normal" period as defined by the World Meteorological Organisation (WMO). The current WMO normal period is 1961-1990.<br><br>Following the above guideline, the rationale behind selection of time scales in this study are presented below:<br><br>Most of the river gauge data used in this study was starting from around 1960. The General Circulation Model (GCM) data used for future climate scenarios are available for the periods are 2046-2065 and 2081-2100. The hind cast GCM data available were for the period 1961-2000. Considering the availability periods of observed river flow data, GCM hind cast and projected climate scenario data and following the guidelines as presented in the IPCC, a 20 year time baseline period has been adopted in this study (1961-1980). This of course created an issue of presenting data of most recent climate (2001-2010). To address this issue decadal changes of climate record and future projections are presented i.e. a 10 year time scale is used considering 1961-1970 as base period. Also, in addition to climate change impact on rainfall and runoff, water resources managers and policy makers are interested in short term (e.g. decadal) changes in rainfall and runoff. The presentation of decadal changes (based on 1961-1970) of rainfall and runoff will help to meet this need. As hind cast data is available from 1961-2000, this period has been considered as historical period.<br><br><br>Intergovernmental Panel on Climate Change (IPCC): Guidelines on the use of Scenario Data |

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| | for Climate Impact and Adaptation: Task Group on Scenarios for Climate Impact Assessment, Version 1, 1999. |
| 2 | Page 12029, Line 9: Missing relevant research work on drying surface water catchments<br>in SWWA region (e.g. Petrone et al. 2010).<br><br>Line 13: Please clarify that Darling<br>Range catchments are Surface water Supply scheme. |
| | Suggested reference has been included:<br>Since late 1970s, the south west of Western Australia (SWWA) has experienced declined rainfall and runoff which is widely acknowledged and reported in many researches ( Bari and Ruprecht, 2003, Li et al., 2005; Joyce, 2007; CSIRO, 2009; Petrone et al., 2010; DoW, 2010; Anwar et al., 2011).<br><br>Petrone, K. C., Hughes, J. D., Van Niel, T. G., & Silberstein, R. P. (2010). Streamflow decline in southwestern australia, 1950-2008. *Geophysical Research Letters, 37*(11) doi:http://dx.doi.org/10.1029/2010GL043102<br><br>Location of Perth's surface water supply catchments has been clarified as follows:<br>Perth's surface water catchments are located in the Darling Ranges in SWWA. The winter rainfall in the Darling Ranges has decreased up to 20% over the past 30 years, resulting in a 40% or more reduction in runoff to reservoir supplying water to Perth (IOCI, 2002; Bari and Ruprecht, 2003; Water Corporation, 2009). |
| 3 | Page 12030, Line 11: What is IPCC AR4 data? Lines 19-20: What are MRI-CGCM2 and CCSR/NIES/FRCGC-MIROC under the SRES A2 scenarios? Line 25: This is the first time that the reader knows that the A2 and B2 are high and low emission scenarios. This sentence should be placed before the CC models' review. |
| | Elaborated as follows:<br>IPCC Fourth Assessment Report (AR4) data.<br>Changed as follows:<br>of two GCM, MRI-CGCM2 (Yukimoto et al., 2001) and MIROC (K-1 Model Developers, 2004)<br><br>In second paragraph under Introduction following sentence has been added to give reader an idea about the emission scenarios A2 and B1 beforehand:<br>From warmest to coolest the emission scenarios presented in the IPCC Special Report on Emission Scenarios (SRES) are A1FI, A2, A1B, B2, A1T, and B1 (IPCC, 2000). |
| 4 | Page 12031, Lines 15-16: More jargon as above. Please clarify.<br>Line 24: Charles et al. (2007) was already mentioned in Line 13 as a study of the CC's impact. |
| | The jargons are GCM names and these has been changed as follows:<br><br>In Australia, Charles et al. (2007) investigated rainfall and runoff change during mid-century (2035-2064) along with quantifying the uncertainty involved in downscaling multi-site daily precipitation across SWWA using multiple GCMs the SRES A2 emission scenario. The annual rainfall decrease during mid-century for two GCM, CSIRO Mk3, and CSIRO Conformal Cubic Atmospheric Model (CCAM) was found 12-14% and the resulting decrease of runoff was found 30 - 44%.<br><br>Deleted reference of Charles et al. (2007) form line 13. |
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| | Lines 5-6: Too much detail by naming rainfall stations. The readers do not have info at this point in the manuscript on the stations whereabouts.<br>Lines 13-20:<br>The aim of the study focused on investigating the climate change impact on rainfall and runoff for a particular catchment using 11 climate model data and two emission scenarios. It seems that the only difference to previous studies is on the use of 11 models to provide input for CC scenarios. Please bring up the novelty of the work here: Why is this catchment selected for the study? Is it due to data availability? Why is this catchment important? How representative is this catchment of the SWWA? What kind of water management issue affects this catchment? |
| | Line 5-6: Too much detailing of the findings of the previous study has been removed.<br>Lines 13-20: The novelty of this work has been added as in the last two paragraph of introduction as follows:<br><br>With a recent trend of drying climate in SWWA, understanding of future climate change impact is a necessity, particularly for planning future water resources. Water agencies in Western Australia are shifting their policy from surface water dependence to more reliance on ground water and desalination. For planning water resources, water resources managers and policy makers need to answer question like "will the declining trend of rainfall and runoff in Perth's surface water catchments continue during mid and late this century?" Limited study has been carried out in the SWWA using multiple GCM data for different climate scenarios for longer period. Literatures suggest that climate change and its impact vary widely geographically, from continent to continent, country to country and even catchment to catchment. In addition, though GCMs are the best available tools for generating the climate change scenarios based on emission scenarios, the results of the GCMs very considerably. Selection of downscaling methods and hydrologic model also affects the outcome of climate change impact study though GCMs are still the largest sources of uncertainty. Hence, to develop a range of plausible scenarios of future impact, drawing multiple trajectories using multiple GCM output is a recent trend in climate change impact study. Therefore, Hence, there is a prevailing research gap regarding the probable climate change impact on water resources catchments in SWWA addressing the need of water resources planning, particularly using multiple climate model scenarios.<br><br>Most of Perth's surface water supply dams are located along a line from Mundaring (about 90 km east of Perth) to Wellington (about 40 km east of Bunbury), north to south (Fig. 1). Murray River basin lies in middle part of this line and three dams located in the lower areas of the basin are Serpentine, North Dandalup and South Dandalup. Murray-Hotham catchment is located in upper areas of the Murray River basin (Fig. 1) and it has been selected for this study as a representative catchment of Perth's surface water supply catchments. The aim of this study is to investigate the climate change impact on rainfall and runoff across the Murray-Hotham catchment during mid (2055) and late this century (2090) using 11 climate model data reported in IPCC AR4 (IPCC, 2007) for A2 and B1 emission scenarios. Preliminary findings of this research focusing on stream flow reduction have been presented in a conference (Anwar et al., 2011). In this paper, spatial and temporal variability along with probability of exceedance of observed and projected rainfall and runoff are presented. In addition, a catchment scenario map is developed plotting decadal rainfall and runoff change for observed and projected period which can be used for future water resources planning. |
| 6 | Page 12033, Lines 10-17: Catchment description focused only on climate characteristics.<br>There is no enough information in relation to soil types and depth, topography and land uses yet all of them of relevance to the hydrological model. |

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| | Following sentences have been added to catchment description.<br><br>Geologically, the catchment is located in the Darling Plateau, the surface of Yilgarn Block. With an average elevation of about 300 m, the Plateau is veneered with laterite of Tertiary age formed through weathering of the basement rocks, overlaying the Archaean granite and metamorphic rocks (DoW, 2011).<br><br>Murray is the only free flowing river (devoid of dam) in the northern Jarrah forest in Western Australia.<br><br>Recent vegetation in the catchment is mostly Eucalyptus woodland form Marradong Road Bridge to east and in the remaining part Eucalyptus open forest (DoW, 2011). |
| 7 | Section 3. Data and methods<br>Page 12033, Lines 22-23: The reader needs information on what emission scenarios of A2 and B1 are. Please clarify. |
| | In second paragraph under Introduction following sentence has been added to give reader an idea about the emission scenarios A2 and B1 beforehand:<br>From warmest to coolest the emission scenarios presented in the IPCC Special Report on Emission Scenarios (SRES) are A1FI, A2, A1B, B2, A1T, and B1 (IPCC, 2000). |
| 8 | Page 12034.<br>Lines 1-10: Finally, the authors have explained scenarios here but a brief explanation on A2 and B1 needs to be placed in a previous section.<br><br>Lines 20-21: What is the valid reference for the LUCICAT Model? Why is Charles et al. reference used here? Please clarify. |
| | In second paragraph under Introduction following sentence has been added to give reader an idea about the emission scenarios A2 and B1 beforehand:<br>From warmest to coolest the emission scenarios presented in the IPCC Special Report on Emission Scenarios (SRES) are A1FI, A2, A1B, B2, A1T, and B1 (IPCC, 2000).<br><br>Added valid reference for the LUCICAT model and deleted Charles et al. reference.<br>(Bari and Smettem, 2003) |
| 9 | Page 12035,<br>Lines 5-6: Remove the word “widely”. Two applications of the model are not enough for the claim. This reviewer suggests the use of “successfully applied” or “developed for Western Australian catchments”. |
| | In fact, the LUCICAT model has been applied for water resources catchment in most of the Western Australian catchment and few eastern state catchments. Deleted the reference from this sentence which might have created confusion.<br><br>The sentence has been changes as follows:<br><br>The LUCICAT model is used widely for water resources assessment in most of the Western Australian catchments and few eastern states catchments. |
| 10 | Figure 2: Is it the same figure from Islam et al. manuscript? If yes permission from the publisher is required to use here, please check Journal requirements.<br><br>Also, what do the authors mean by “LUCICAT observed rainfall as output” model? Is the model converting/interpolating the rainfall time series?<br><br>Why do the authors need to calibrate again LUCICAT when using the climate data? |

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| | Please clarify.<br><br>Why does the historical data period go until year 2000? What happens with the data for 2000-2010 periods? |
| | The figure 2 is not exactly same of Islam et al. manuscript. Figure 2 has been taken from Islam et al. and updated or modified to suit current study.<br>The authors for Islam et al. are same as in this paper. The reference has changes as follows.<br><br>Fig. 2. Conceptual diagram of the LUCICAT modelling process with climate change scenarios (modified from Islam et.al, 2011)<br><br><br>LUCICAT interpolates rainfall to calculate rainfall for each Response Unit (RU). This is presented now as “LUCICAT processed rainfall for RU”.<br><br>“LUCICAT observed rainfall” changed into “LUCICAT processed rainfall”<br>“LUCICAT observed flow” changed into “LUCICAT generated flow ”<br><br>Here, actually the LUCICAT model has not been calibrated again using climate data rather climate data is used as an input into the calibrated model.<br><br>The model has been run for calibration 1960-2004 and for validation 2005-2009. The GCM hind cast data available for period 1961-2000. Hence for comparison of observed (and processed) rainfall and runoff with processed hind cast rainfall and runoff a time frame of 1961-2000 has been selected.<br><br>The data from 2000-2009 has been used in calibration and validation of the model, in explaining catchment hydrology (section 4.1), also in explaining decadal change of rainfall and runoff (observed and projected) in section 4.5. |
| 11 | Section 4. Results and discussion Page 12037, Lines 6-19: The text is just a summary of what follows and it does not add any relevant information to the manuscript. Please remove.<br><br>Line 21: Do you mean runoff Ratio? (Runoff divided by rainfall) A rate involves time reference.<br><br>Lines 22-24: Similar issue with the use of historical climate data for period 1961-2000.<br><br>Lines 21-25: Figure 3 shows annual flow (GL) but the text refers to ‘runoff rates’. Please modify text or figures accordingly for consistency. |
| | Removed lines 6-19.<br><br>The intent of the authors here to present rainfall in mm and runoff as GL. For this reason instead of “runoff ratio”, here “runoff rate” has been used. Here, apart from time reference, the term “rate” has been used as comparison between two different units (GL and mm).<br><br>Line 22-24: historical climate period 1961-2000, explained earlier under specific comment 1. |

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| 12 | Page 12038,<br>Line 8: Where is the 5.5 % mean difference of annual flow criteria coming from?<br><br>Lines 8-9: Table 1 should present the length of the records for each station.<br><br>Line 15: Remove Fig. 5 but leave the text regarding the R-square values.<br><br>Lines 17-19: The authors stated "..In addition to annual flow, the model was also calibrated for daily flow..". This is confusing. How many calibrations were performed? LUCICAT runs on daily time-step and calibration is done for daily flows. Monthly and annual (additive<br>response of the model) does not require any calibration. Is this correct? Please clarify. |
| | Standard practice with LUCICAT model calibration is the simulated mean annual stream flow need to be close to ± 5-10% for all gauging stations to achieve a good calibration.<br><br>Added station commencement date in Table 1<br><br>Removed Fig. 5 and left text regarding $R^2$ value.<br><br>LUCICAT model need to calibrate only once at all the gauging stations in a catchment following the calibration criteria as presented below. Annual water balance at all the gauging station is part of calibration criteria.<br>(i) joint plot of observed and simulated daily flow series,<br>(ii) scatter plot of monthly and annual flow,<br>(iii) flow-period Error Index (daily),<br>(iv) Nash-Sutcliffe Efficiency (daily),<br>(v) Explained variance (daily),<br>(vi) Correlation Coefficient (daily),<br>(vii) overall water balance (daily, monthly, annual) and<br>(viii) Flow duration curves (daily).<br>More details about LUCICAT calibration process can be found as:<br>(https://publications.csiro.au/rpr/download?pid=csiro:EP113799&dsid=DS6) |
| 13 | Page 12039,<br>Line1: Again, issue with the consideration of time period for recent climate base on observed annual rainfall. Data up to 2010 is available and presented by the authors. Please clarify.<br>Lines 19-21. Rewrite the sentence to avoid repetition of "part of the catchment". |
| | Selection of time period explained earlier under response to specific comments 1.<br><br>Lines 19-21: This sentence has been rewritten as follows to avoid "part of the catchment".<br>Contributing catchment at Yarragil belongs to a high rainfall part of the catchment with historical, past and recent mean annual rainfall of 964 mm, 975 mm and 953 mm. |
| 14 | Page 12040,<br>Lines 25-28: What follows is a description of spatial distribution of mean annual rainfall. This section should be presented in the catchment description (for example after the temporal distribution of rainfall). |
| | Lines 25-28: Removed for here and presented in the catchment description (section 2). |
| 15 | Page 12041,<br>Lines 10-11: Rewrite. High rainfall does not disappear "from the Figure" but from "the catchment area".<br>Lines 26-28. What does 'ile' stand for? Please clarify. What follows is also confusing |

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| | as high rainfall (magnitude? or probability of exceedance?) is defined as > 50% ile. In a PAE plot high rainfall has the lower probability of exceedance (similar that Flood frequency analysis). Please clarify. The complete section needs improvement and better discussion for the differences between scenarios particularly for the Figure panels c-d and g-h. |
| | Line 10-11: Rewritten "catchment area" instead of "Figure".<br><br>The complete section (4.3.3) has been rewritten with better discussion for the differences between scenarios for improved understanding. |
| 16 | Page 12042, Line 16: Missing verb in sentence (was observed). Similarly for Line 22.<br>Line 20: Discussion about reduction in percentiles of annual runoff begins here without presenting those particular results. Fig. 10 is about annual flow in GL. Please modify accordingly. |
| | Added missing verb in line 16 and line 22<br>Referred Table 5 as results for discussion about percentiles of annual runoff change. |
| 17 | Page 12043. This section is hard to follow and the reader is presented with flow quantities and percentiles and the use of short sentences which does not help to get the message across. Please rewrite. |
| | This section (4.4.1) has been rewritten with effort to provide meaningful long sentences. Effort has been made to refer as much as possible to the results and to be specific about catchment location and time duration. |
| 18 | Page 12044,<br>Line 10: What do the authors mean by "some medium runoff areas falls into upper middle part"? Please clarify. Also, why did the authors change the units for runoff? This section now deals with runoff expressed in "mm" unlike previous sections (percentages and GL). Please be consistent with the units. Similar issue appears in Line 15 for rainfall amounts (reduction in percentage and in mm). |
| | Lines 10-12: Deleted.<br>We have used the unit mm for explaining spatial distribution and variability of runoff. When flow is measured at a gauging station, the unit GL is used as a measure of flow from the contributing catchment to the gauge.<br><br>Line 15: Similar issue appears in Line 15 for rainfall amounts (reduction in percentage and in mm). This comment is not clear and have not addressed. |
| 19 | Page 12045, Lines 3-5: Check grammar for missing verb. |
| | Line 3-5: added missing verb |
| 20 | Page 12046,<br>Lines 8-15: The authors brought into consideration important research for SWWA in relation to storm pattern changes responsible for reduction in rainfall. Then, they speculate that plausible reasons of reduction in runoff could be the reduction in rainfall quantity.... WHAT! The whole manuscript is on how reduction in rainfall amount<br>leads to reduction in runoff. Please clarify.<br><br>Line 13. What do the authors refer to by using 'the ramification of these three events'? Please clarify.<br><br>Lines 20-25: The Silberstein et al. work was conducted mostly in forested catchments of the SWWA which results are only relevant to the 10% of the total area for the Murray-Hotham catchment. It is not clear what the authors try to achieve by including this discussion here. Please clarify. |
| | In this manuscript, hydrologic impact of climate change on the catchment is assessed through projection of rainfall and runoff based on future climate scenarios. |

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| | From historical observation of rainfall data it is revealed that there is significant reduction of high rainfall event in SWWA in recent times compared to the past. It is obvious from hydrologic point of view that low rainfall leads to lower runoff and this has been observed in recent times in SWWA.<br><br>The reason for declining rainfall in SWWA is little explored and reason is not quite clearly understood. By referring the research related to storm activity here we tried to explain some reasons of low rainfall in recent times in SWWA. This also helps to understand about future projection of further rainfall reduction during mid and late this century. Then we tried to explain how this low rainfall affects the runoff generation process.<br><br>It is true to some extent that The Silberstein et al. work was conducted mostly in forested catchments of the SWWA. But the Murray catchment is an experimental catchment of this study (Table 6, page 20 of the Draft Report). Also, though 60% of the Murray-Hotham catchment is cleared of native forest, approximately 75% of catchment towards east has Eucalyptus Woodland and rest (25%) towards west has Eucalyptus open forest (Figure 2.6, page 17, DoW 2011). Hence, we referred only the findings of Silberstein et al. work which is relevant to this study. |
| 21 | Page 12047,<br>Line 4: Arbitrary change for the base time-period for comparison. Why? Please clarify.<br><br>Line 7: What do the authors mean by reduction in time scale? Please modify sentence accordingly.<br><br>Lines 14-15: The section focused on future projections so speculation on what caused the low runoff between 1980-1990 is not relevant here. Please modify.<br><br>Lines 15-to end: This section presents the same results than a previous one but now on decadal time scale. What is the purpose? How and why is it relevant for water resources planning for this catchment? This needs to be clarified. |
| | This section (4.5) has been rewritten.<br><br>A 30 year time scale is preferred time scale for observing climate change. In this study historical river flow data at the gauging stations was available from about 1960. Future GCM data for emission scenarios used in this study is for 2046-2065 and 2081-2100. Based on the data availability and inter comparison of historical and projected data, here a 20 year time period has been selected in this study for climate change observation which are 1961-1980 (past), 1981-2000 (recent), 2046-2065 (mid-this century) and 2081-2100 (late this century). This resulted into a difficulty of presenting most recent data 2001-2010. Also, though water resources managers and policy makers are interested to know about climate change impact on longer term, they are more interested to know about short term (e.g. decadal) changes. In this section a decadal changes of rainfall and runoff has been presented particularly to meet the need for water resources managers and policy makers with an effort to develop a tool which is likely to be useful for planning future water resources. Each point in Fig. 13 is a decadal change of runoff with respect to decadal change of rainfall at particular gauging stations. This plot would be useful to estimate likely change of rainfall and corresponding runoff at a gauging station in decadal scale. For example, at Saddleback Road Bridge, 10% reduction of mean annual rainfall (compared to the past) will result into around 40% reduction of runoff (compared to the past). As the amount of mean annual rainfall and runoff for the past are of known quantity, the corresponding quantity for any desired assumption can be calculated (based on Table 1). Hence, the Fig. 13 could be used as a useful |

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| | water resources planning tool.<br><br>Line 7: “in time scale” changed to “in terms of time period”<br>Lines 14-15: Deleted. |
| 22 | 5. Conclusion.<br>Page 12049,<br>Line 8: The authors assessed only the impact of CC on rainfall-runoff for Murray-Hotham. This reviewer argues that “water resources” have a much broader meaning.<br><br>Lines 11-13: This sentence is not a conclusion, is it? This section is just a summary or abstract of the work. Where are the conclusions of this work? Please rewrite it and clearly highlight what are the relevant findings of this work and its implications for future water management in the area. Can we use this knowledge elsewhere? How? Howto overcome main obstacles in conducting this kind of research? Please modify the section. |
| | Line 8: “water resources” changed to “rainfall-runoff”<br><br>Conclusion section has been rewritten. |
| 23 | Table 3. There is no indication in the manuscript on what the errors on water balance and flow period indexes represent. A value of -0.07 for water balance, what does it mean? The same applies to EI. Please clarify in the manuscript or as a footnote in the table. |
| | Water balance and flow period error index are explained under calibration (section 3.4) as follows:<br><br>The EI is a numerical measure of the difference of the between the daily non-zero flow periods of observed and modelled flow. Overall water balance (E) is the measure of difference of mean daily observed flow and mean daily modelled flow compared to mean daily observed flow for the period.<br><br>Table 3 has been explained as follows as under section 4.2:<br>The overall (1960-2009) water balance (E) varied from -0.01 to 0.07 (Table 3) across the catchment which means variation of mean daily modelled flow with mean daily observed flow is -1% to 7% for the calibration and validation period (1960-2009). The overall (1960-2009) Nash Sutcliffe Efficiency (E2) has been varied from 0.48 to 0.7 and Flow Period Error Index (EI) varied from 0.86 to 1.02 across the catchment (Table 3). Correlation Coefficient (CC) between daily observed and model flow has been noticed for both calibration and validation (Table 3). |
| 24 | Figures 4 and 5 present the same data in different plots. Please remove Figure 5 as Figure 4 clearly shows good performance of the model and tracks the decline in runoff. |
| | Figure 5 removed. |
| 25 | Figure 6. Panels a-d should be presented for the same year (e.g. 1988) for all catchments for comparison. Please modify for consistency. |
| | Figure 6: Panels a-d has been presented for the same year (1987). |
| 26 | Figure 8. It is ok but needs some changes to improve readability. Add the text “A2-Mid” and “B1-Mid” and A2-Late B1- Late. Also change the colour bar scale for panel k and scale from -40 to 0. |
| | Figure 8: Changed colour bar scale for panel K and scale from -30 to 0. |
| 27 | Figure 13. This figure really adds little to the manuscript. Why is the base period for comparison changed again (1961-1970)? |
| | Application of Figure 13 in water resources planning has been explained in this section (as well as in earlier reply to comment associated to page 12047. Also selection of based |

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| | period for this section has been explained. |
| 28 | References. The list of references is too long, sixteen manuscripts on CC for Western<br>Australia are listed. Please leave only the most important and relevant references for this work. Conferences proceedings that are not accessible to the readers should be removed. |
| | Web link for the following conference paper has been provided below:<br><br>Anwar, F. A., M., Bari, M. A., Want, R. M., and Islam, S. A.: The effect of climate change on stream flow reduction in Murray-Hotham river catchment, Western Australia, Sustainable Water Solutions for a Changing Urban Environment, Singapore, 4-8Jul 2011, 2011.<br><br>http://www.editorialmanager.com/iwa-conferences/download.aspx?id=36144&guid=542e8e42-0803-4062-a05e-ce36c4964381&scheme=1<br><br>The following three reference has been deleted:<br><br>Candela, L., Tamoh, K., Olivares, G., and Gomez, M.: Modelling impacts of climate change on water resources in ungauged and data-scarce watersheds. Application to the Siurana catchment (NE Spain), Science of The Total Environment, 8, 2012.<br><br>Indian Ocean Climate Initiative (IOCI): Second Research Report- Towards an Understanding of Climate Variability in south western Australia, Research reports on the Second Research Phase of the Indian Ocean Climate Initiative, Indian Ocean Climate Initiative Panel, Hyatt Centre, 3 Plain St., East Perth, Western Australia, 204 pp., 2001.<br><br>Indian Ocean Climate Initiative (IOCI): Towards understanding climate variability in south western Australia-research reports on the first phase of the Indian Ocean Climate Initiative, Indian Ocean Climate Initiative Panel, Hyatt Centre, 3 Plain St., East Perth, Western Australia, 1999.<br><br>Ruprecht, J., and Rodgers, S.: The effect of climate variability on streamflow in south western australia, surface water hydrology series, swh no. 25, Water and Rivers Commission, Perth, Western Australia, 1999. |
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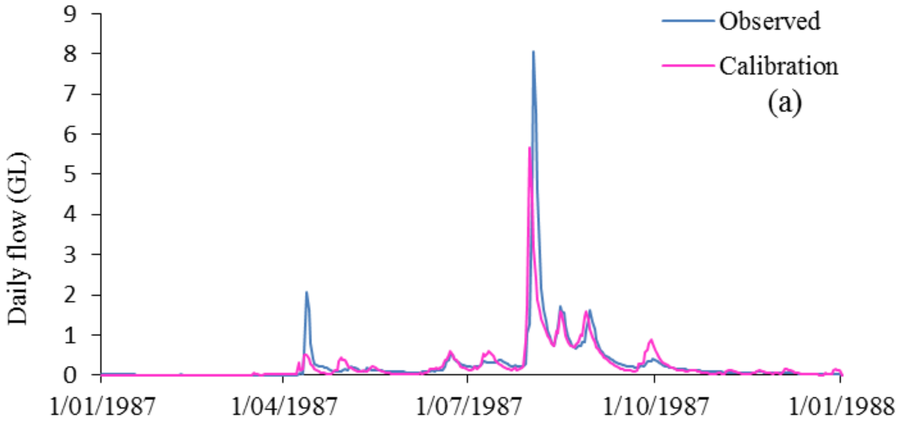
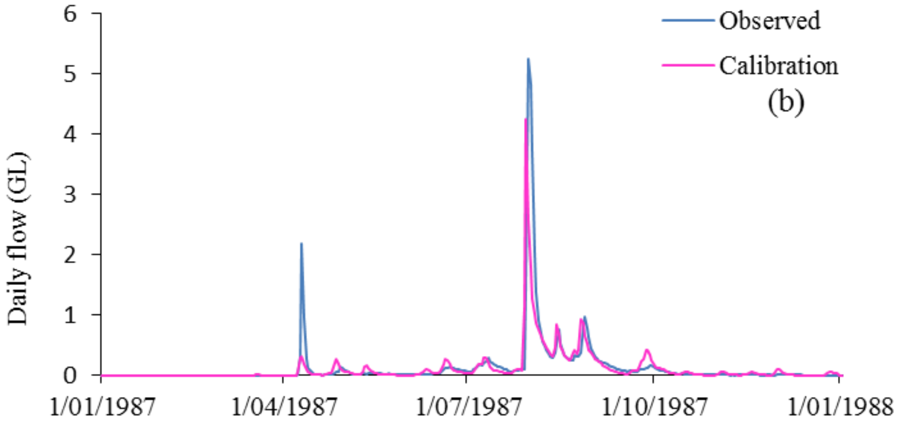
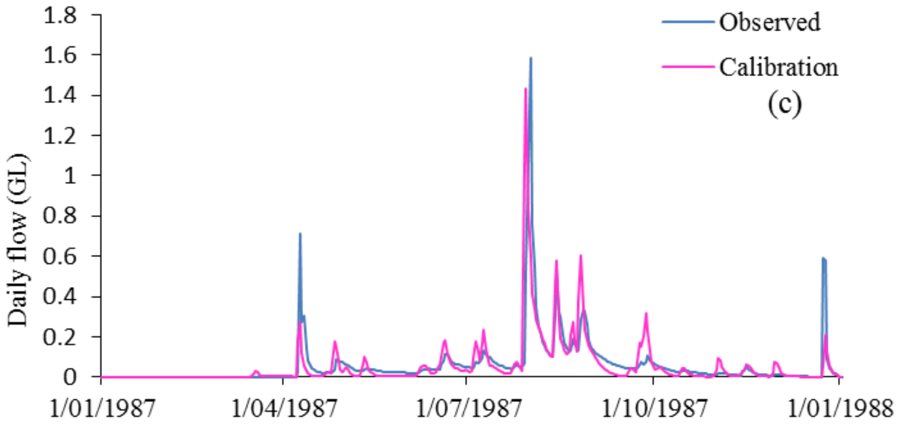
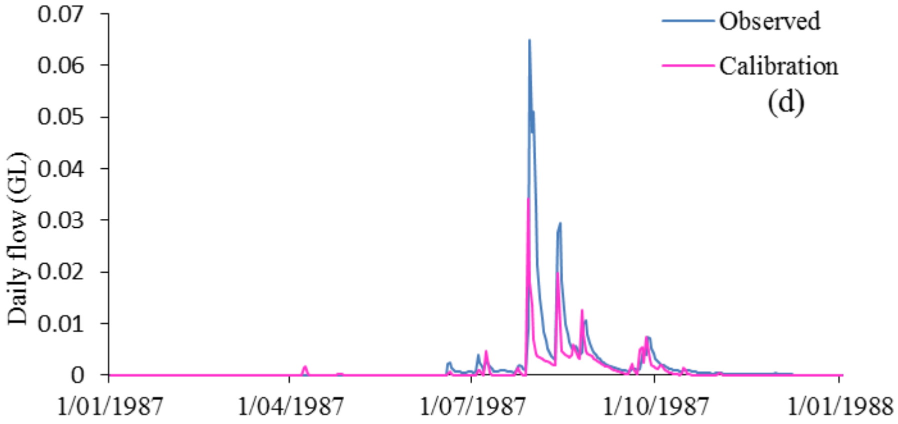
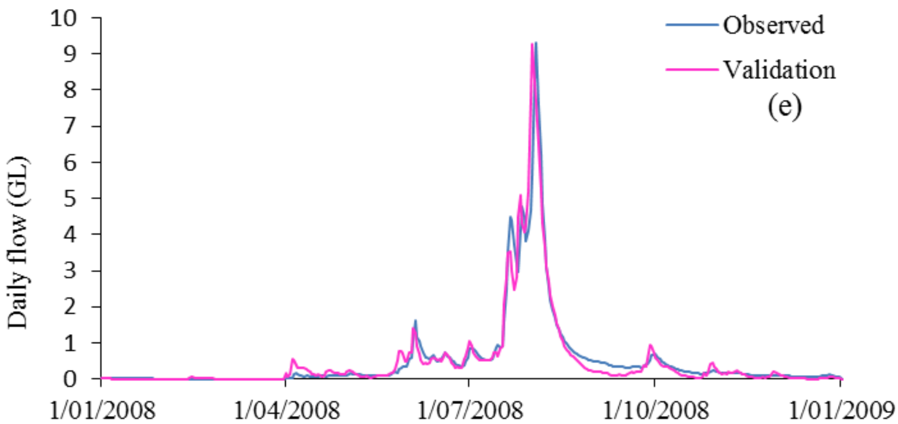

Daily flow (GL)
Observed
Calibration
(a)
1/01/1987
1/04/1987
1/07/1987
1/10/1987
1/01/1988


Daily flow (GL)
Observed
Calibration
(b)
1/01/1987
1/04/1987
1/07/1987
1/10/1987
1/01/1988

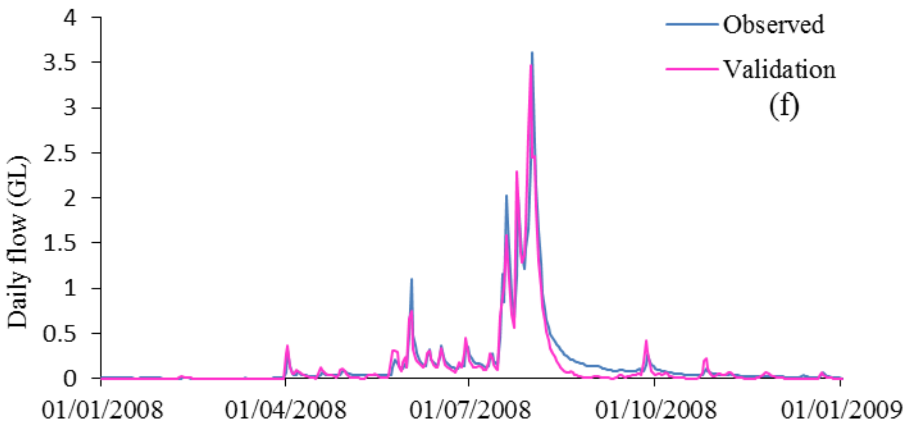

Daily flow (GL)
Observed
Calibration
(c)
1/01/1987
1/04/1987
1/07/1987
1/10/1987
1/01/1988



Observed
Calibration
(d)
Daily flow (GL)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1/01/1987
1/04/1987
1/07/1987
1/10/1987
1/01/1988

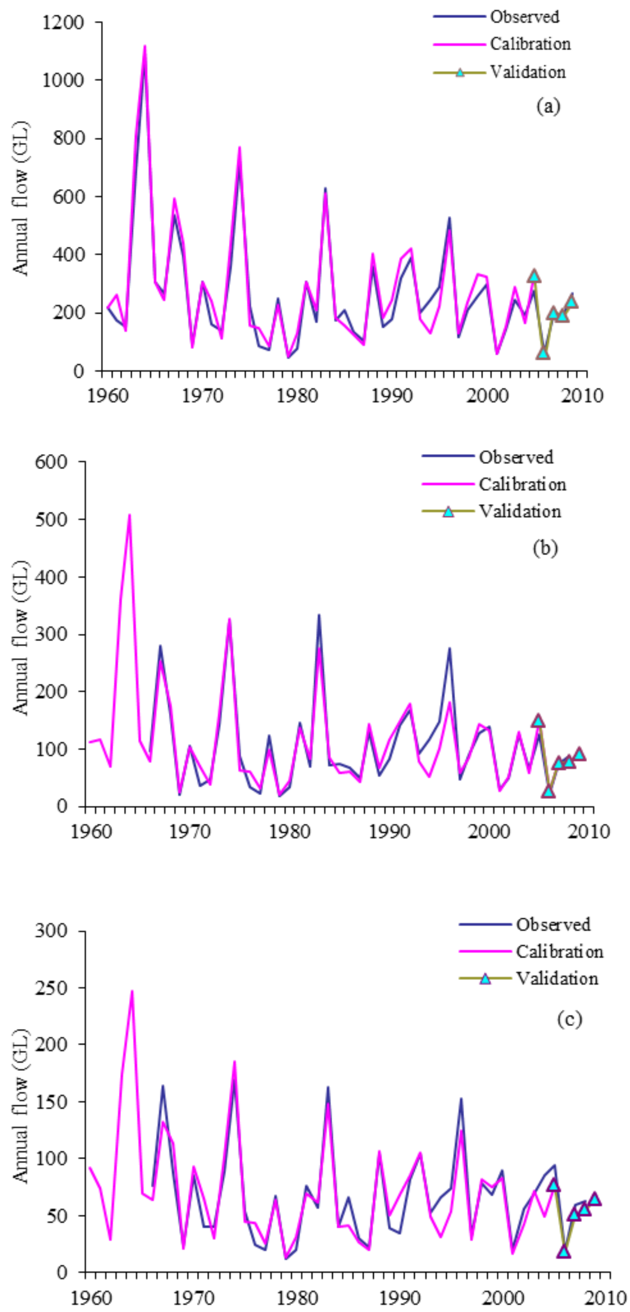



Observed
Validation
(e)
Daily flow (GL)
10
9
8
7
6
5
4
3
2
1
0
1/01/2008
1/04/2008
1/07/2008
1/10/2008
1/01/2009

Observed
Validation
(f)
Daily flow (GL)
4
3.5
3
2.5
2
1.5
1
0.5
0
01/01/2008
01/04/2008
01/07/2008
01/10/2008
01/01/2009

Fig. 5. Example observed and modelled daily flow at four gauging stations at (a) Baden Powell, (b) Marradong Bridge, (c) Saddleback and (d) Yarragil Formation within calibration period while (e) and (f) are representing the same for validation period at Baden Powell and Saddleback respectively.



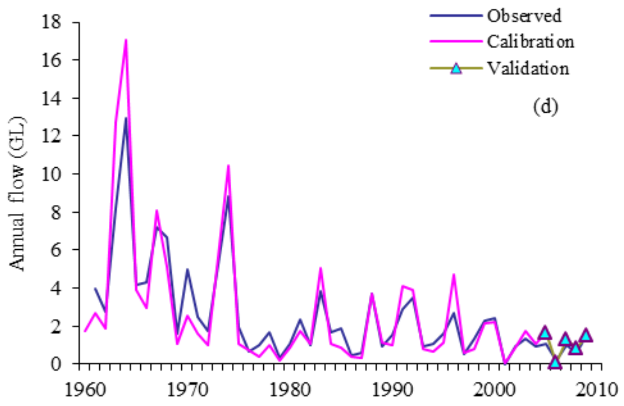



Fig. 4. Observed annual in flow and modeled inflow at four gauging station (a) Baden Powell, (b) Marradong Bridge, (c) Saddleback and (d) Yarragil.

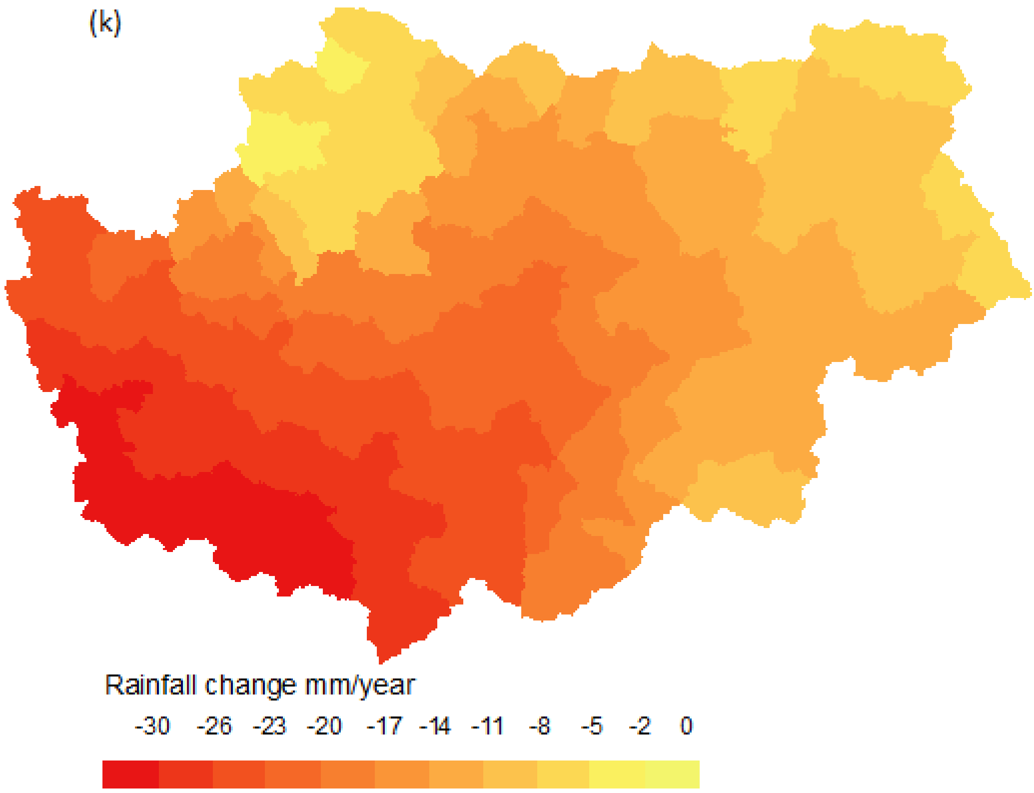



Fig. 7. Spatial distribution of observed and projected (ensemble mean) rainfall and changes in average annual rainfall under scenario A2 and B1. All the mean annual rainfall presented in the figure is 20 years mean and changes are calculated considering 1961-1980 as base periods. (a) and (b) are observed mean annual rainfall for the period 1961-1980 and 1981-2000, (c) and (d) are for

mid-century (2046-2065) while (e) and (f) are for late-century (2081-2100) under scenario A2 and B1 respectively. Changes in projected rainfall are presented as (g) and (h) for mid-century and (i) and (j) for late-century under scenario A2 and B1 respectively while observed changes (1981-2000) in rainfall is presented as (k).