CLIMATE PROJECTIONS FOR THE EIGHT AGRICULTURAL DEVELOPMENT DIVISIONS IN MALAWI

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Dec 2022

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Background

Malawi is developing the National Adaptation Plan (NAP) that will contribute to the government's commitment to prioritizing climate change adaptation. The NAP is the medium to long-term strategy for Malawi to address the adaptation needs, and as part of the NAP process, Malawi requires to have climate change projections that provide the science of the changing climate and support the adaptation programmes and decisions

The Department of Climate Change and Meteorological Services (DCCMS) was engaged to develop the climate change projections for Malawi that will inform the formulation of NAP. The main objective was to conduct climate change modelling (CCM) and develop a set of nationally agreed climate change projections for the country, especially temperature, precipitation and extreme climate events such as heavy rains (floods), droughts, heatwaves, strong winds and cyclones. The project will apply the updated Global Climate Models (GCMs) of the Coupled Model Intercomparison Project 6 (CMIP6) to develop the climate projections for Malawi for 2040s, 2060s and 2080s.

1.2 Climate of Malawi

Located in the tropics, Malawi experiences two main seasons; summer and winter. Rainfall in Malawi comes during summer and the rainfall season starts from October to April. The main rain bearing systems are the Inter-Tropical Convergence Zone (ITCZ), Congo airmass and unstable easterlies. The country is also affected by tropical cyclones that develop in the Southwest Indian Ocean.

Malawi is vulnerable to several climatic hazards, the critical ones being floods, droughts, dry spells, strong winds, hailstorms, pest infestations and disease epidemics. Their impacts coupled with degraded landscapes contributes towards poverty, food insecurity and high levels of vulnerability. Effective climate change adaptation planning will help Malawi to manage these impacts.

1.3 Scope of the Work

The project involved the generation of climate change projections for Malawi and further details are provided for eight districts representing the eight Agricultural Development Divisions (ADDs), Fig.1-1. The ADDs and target districts are presented in Tab.1-1 and are as follows: Karonga ADD-Karonga District, Mzuzu ADD-Rumphi district, Kasungu ADD-Kasungu District, Lilongwe ADD-Dedza district, Salima ADD-Salima District, Shire Valley ADD-Chikwawa District, Machinga ADD-Machinga District, and Blantyre ADD- Phalombe District (Fig.1-1).

The work focussed on rainfall, maximum temperature, minimum temperature and mean temperature. The mean temperature is derived from global model outputs of maximum temperature and minimum temperature. Further analysis of extreme climate events was also analysed particularly droughts, rainfall exceeding 100mm in 24 hours (proxy to flash floods), rainfall exceeding 150mm in 24 hours (proxy to storms/cyclones), heatwaves and coldwaves. The rainfall characteristcs such as rainfall onset, cessation, dry spells and rainfall season length are also analysed to stablish future changes.

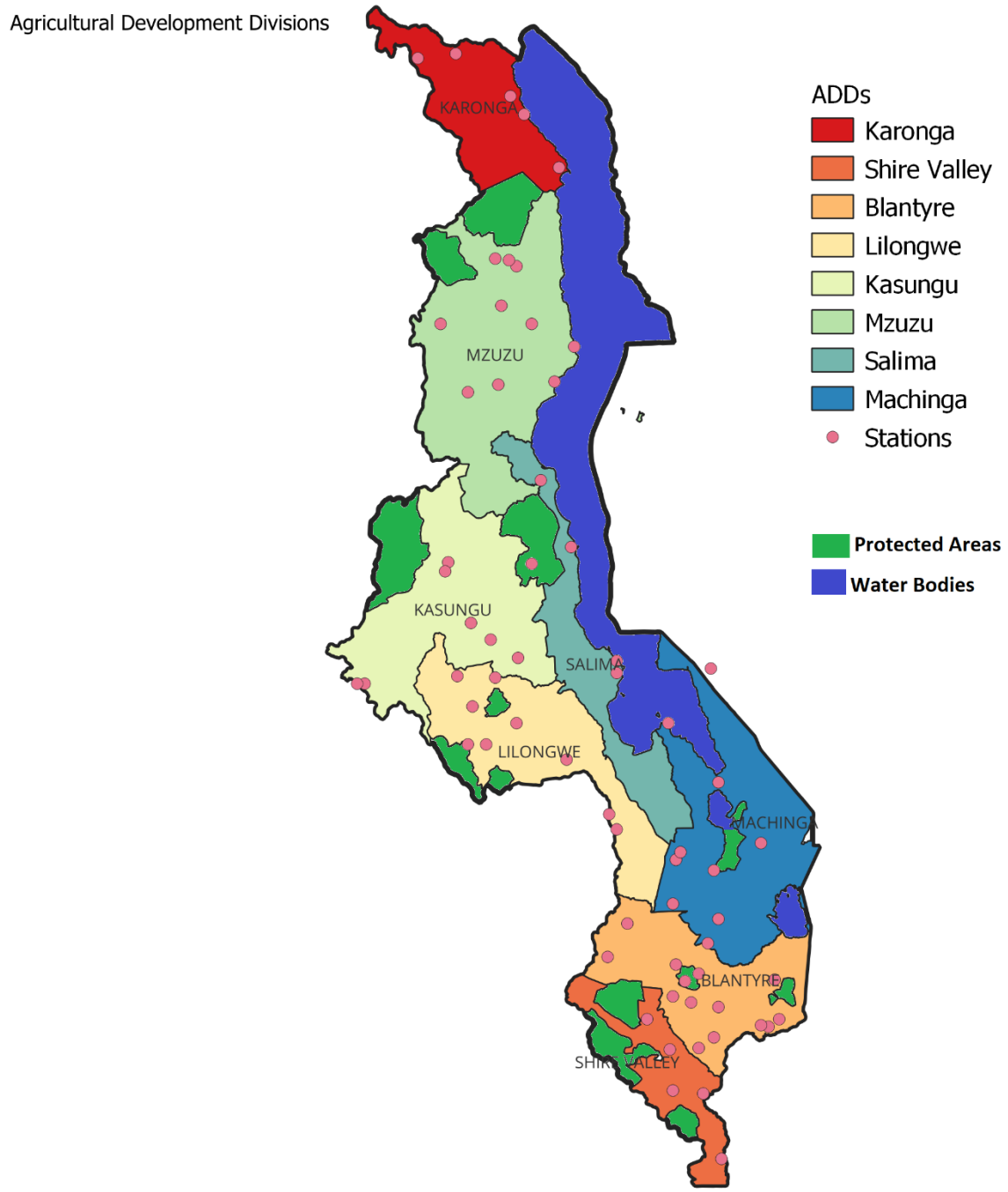

Figure 1-1 Area of study map indicating the eight Agricultural Development Divisions (ADDs)

Table 1- 1 Agricultural Development Divisions and associated target districts

Agricultural Development Division, ADD	*Target District*
Karonga	Karonga
Mzuzu	Rumphi
Kasungu	Kasungu
Lilongwe	Dedza
Salima	Salima

Machinga	Balaka
Blantyre	Phalombe
Shire Valley	Chikwawa

2. DATA AND MODELS

2.1 Data

Rainfall from 64 stations is used in the study (Fig. 1-1) accessed from the Department of Climate Change and Meteorological Services (DCCMS). The temperature data is from 21 stations across Malawi which was used to extrapolate to other parts of the country. Though this is a limitation, it is also understood that temperature does not vary much in space comparing to rainfall. The data runs from 1971 to 2020.

2.2 Global Climate Models

The assignment has used the Coupled Model Intercomparison Project 6 (CMIP6) - Global Climate Models (GCMs). The GCMs are used to estimate the changes in climate elements and ocean circulation for the future by means of shared socio-economic pathways (SSPs). The SSPs represent range of possible paths the world might take during the coming century from population changes to education, gross domestic product (GDP), economic growth, rate of technological developments, urbanization, greenhouse gas and aerosol emissions, energy supply and demand, to land use changes, etc. There are five SSPs under CMIP6 from SSP1 to SSP5. The Tab.2-1 provides a brief overview of each scenario. The SSPs are designed to work together with the Representative Concentration Pathways (RCPs) that were used in Coupled Model Intercomparison Project (CMIP5) that are based on the radiative forcing levels. Tab.2-1 has related the SSPs with the RCPs and the brief description of each of the SSP is presented. The table has only concentrated on the priority scenarios. Otherwise, there are also additional scenarios such as SSP1-1.9 and SSP4-3.4 that are not discussed in this report. The SSP1-1.9 is a scenario that was added after the Paris Agreement (United Nations, 2015) that intends to limit the global temperature increase below 1.5 degrees Celsius by 2100 above the pre-industrial levels.

Table 2-1The combination of the shared socio-economic pathways (SSPs) in the Coupled Model Intercomparison Project 6 (CMIP6) and the representative concentration pathways (RCPs) in the Coupled Model Intercomparison Project 5 (CMIP5). Source: https://climate-scenarios.canada.ca/?page=cmip6-overview-notes

Shared Socio-economic Pathways (SSPs)	***Representative Concentration Pathways (RCPs)***	***Combination***	***Brief Explanation***
SSP1	RCP2.6	SSP1-2.6	**Sustainability - Taking the green road (low challenges to mitigation and adaptation)** The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.

SSP2	RCP4.5	SSP2-4.5	**Middle of the road - (medium challenges to mitigation and adaptation)** The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.
SSP3	RCP7.0	SSP3-7.0	**Regional rivalry - A rocky road (high challenges to mitigation and adaptation)** A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Population growth is low in industrialized countries and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.
SSP4	RCP6.0	SSP4-6.0	**Inequality-A Road divided (low challenges to mitigation, high challenges to adaptation)** Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally-connected society that contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labor intensive, low-tech economy.

			Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle- and high-income areas.
SSP5	RCP8.5	SSP5-8.5	**Fossil-fuelled development - Taking the highway (high challenges to mitigation, low challenges to adaptation)** This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

The project has analysed the SSP2-4.5 and SSP5-8.5 scenarios. The SSP2-4.5 which is the middle of the road is the moderately controlled scenario. The SSP2-4.5 shows a higher starting point of temperature increase but slightly slower declines than RCP4.5. While the SSP5-8.5 is the fossil fuelled development and has the substantially higher CO2 emissions than RCP8.5 but with correspondingly larger cuts in non-CO2 emissions[1] . The two scenarios are selected to provide a range of possible climate change trajectory in Malawi.

The GCMs used are presented in Tab. 2-2. The project has included only models that comprise of all the weather parameters for the two scenarios covering the period from 1981 to 2100. The

[1] (https://www.carbonbrief.org/cmip6-the-next-generation-of-climate-models-explained/)

study has looked at rainfall, maximum temperature, minimum temperature and mean temperature. The reference period is from 1981 to 2014 and the models have different spatial resolutions ranging from 100 to 250km. Tab.2-2 is presenting the details of the models used in this study.

Table 2-2The Global Climate Models (GCMs) used in the study.

No.	Global Climate Model (GCM)	Resolution (lon x lat)	Institution	Country
1	Australian Community Climate and Earth System Simulator Climate Model Version 2 (ACCESS-CM2)	1.88 × 1.25	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Australia
2	Meteorological Research Institute - Earth System Model version 2 (MRI-ESM2-O)	1.13 × 1.12	Meteorological Research Institute (MRI)	Japan
3	The sixth version of the *Model* for Interdisciplinary Research on Climate (MIROC6)	1.4 × 1.4	Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Kanagawa, Japan, Atmosphere and Ocean Research Institute (AORI), The University of Tokyo, Chiba, Japan, National Institute for Environmental Studies (NIES), Ibaraki, Japan, and RIKEN Center for Computational Science, Hyogo, Japan	Japan
4	Earth Consortium Version 3 (EC-EARTH3-CC)	0.7 × 0.7	EC-Earth consortium, Rossby Center, Swedish Meteorological and Hydrological Institute/SMHI, Norrkoping, Sweden	Sweden
5	Max-Planck Institute - Earth System Model version 1.2 low resolution (MPI-ESM1-2-LR)	1.88 × 1.88	Max Planck Institute for Meteorology (MPI-M)	Germany
6	Centro Euro-Mediterraneo sui Cambiamenti Climatici - Earth System Model Version 2 (CMCC-ESM2)	1.25 × 0.94	Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)	Italy
7	Centre National de Recherches Meteorologiques - Climate Model Version 2 (CNRM-CM2-1)	1.4 × 1.4	Centre National de Recherches Meteorologiques (CNRM) and Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique (CERFACS)	France
8	Earth Consortium Version 3 – Vegetation (EC-EARTH3-VEG-LR)	1.13 × 1.13	EC-Earth consortium, Rossby Center, Swedish Meteorological and Hydrological Institute/SMHI	Sweden
9	Institute for Numerical Mathematics - Climate Model Version 4 (INM-CM5-0)	2 × 1.5	Institute for Numerical Mathematics (INM), Russian Academy of Science	Russia

3. GLOBAL CLIMATE MODELS (GCMs) BIAS CORRECTION

3.1 Empirical Quantile Mapping (EQM) Method

The GCMs do often contain huge uncertainty and biases. To address this problem, the models are bias corrected using station data. There are many methods of bias correcting, but this study has adopted the empirical quantile mapping (EQM) method called the Cumulative Distribution Function transform (CDF-t) method which is becoming popular since it seeks a transfer function to adjust the quantiles of the GCMs to match those of observations (e.g. Piani *et al.*, 2010; Themeßl, Gobiet and Heinrich, 2012; Mtilatila et al 2022). The method has proved to reduce the uncertainty among the GCMs and provide a better representation of observations in Malawi (Mtilatila et al 2022). The study has bias corrected GCMs with reference to 1981 to 2014.

3.2 Performance of the Bias Corrected Global Climate Models (GCMs)

3.2.1 Rainfall

Rainfall is generally performing well after bias correction. The bias that was over 30% is reduced significantly to less than 5%. Before the bias correction, many models were overestimating the rainfall, as shown in the sample Fig 3.1. The mean annual rainfall for the observations at Balaka is 946mm while the annual mean for the models range from 912 to 985 mm while the ensemble mean is 938mm.

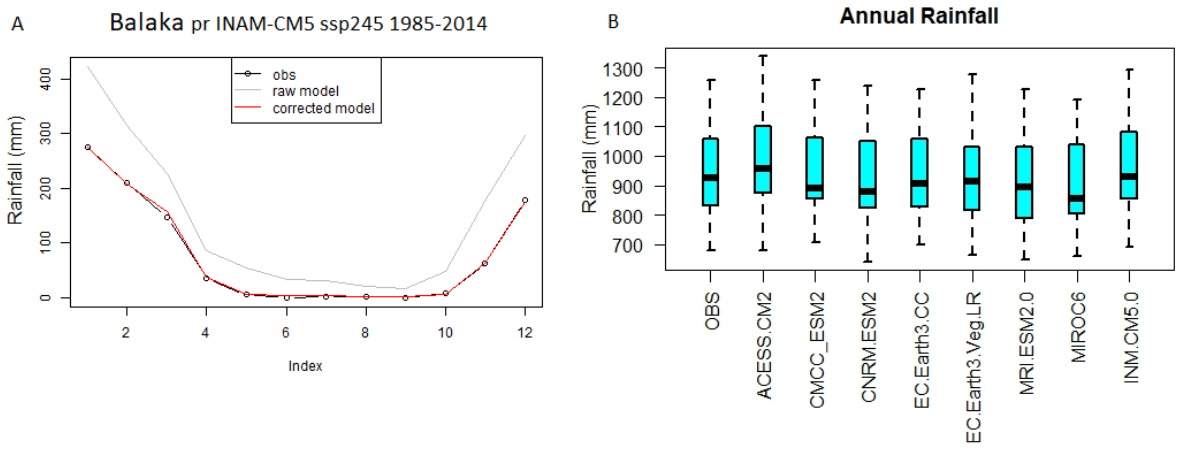

Fig.3-1 The performance of bias corrected Global Climate Models (GCMs); A. Balaka for INAM-CM5 model for SSP2.45; B. All models compared to observations (OBS)

Fig 3-2 is showing the historical maps of bias corrected ensemble mean of SSP2.45 and SSP5.85 rainfall that are compared to observations. Both scenarios are generally overestimating the rainfall with a maginitude of about 100mm annually except the western side of Mzuzu ADD where the SSP2.45 is underestimating. This information is showing the limtations of the scenarios which is important to consider when applying these projections.

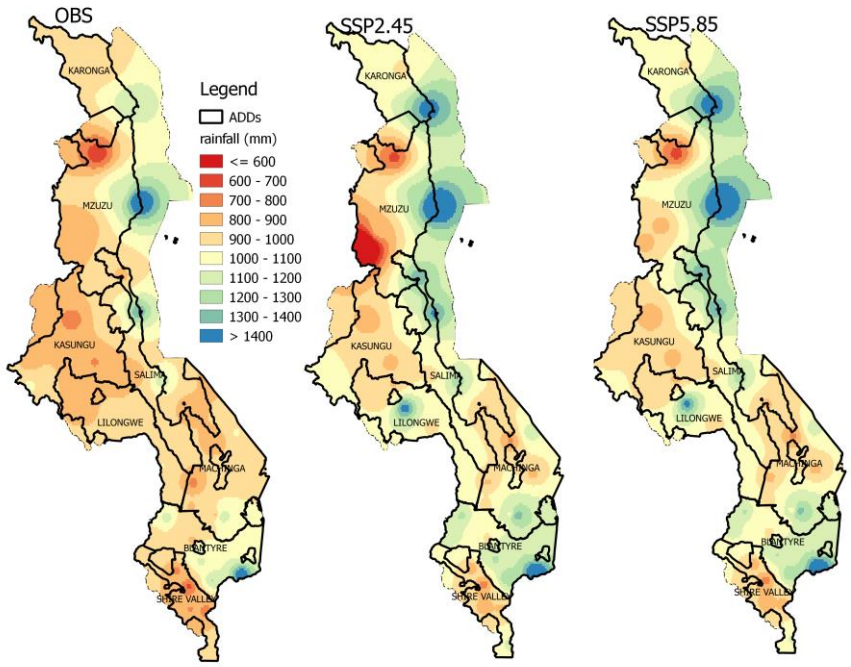

Fig.3-2 The comparison of bias corrected ensemble mean of SSP2.45 (middle) and SSP5.85 (right) with observations (left).

3.2.2 **Maximum Temperature**

The performance of maximum temperature as compared to observations is shown in Fig. 3-3. In this example, the bias of EC-Earth3-CC is noted where the model underestimates maximum temperature from January to August and underestimates the rest of the months. The CDF-t method has corrected the bias as is noted in Fig.3-3A. Similar results are also shown in Fig 3-3B where all the models resemble the observations in both mean and extreme variations after the bias correction.

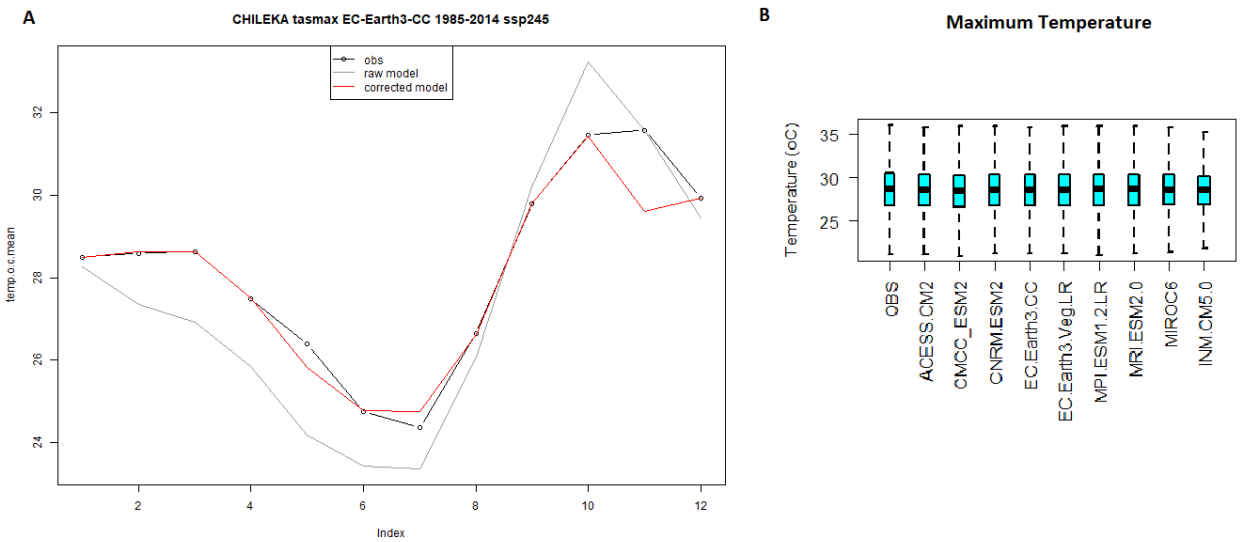

Figure 3-3 The performance of bias corrected Global Climate Models (GCMs); A. Chileka for EC-Earth-CC model for SSP2.45; B. All models compared to observations (OBS)

Spartially, the maximum temperature of the ensemble mean of SSP2.45 and SSp5.85 are.....the observations.

3.2.3 Minimum Temperature

Like the performance of maximum temperature, minimum temperature of the bias corrected data is similar to that of observations, Fig. 3.3. Otherwise before the correction, the EC-Earth3-CC model in this example, underestimates minimum temperature during the months of September, October, November, December, January and February and overestimates from March to August. All the models are representing the region well after bias correction in terms of mean. However, it is also noted that all the models have a wider range of extreme values than observations as is shown in Fig. 3-3B.

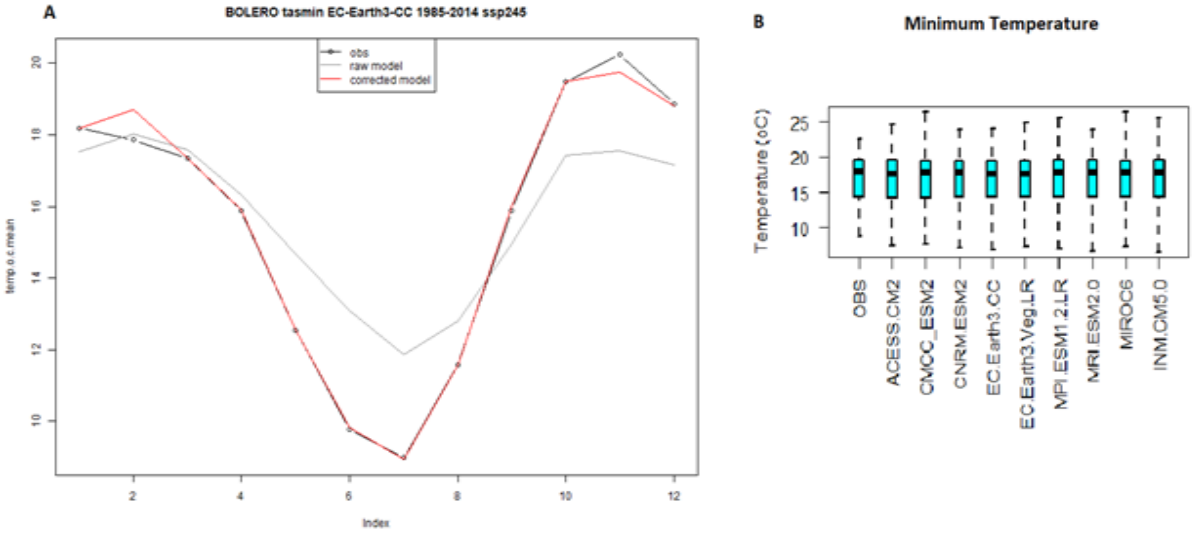

Figure 3-3 The performance of bias corrected Global Climate Models (GCMs); A. Bolero for EC-Earth-CC model for SSP2.45; B. All models compared to observations (OBS)

4. CLIMATE CHANGE IN MALAWI

4.1 Rainfall

To obtain the spatial pattern of annual rainfall changes in the future, the ensemble averages of all the models are presented in Fig. 4-1 for historical period (1991-2020), 2040s, 2060s and 2080s. The annual rainfall changes with reference to 1991-2020 are also shown in Tab. 4-1. The wettest spots are in northern lakeshore areas including Mzuzu, Karonga and Salima ADDs, some more high rainfall spots are also found in Blantyre and Lilongwe ADDs. While the driest spots are in Northern Mzuzu, Kasungu, Machinga and Shire Valley ADDs. The mean annual rainfall during the reference period is 962mm in Malawi.

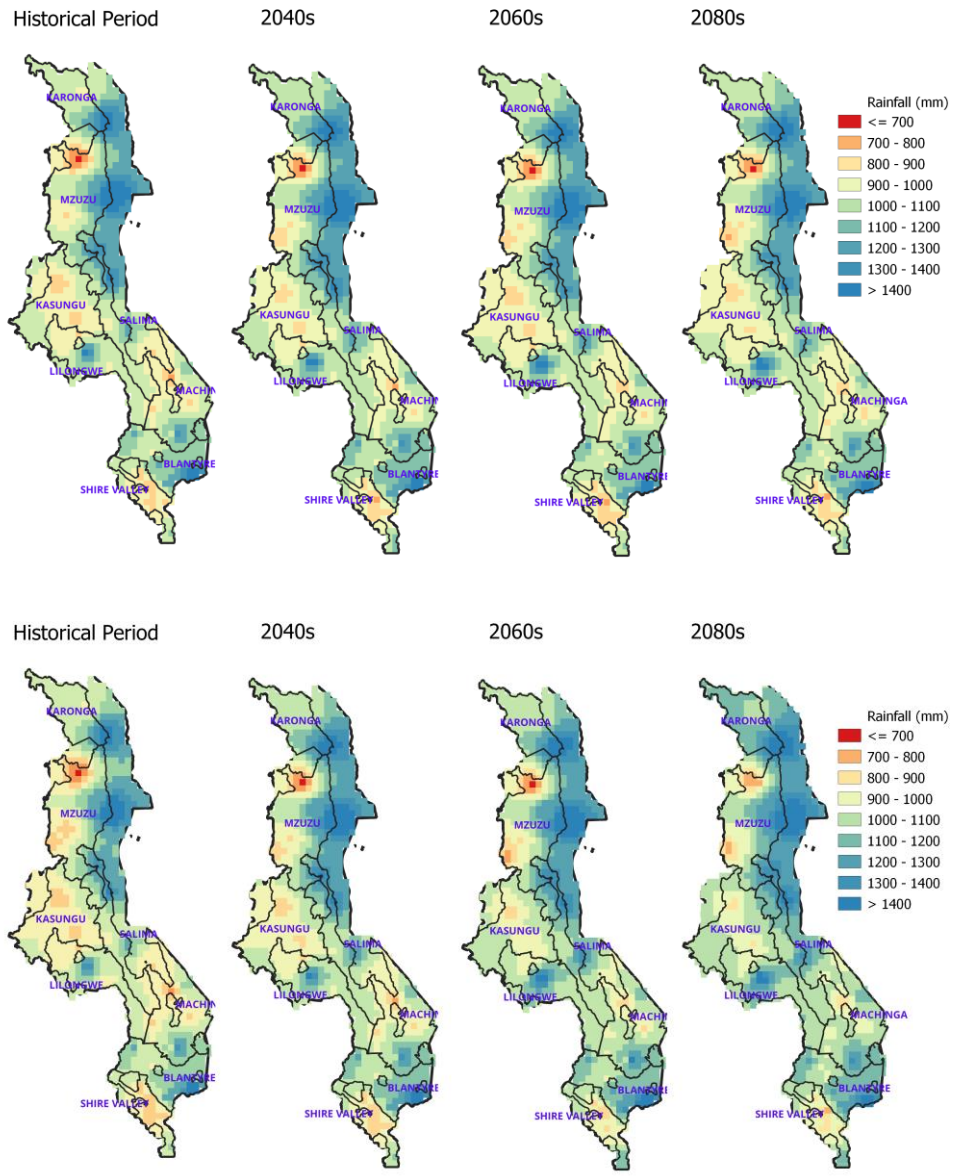

Figure 4- 1 The ensemble annual mean rainfall from 2020s (historical period) to 2040s, 2060s and 2080s. Upper panel is showing the SSP2.45 and lower panel is for SSP5.85. The eight ADDs are overlaid on the distribution.

However, the future rainfall changes are uncertain (Tab 4-1), as the direction of change of models is not certain. For instance, during 2040s, 45,2% of models indicate the positive trend while the negative constitutes the 54.8%. During the 2060s, the positive models are at 44.6% while the negative models are at 55.4%. And during 2080s, the positive models are at 50.9% and negative at 49.1%. While the SSP5.85 is leaning more towards the positive changes in the future. During 2040s, the positive models were at 55.4% while the negative models are at 44.6%, as we progress into 2060s, the positive models are at 60.5% while the negative models are at 39.5%. During, 2080s, the positive models are at 68,6% and negative models at 31.4%.

The ensemble mean change is near zero since the models nearly cancel each other (Fig. 4-1) among 2020s, 2040s, 2060s and 2080s for both scenarios. The rainfall changes range from –12.9 to +7.9% during 2040s for SSP2.45 while the ensemble mean is +0.2%. This magnitude of uncertainty is also noted during 2060s and 2080s, though the mean change in 2060s is –0.4% and +0.1% for 2080s. As is noted that the rainfall changes for SSP5.85 lean towards the positive, the individual model range is also leaning more towards positive side than negative. For example, during 2040s, the mean change is +1.1% and the range

is between –4.2 and +9.4%, during 2060s the mean change is +3.5% while the range is from –3.7 to +16%. During 2080s the mean change is +3.4% and the range is between –12.2% and +17.1%.

Appreciating if the mean rainfall is going to increase or decrease spatially in future, the area that will have mean rainfall less than 800mm, does not change much for both scenarios. Similarly, the area with mean rainfall greater than 1300mm does also not change much for SSP2.45 though it is slightly noticeable with SSP5.85 with the area changes from 16% to 18% during 2040s and 20% during 2060s and 2080s, Tab 4-1.

Table 4-1 The rainfall changes in 2040s, 2060s and 2080s with reference from 1991-2020 (2020s). The range is the change range for the individual models. The area proportion that has a mean rainfall greater than 1300mm and less than 800mm are also presented.

Period	Mean (mm)		Proportion of area with <800 mm (%)	Proportionof area>1300mm (%)				
Historical (2020s)	962		7	16				
	SSP2.45				SSP5.85			
	Mean Change (%)				Mean Change (%)			
	Mean (%)	Range (%)	Proportion of area with <800mm (%)	Proportion of area>1300mm (%)	Mean	Range	Proportion of area with <800mm (%)	Proportion of area>1300mm (%)
2040s	0.2	-12.9,+7.9	6	16	1.1	-4.2,+ 9.4	6	18
2060s	-0.4	-11.4, +5.3	6	16	3.5	-3.7, +16	6	20
2080s	0.1	-9 , +7.7	8	16	3.4	-12.2, +17.1	6	20

4.2 Maximum Temperature

To have a spatial status on how maximum temperature may change in the future, the ensemble mean of all the models is represented in Fig. 4-2. The temperature changes with reference from 1991-2020 are also shown in Tab. 4-2. The hottest ADD is Shire Valley while the coolest is Lilongwe. On average, the mean maximum temperature in Malawi is 28 degrees Celsius during the reference period. However, the mean maximum temperature is expected to increase by +0.3 on average based on SSP2.45 and +0.7 based on SSP5.85 during the 2040s. While the individual models indicate the maximum temperature increase ranging from +0.03 to +1.1 degrees Celsius between the two scenarios.

SSP2.45

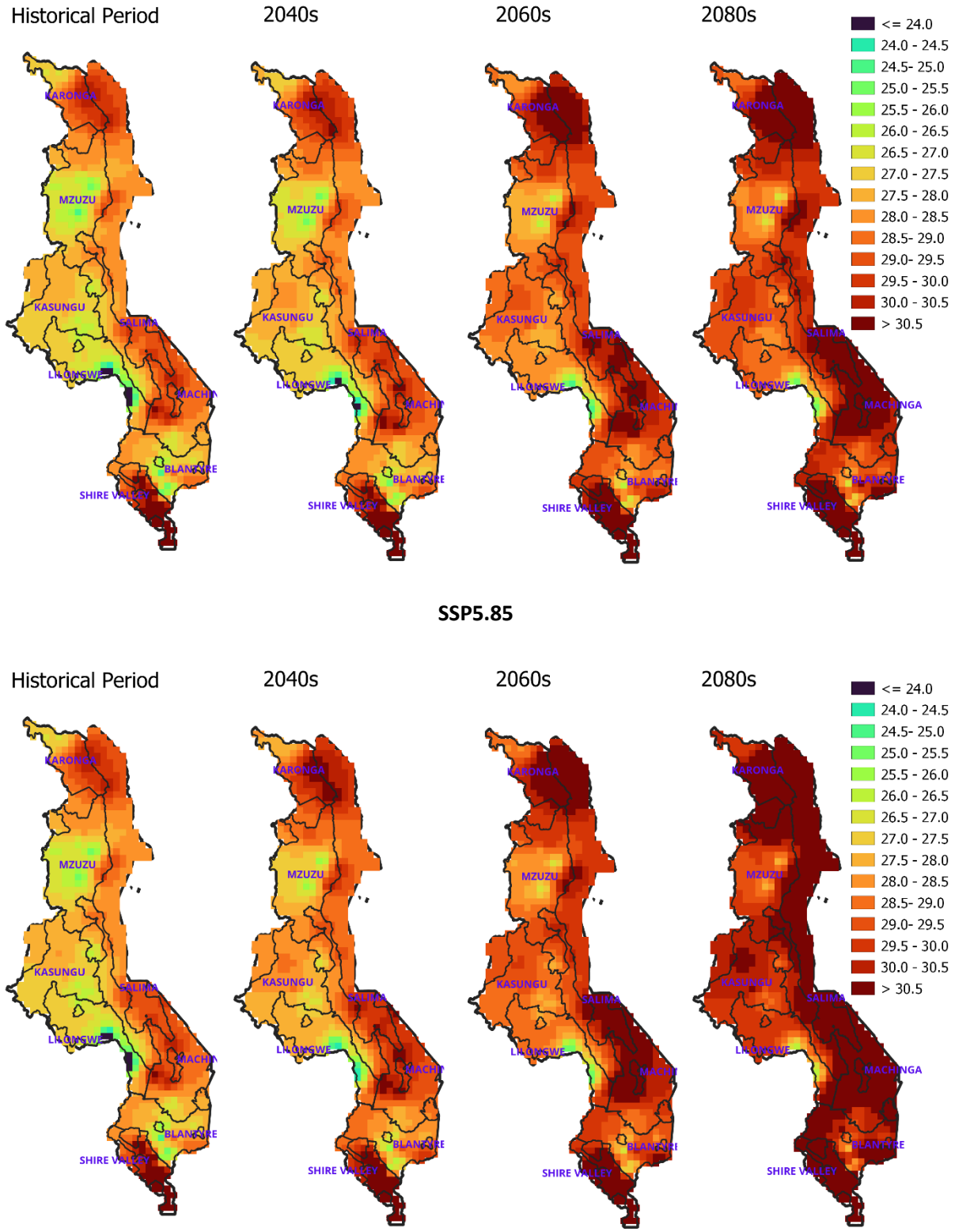

Figure 4-2 The ensemble maximum temperature from 2020s (historical period) to 2040s, 2060s and 2080s. Upper panel is showing the SSP2.45 and lower panel is for SSP5.85. The maximum temperatures are overlaid on the eight ADDs.

In 2060s, the maximum temperature is expected to increase by +1.3 degrees Celsius on average based on SSP2.45 while SSP5.85 has an increase by +1.6 degrees Celsius. However, the individual models indicate the increase ranging between +0.8 and +2.3 degrees Celsius. The maximum temperature may further increase by +1.9 and +2.8 degrees Celsius for SSP2.45 and SSP5.85 respectively during the 2080s.

However, the individual models show an increase range between +1.2 and +3.1 degrees Celsius for SSP2.45 and +1.4 to +4 degrees Celsius for SSP5.85 during this period.

The area that has the mean maximum temperature greater than 30.5 degrees Celsius during 2020s is about 15.4% and is mostly in the Shire Valley ADD. But this is likely to extend to Machinga and Karonga ADDs during the 2040s and area may reach 20% considering the SSP2.45 scenario or 24.6% for SSP5.85. During 2060s, the area proportion may reach 27.7% and 33.9% for SSP2.45 and SSP5.85 scenarios respectively. During 2080s the area may extend to Mzuzu ADD, Kasungu ADD, Salima ADD and Blantyre ADD for SSP5.85 and the area proportion may reach 53.9% while for SSP2.45 the area proportion may reach 38.5% during this period.

Table 4- 2 The maximum temperature changes in 2040s, 2060s and 2080s with reference from 1991-2020 (2020s). The range is the change range for the individual models. The area proportion that has a mean maximum temperature greater than 30.5 degrees Celsius is also presented.

Maximum Temperature Change (oC)						
Period	Mean		Proportion Area >30.5 deg (%)			
Historical (2020s)	28		15.4			
	SSP2.45			SSP5.85		
	Mean change			Mean change		
	Mean	Range	Proportion Area >30.5 deg (%)	Mean	Range	Proportion Area >30.5 deg (%)
2040s	0.3	0.03-0.4	20	0.67	0.4-1.1	24.6
2060s	1.3	0.8-2.3	27.7	1.6	0.9-2.3	33.9
2080s	1.9	1.2-3.1	38.5	2.8	1.4-4.0	53.9

4.3 Minimum Temperature

The spatial status of minimum temperature is presented in Fig. 4-3 based on the mean from all the models. The temperature changes with reference from 1991-2020 are also shown in Tab. 4-3. The warmest ADDs are the Shire Valley, Machinga, Salima and Karonga while the coldest are Lilongwe, Kasungu and Mzuzu ADDs. On average, the mean minimum temperature in Malawi is 17.2 degrees Celsius. The minimum temperature is expected to increase by about +0.6 degrees Celsius for both scenarios on average during the 2040s. But the individual models show the possibility to range from +0.3 to +0.9 degrees Celsius during this period.

SSP2.45

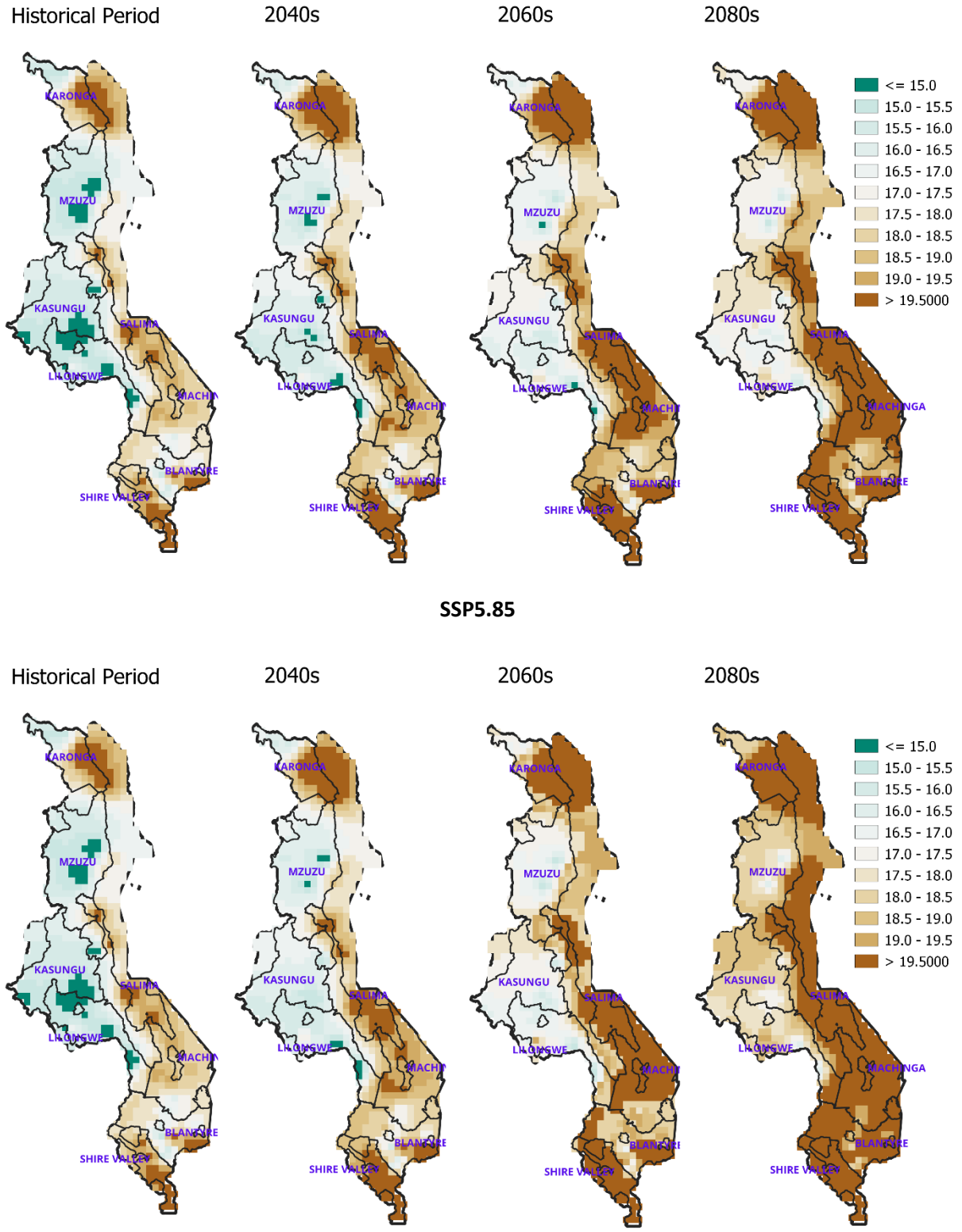

Figure 4-3 The ensemble minimum temperature from 2020s (historical period) to 2040s, 2060s and 2080s. Upper panel is showing the SSP2.45 and lower panel is for SSP5.85. The minimum temperatures are overlaid on the eight ADDs.

In 2060s, the minimum temperature is expected to increase by +1.2 degrees Celsius based on SSP2.45 while SSP5.85 has an increase by +1.6 degrees Celsius on average. The individual models, however, indicate the range between +0.9 and +2.1 degrees Celsius for both scenarios. The minimum temperature

may further increase by +1.8 and +2.7 degrees Celsius on average for SSP2.45 and SSP5.85 respectively during the 2080s. However, the individual models show an increase range between +1.1 and +2.7 degrees Celsius for SSP2.45 and +1.9 to +3.7 degrees Celsius for SSP5.85 during this period.

The area that has a mean minimum temperature of less than 15 degrees Celsius during 2020s is 23.1% and is mostly in the Lilongwe ADD, Kasungu ADD and Mzuzu ADD. But the area may reduce to 13.9 and 12.3% with respect to SSP5.85 and SSP2.45 scenarios respectively during 2040s. While during 2060s, the area proportion may reduce to 7.7% for SSP2.45 and 0% for SSP5.85. There is no area with mean minimum temperature of less than 15 degrees Celsius for both scenarios during 2080s.

Table 4-3 The minimum temperature changes in 2040s, 2060s and 2080s with reference from 1991-2020 (2020s). The range is the change range for the individual models. The area proportion that has a mean minimum temperature less than 15 degrees Celsius is also presented.

Minimum Temperature Change (oC)						
	Mean		Proportion Area <15 deg (%)			
Historical (2020s)	17.2		23.1			
	SSP2.45			SSP5.85		
	Mean change			Mean change		
	Mean	Range	Proportion Area <15 deg (%)	Mean	Range	Proportion Area <15 deg (%)
2040s	0.58	0.3-0.9	12.3	0.64	0.5-0.9	13.9
2060s	1.2	0.9-1.8	7.7	1.55	1.2-2.1	0
2080s	1.8	1.1-2.7	0	2.68	1.9-3.7	0

4.4 Mean Temperature

The spatial status of mean temperature is presented in Fig. 4-4 based on the mean generated from all the models. The temperature changes with reference from 1991-2020 are also shown in Tab. 4-4. Like the maximum temperature, the warmest ADD is the Shire Valley and coolest is Lilongwe. On average, the mean temperature in Malawi is 22.6 degrees Celsius. The mean temperature is expected to increase by about +0.4 degrees Celsius on average for the SSP2.45 and +0.7 degrees Celsius for the SSP5.85 during the 2040s. But the individual models indicate the range between +0.2 and +1 degrees Celsius.

SSP2.45

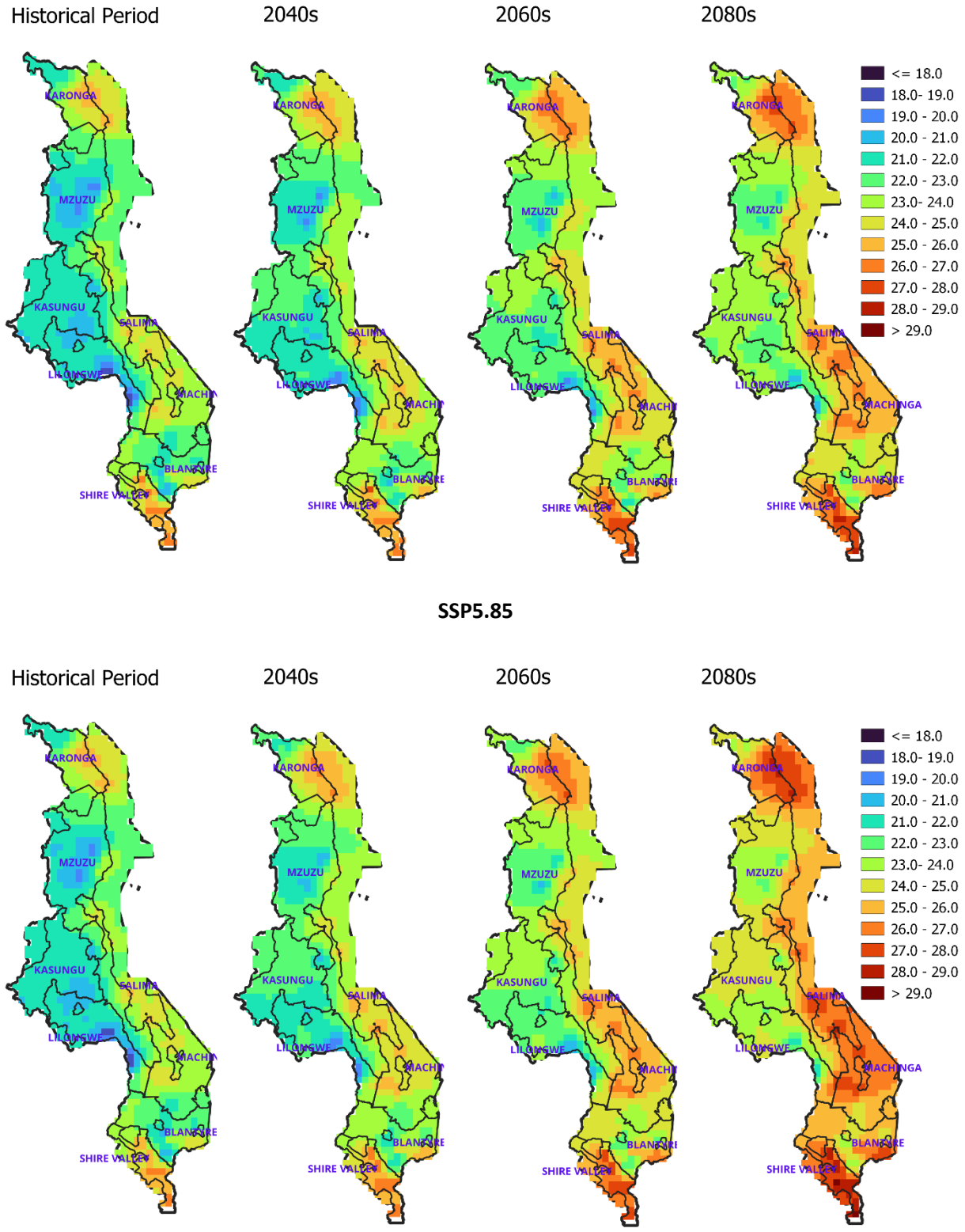

Figure 4- 4 The ensemble mean temperature from 2020s (historical period) to 2040s, 2060s and 2080s. Upper panel is showing the SSP2.45 and lower panel is for SSP5.85. The mean temperatures are overlaid on the eight ADDs.

In 2060s, the mean temperature is expected to increase by +1.2 degrees Celsius on average based on SSP2.45 while SSP5.85 indicates the increase of +1.6 degrees Celsius. The individual models indicate the range from +0.9 to +2.2 degrees Celsius for both scenarios during this period. The mean temperature

may further increase by +1.9 and +2.7 degrees Celsius for SSP2.45 and SSP5.85 respectively during the 2080s. However, the individual models show the increase range between +1.1 and +2.9 degrees Celsius for SSP2.45 and +1.9 to +3.2 degrees Celsius for SSP5.85 during this period.

The Paris Agreement states the need to control the global mean temperature increase to be within +2 degrees Celsius or preferably +1.5 degrees Celsius with reference to the preindustrial era. The two scenarios indicate the possibility of the mean temperature increase to go beyond +1.5 degrees Celsius during the 2060s between 11.1% considering the SSP2.45 and 55.6% for SSP5.85. The possibility extends to 77.8% and 100% for both scenarios during 2080s respectively. While the possibility of the temperature to increase beyond +2 degrees Celsius is about 11.1% during 2060s for both scenarios. But increases to 44.4% considering the SSP2.45 and 77.8% for SSP5.85.

Table 4-4 The mean temperature changes in 2040s, 2060s and 2080s with reference from 1991-2020 (2020s). The range is the change range for the individual models. The number of models projecting the mean temperature increase beyond the global limit of Δ1.5 and Δ2 degrees Celsius are also presented.

Mean Temperature Change (oC)								
	Mean							
Historical (2020s)	22.6							
	SSP2.45				SSP5.85			
	Mean Change				Mean Change			
	Mean	Range	No. Models > Δ1.5 oC (%)	No. Models > Δ2 oC (%)	Mean	Range	No. Models > Δ1.5 oC (%)	No. Models > Δ2 oC (%)
2040s	0.44	0.2-0.6	0	0	0.66	0.5-1	0	0
2060s	1.2	0.9-2.1	11.1	11.1	1.6	1.1-2.2	55.6	11.1
2080s	1.85	1.1-2.9	77.8	44.4	2.72	1.9-3.2	100	77.8

5. CLIMATE CHANGE IN EIGHT ADDS

5.1 Rainfall

5.1.1 Current Rainfall

5.1.1.1 Seasonal Variations

The rainfall season in Malawi starts from October to April that extends to May is some areas especially northern ADDs, Fig5-1.

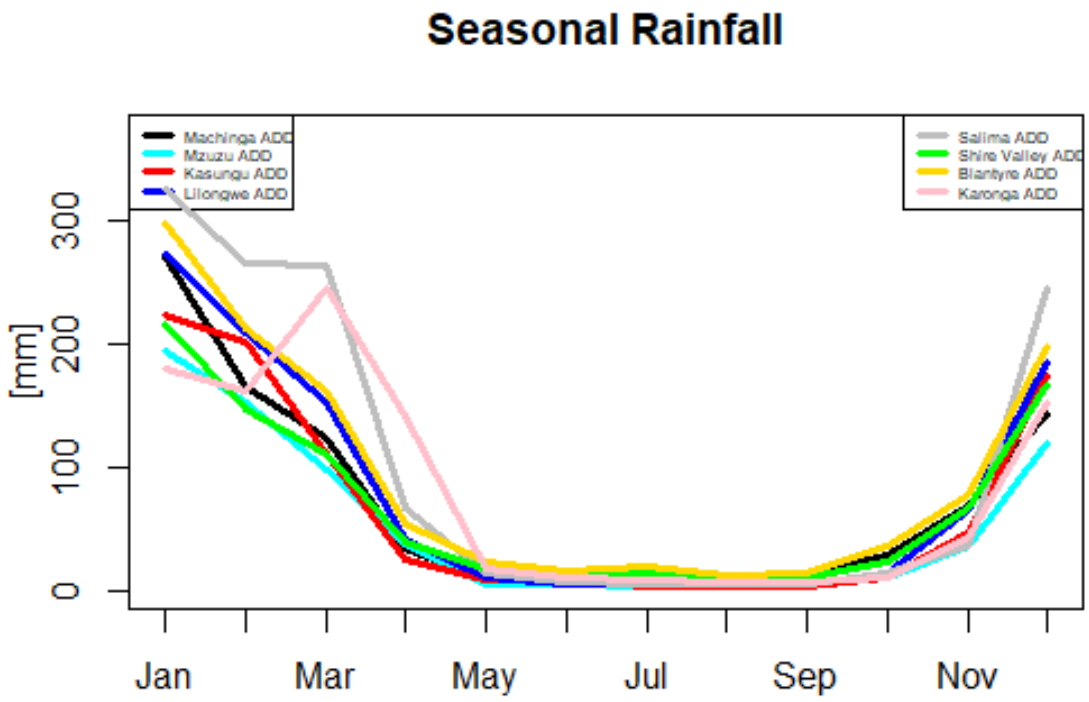

Figure 5- 1 Current seasonal variations of the monthly rainfall in eight ADDs

5.1.1.2 **Monthly Rainfall**

As the season starts in October, there is less chance for the rainfall to exceed 50mm in almost in all ADDs. In November, the rainfall amounts increase to around 100 mm and all the ADDs have similar patterns. As the rainfall is between 100 and 250mm in December, the lowest rainfall is received in Mzuzu ADD especially the northern areas. And the highest rainfall amounts are recorded in Salima ADD. There is a large variability among ADDs in January. Blantyre ADD has the largest rainfall amounts exceeding 300 mm. While in February, the highest rainfall is received in ADD and in March the highest rainfall amounts are recorded in Salima and Karonga ADDs. During this month the tailing off of rainfall in Southern Malawi begins. While the central areas are also tailing off in April, The Karonga ADD has the highest rainfall during this month, Fig 5-2. During May, June and July, the rainfall received is generally less than 20 mm. While August and September are the driest months.

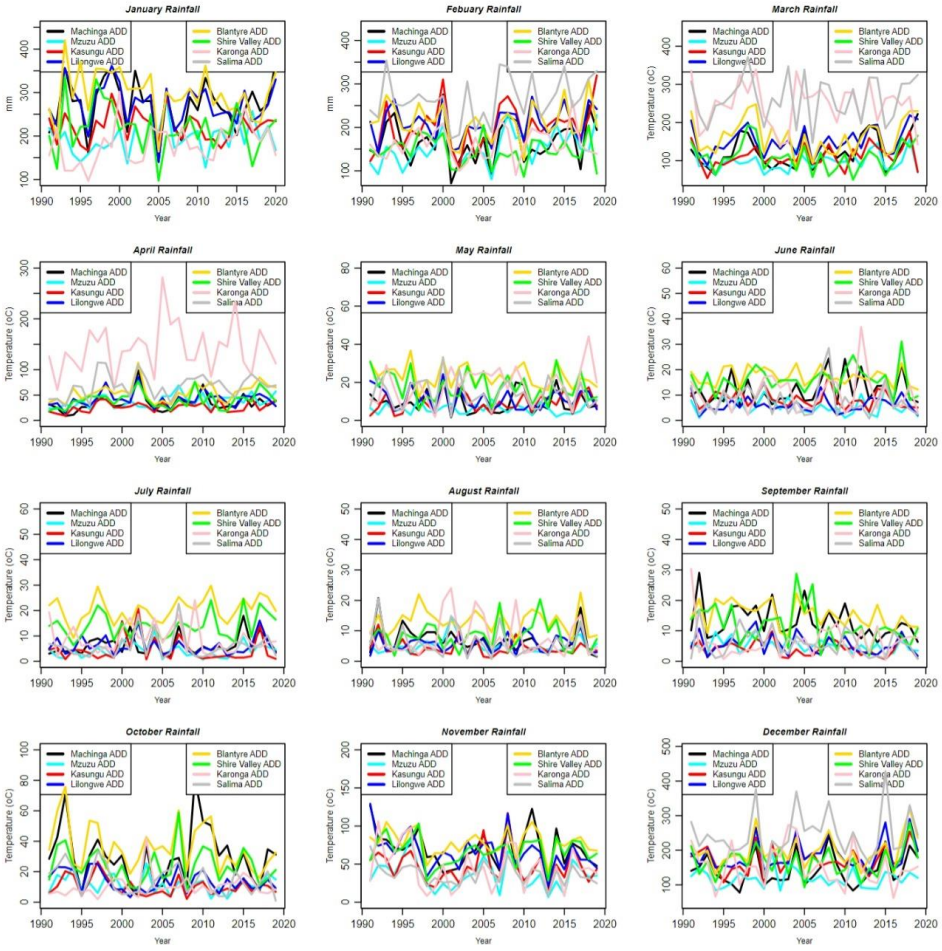

Figure 5- 2 Current (1991-2020) monthly rainfall in eight ADDs

The rainfall is generally increasing during January, February, March and April and the trends are significant in the month of January in Karonga ADD, Tab 5-1. The increasing trend is also significant in February in Mzuzu and Kasungu ADD (Tab 5-2 and TAB 5-3). And again, the positive trend is significant in April in Mzuzu ADD. While in Machinga ADD the positive trend is positive in March, Tab 5-7. The negative trends are generally during drier months of September, October and November. For instance, the significant negative trend is noted in Mzuzu ADD in the month of September (Tab 5-2). October and November in Lilongwe ADD (Tab 5-4), October in Salima ADD (Tab 5-5), September in Shire Valley and Machinga ADD (Tab 5-6 and Tab 5-7). While in Blantyre ADD, the rainfall decrease is noted in September and October, Tab 5-8.

Table 5- 1 Characteristics of the trends from the current time series (1991-2020) of rainfall by month in Karonga ADD, significant changes are presented in bold

Month	Slope (mm/year)	P-Value	R^2	NRME	Mean 1991-2020 (mm)
Jan	**1.84**	**0.05**	**0.13**	**0.20**	**180.21**
Feb	0.55	0.51	0.02	0.21	162.16
Mar	-0.38	0.78	0.00	0.29	245.97
Apr	0.96	0.39	0.03	0.22	142.25
May	0.33	0.11	0.09	0.20	18.73
Jun	0.06	0.73	0.00	0.21	10.25
Jul	-0.10	0.44	0.02	0.25	8.93
Aug	0.00	0.98	0.00	0.28	7.91
Sep	-0.05	0.70	0.01	0.19	6.67
Oct	0.13	0.42	0.02	0.18	10.47
Nov	-0.69	0.28	0.04	0.28	44.35
Dec	-1.29	0.31	0.04	0.26	152.44

Table 5- 2 Characteristics of the trends from the current time series (1991-2020) of rainfall by month in Mzuzu ADD, significant changes are presented in bold.

Month	Slope (mm/year)	P-Value	R^2	NRME	Mean 1991-2020 (mm)
Jan	0.96	0.21	0.06	0.22	194.84
Feb	**2.23**	**0.01**	**0.25**	**0.21**	**152.60**
Mar	0.38	0.52	0.02	0.27	98.45
Apr	**0.64**	**0.03**	**0.17**	**0.23**	**37.91**
May	0.02	0.71	0.01	0.29	6.29
Jun	-0.04	0.59	0.01	0.26	5.31
Jul	0.04	0.54	0.01	0.24	4.17
Aug	0.02	0.78	0.00	0.21	5.32
Sep	**-0.08**	**0.09**	**0.11**	**0.25**	**5.26**
Oct	-0.12	0.37	0.03	0.24	11.72
Nov	-0.42	0.33	0.04	0.24	36.27
Dec	-0.20	0.75	0.00	0.23	119.12

Table 5- 3 Characteristics of the trends from the current time series (1991-2020) of rainfall by month in Kasungu ADD, significant changes are presented in bold.

Month	Slope (mm/year)	P-Value	R^2	NRME	Mean 1991-2020 (mm)
Jan	0.05	0.94	0.00	0.25	223.24
Feb	**2.11**	**0.06**	**0.12**	**0.22**	**200.82**
Mar	0.73	0.26	0.05	0.22	111.19
Apr	0.34	0.13	0.08	0.27	26.38
May	0.08	0.53	0.01	0.26	9.79
Jun	-0.09	0.25	0.05	0.23	8.29
Jul	-0.06	0.60	0.01	0.24	4.58
Aug	-0.05	0.37	0.03	0.23	4.34
Sep	-0.06	0.27	0.04	0.26	4.23
Oct	-0.18	0.17	0.07	0.23	10.19
Nov	-0.21	0.67	0.01	0.21	46.70
Dec	0.84	0.33	0.04	0.25	174.46

Table 5- 4 Characteristics of the trends from the current time series (1991-2020) of rainfall by month in Lilongwe ADD, significant changes are presented in bold.

Month	Slope (mm/year)	P-Value	R^2	NRME	Mean 1991-2020 (mm)
Jan	-0.63	0.55	0.01	0.21	272.72
Feb	0.78	0.37	0.03	0.29	208.56
Mar	1.11	0.16	0.07	0.26	151.91
Apr	0.22	0.54	0.01	0.21	41.42
May	-0.14	0.29	0.04	0.26	11.17
Jun	0.01	0.93	0.00	0.25	6.08
Jul	-0.01	0.89	0.00	0.25	6.01
Aug	0.03	0.62	0.01	0.29	5.68
Sep	-0.09	0.20	0.06	0.26	5.59
Oct	**-0.26**	**0.08**	**0.11**	**0.28**	**13.81**
Nov	**-1.12**	**0.03**	**0.17**	**0.19**	**66.24**
Dec	1.26	0.19	0.06	0.26	185.48

Table 5- 5 Characteristics of the trends from the current time series (1991-2020) of rainfall by month in Salima ADD, significant changes are presented in bold.

Month	Slope (mm/year)	P-Value	R^2	NRME	Mean 1991-2020 (mm)
Jan	-0.13	0.93	0.00	0.22	324.62
Feb	1.52	0.18	0.07	0.27	265.22
Mar	0.64	0.63	0.01	0.25	263.16
Apr	0.61	0.24	0.05	0.26	68.01
May	-0.08	0.64	0.01	0.25	13.76
Jun	-0.08	0.57	0.01	0.22	8.08
Jul	0.03	0.77	0.00	0.23	6.06
Aug	-0.13	0.22	0.05	0.23	6.04
Sep	-0.12	0.21	0.06	0.25	5.81
Oct	**-0.40**	**0.05**	**0.14**	**0.26**	**14.42**
Nov	-0.49	0.11	0.09	0.20	36.72
Dec	0.98	0.52	0.02	0.21	245.90

Table 5- 6 Characteristics of the trends from the current time series (1991-2020) of rainfall by month in Shire Valley ADD, significant changes are presented in bold.

Month	Slope (mm/year)	P-Value	R^2	NRME	Mean 1991-2020 (mm)
Jan	-1.02	0.37	0.03	0.22	216.90
Feb	-0.50	0.49	0.02	0.26	146.48
Mar	-0.27	0.75	0.00	0.25	110.16
Apr	0.47	0.20	0.06	0.26	40.42
May	-0.19	0.28	0.04	0.29	17.62
Jun	0.04	0.74	0.00	0.21	15.90
Jul	0.13	0.25	0.05	0.26	14.10
Aug	0.03	0.76	0.00	0.25	8.41
Sep	**-0.27**	**0.06**	**0.13**	**0.22**	**11.68**
Oct	-0.14	0.60	0.01	0.22	23.98
Nov	-0.08	0.85	0.00	0.24	67.08
Dec	0.34	0.71	0.01	0.21	166.88

Table 5- 7 Characteristics of the trends from the current time series (1991-2020) of rainfall by month in Machinga ADD, significant changes are presented in bold.

Month	Slope (mm/year)	P-Value	R^2	NRME	Mean 1991-2020 (mm)
Jan	0.23	0.85	0.00	0.25	271.41
Feb	0.62	0.58	0.01	0.24	165.98
Mar	**1.87**	**0.05**	**0.13**	**0.25**	**122.80**
Apr	0.39	0.33	0.03	0.19	34.20
May	-0.01	0.94	0.00	0.28	9.29
Jun	0.15	0.26	0.05	0.29	11.78
Jul	0.11	0.22	0.05	0.25	6.55
Aug	-0.13	0.17	0.07	0.21	6.97
Sep	**-0.23**	**0.06**	**0.13**	**0.22**	**12.95**
Oct	-0.13	0.75	0.00	0.23	29.86
Nov	-0.66	0.24	0.05	0.22	69.49
Dec	0.89	0.38	0.03	0.26	143.31

Table 5- 8 Characteristics of the trends from the current time series of rainfall (1991-2020) by month in Blantyre ADD, significant changes are presented in bold.

Month	Slope (mm/year)	P-Value	R^2	NRME	Mean 1991-2020 (mm)
Jan	-1.32	0.26	0.05	0.20	298.59
Feb	0.11	0.91	0.00	0.22	213.49
Mar	0.14	0.89	0.00	0.27	162.02
Apr	0.66	0.11	0.09	0.21	55.31
May	-0.20	0.14	0.08	0.23	23.14
Jun	-0.06	0.40	0.03	0.32	17.25
Jul	0.16	0.14	0.08	0.22	20.36
Aug	-0.04	0.65	0.01	0.24	12.98
Sep	**-0.21**	**0.02**	**0.19**	**0.26**	**15.24**
Oct	**-0.62**	**0.07**	**0.12**	**0.24**	**36.09**
Nov	-0.34	0.36	0.03	0.24	78.23
Dec	1.17	0.23	0.05	0.22	197.58

5.1.1.3 Annual Rainfall

The annual summary of rainfall is presented in Fig 5-3 and the characteristics in Tab 5-9. The Northern Mzuzu ADD has the lowest rainfall amounts which are around 600 mm, while the highest is around 1300 mm in Salima ADD. The trend is generally positive in many ADDs except the southernmost ones of

Blantyre and Shire Valley ADD which have negative trend, Tab 5-9. Though the significant positive trends are observed in Mzuzu and Kasungu ADD.

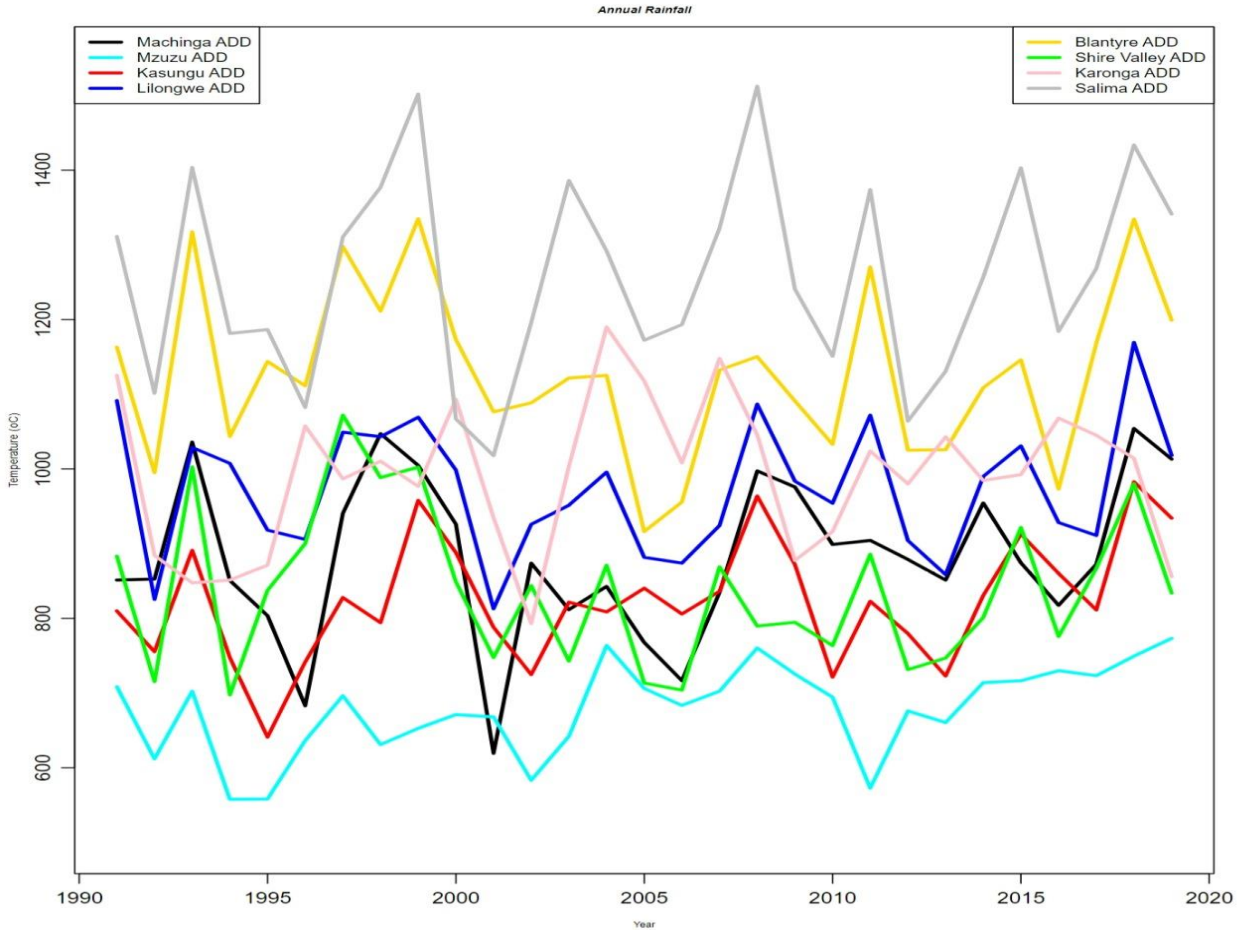

Figure 5- 3 Current annual rainfall in eight ADDs

Table 5- 9 Characteristics of the trends from the current time series (1991-2020) of annual rainfall in eight target ADDs (linear models), significant changes are presented in bold.

ADD	Slope (mm/year)	P-Value	R^2	NRME	Mean 1991-2020 (mm)
Machinga	2.36	0.33	0.04	0.24	881.11
Mzuzu	**3.74**	**0**	**0.28**	**0.23**	**678.22**
Karonga	1.72	0.44	0.02	0.24	991.17
Kasungu	**3.44**	**0.05**	**0.13**	**0.22**	**823.84**
Salima	2.22	0.47	0.02	0.26	1257.31
Lilongwe	0.66	0.74	0	0.24	972.67
Blantyre	-1.05	0.68	0.01	0.26	1128.66
Shire Valley	-1.72	0.46	0.02	0.26	838.91

5.1.2 Rainfall Projections

5.1.2.1 Monthly Rainfall

5.1.2.1.1 Karonga ADD

The rainfall pattern for SSP2.45 and SSP5.85 are similar. They both showing a positive increase during the rainfall season and a decrease during the drier season. This indicates the higher chances of having shorter rainfall seasons in the future. The rainfall increase is positive and significant from January to February for SSP2.45 and January to March for SSP5.85 respectively, Fig 5-4 and Tab 5-10.

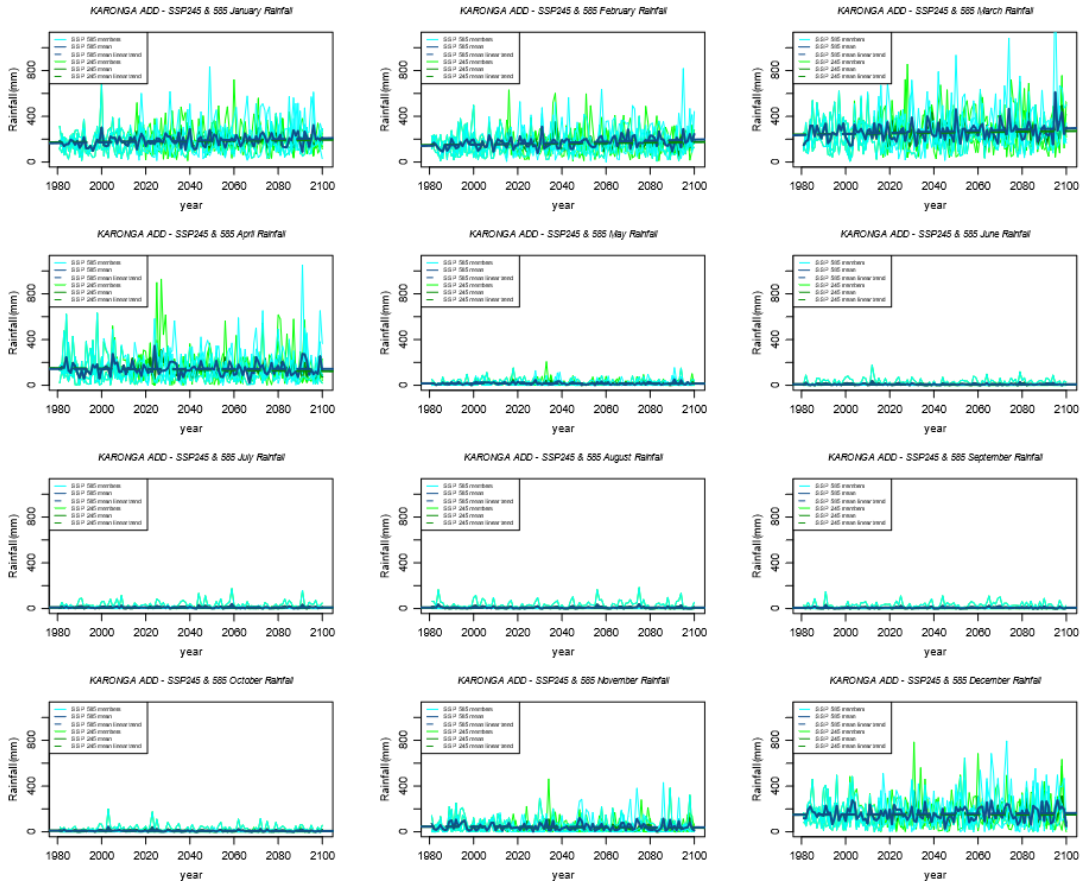

Figure 5- 4 Monthly rainfall projections in Karonga ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 10 Characteristics of the trends from the projected rainfall time series by month in Karonga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Karonga ADD SSP2.45							
Month	**Slope (mm/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.18	0.1	0.02	0.19	122.9 (99 - 133.5)	194.8 (145.4 - 232.6)	191.6 (174.9 - 245)

Feb	0.21	0.1	0.03	0.15	103.6 (83.6 - 118.3)	161.1 (112.8 - 178)	162.2 (143 - 177.2)
Mar	0.25	0.2	0.02	0.19	165.8 (112 - 188.6)	259.5 (178.1 - 296.5)	261.5 (176.9 - 324.9)
Apr	-0.21	0.1	0.02	0.21	109.4 (63.4 - 155)	121.8 (82 - 158.3)	130.8 (67.7 - 178.2)
May	-0.01	0.6	0	0.22	12.9 (4.3 - 31.9)	15.4 (9.9 - 25.6)	16.8 (10.9 - 29.7)
Jun	-0.01	0.5	0	0.16	6.7 (1.9 - 24.9)	6.6 (0.8 - 26.4)	8.4 (0.9 - 36.1)
Jul	0	0.8	0	0.18	5.6 (1.3 - 20.1)	10.6 (1.8 - 42.3)	8.2 (1.3 - 33.3)
Aug	0	0.8	0	0.19	4.5 (0.2 - 19.6)	8 (0 - 38.6)	9.8 (0 - 47.7)
Sep	0	0.9	0	0.18	4.5 (0 - 20.5)	6.6 (0 - 31.5)	7.9 (0.1 - 38.1)
Oct	-0.03	0.1	0.02	0.16	8 (1.4 - 27.6)	7.3 (1.1 - 29.6)	8.1 (0.9 - 34.3)
Nov	-0.08	0.2	0.01	0.22	26.4 (18.6 - 48.6)	39.3 (16.7 - 63.8)	39.2 (23.9 - 66.2)
Dec	0.01	1.0	0	0.19	95.6 (80.4 - 106.9)	149.2 (122.5 - 177)	152 (133.7 - 171.7)
Karonga ADD SSP5.85							
Month	**Slope (mm/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.35	0.0	0.07	0.19	124.3 (99 - 137.5)	184.7 (145.4 - 229.2)	197.3 (159.4 - 237.1)
Feb	0.45	0.0	0.12	0.18	103.2 (83.6 - 114.4)	161.5 (112.8 - 180)	179.2 (143 - 198.9)

Mar	0.49	0.0	0.05	0.15	173.5 (112 - 211.4)	262.5 (178.1 - 335.8)	272.4 (176.9 - 335.5)
Apr	0	1.0	0	0.16	96.6 (63.4 - 101.4)	143.4 (82 - 181.5)	136.1 (67.7 - 204)
May	-0.01	0.7	0	0.19	12.5 (4.3 - 31.9)	15.8 (8.7 - 25.6)	14 (4.9 - 29.7)
Jun	-0.01	0.7	0	0.17	6.7 (0.9 - 24.9)	7.1 (0.8 - 26.4)	8.2 (0.6 - 36.1)
Jul	0	0.8	0	0.17	6.2 (1.7 - 20.1)	10.6 (1.3 - 42.3)	8.1 (0.7 - 33.3)
Aug	0	0.9	0	0.19	4 (0.1 - 19.6)	8.2 (0 - 38.6)	9.9 (0.1 - 47.7)
Sep	0.01	0.7	0	0.18	4.4 (0.1 - 20.5)	6.7 (0.1 - 31.5)	8 (0.1 - 38.1)
Oct	-0.02	0.2	0.02	0.15	6.4 (0.1 - 27.6)	7.3 (1.3 - 29.6)	7.8 (0.6 - 34.3)
Nov	-0.05	0.5	0	0.25	26.8 (16.1 - 48.6)	42.2 (29.6 - 63.8)	42.3 (20.5 - 66.2)
Dec	0.12	0.4	0.01	0.23	105.4 (80.4 - 120.1)	143.3 (118.4 - 160.9)	165.2 (101.3 - 233.8)

5.1.2.1.2 Mzuzu ADD

Like the Karonga ADD, Mzuzu ADD have also both scenarios behaving alike. They both showing a positive increase during the rainfall season and a decrease during the drier season. This indicates the higher chances of having shorter rainfall seasons in the future. The rainfall increase is positive and significant from January to March for both scenarios and again significantly negative in May, August, September, October and November, Fig 5-5 and Tab 5-11.

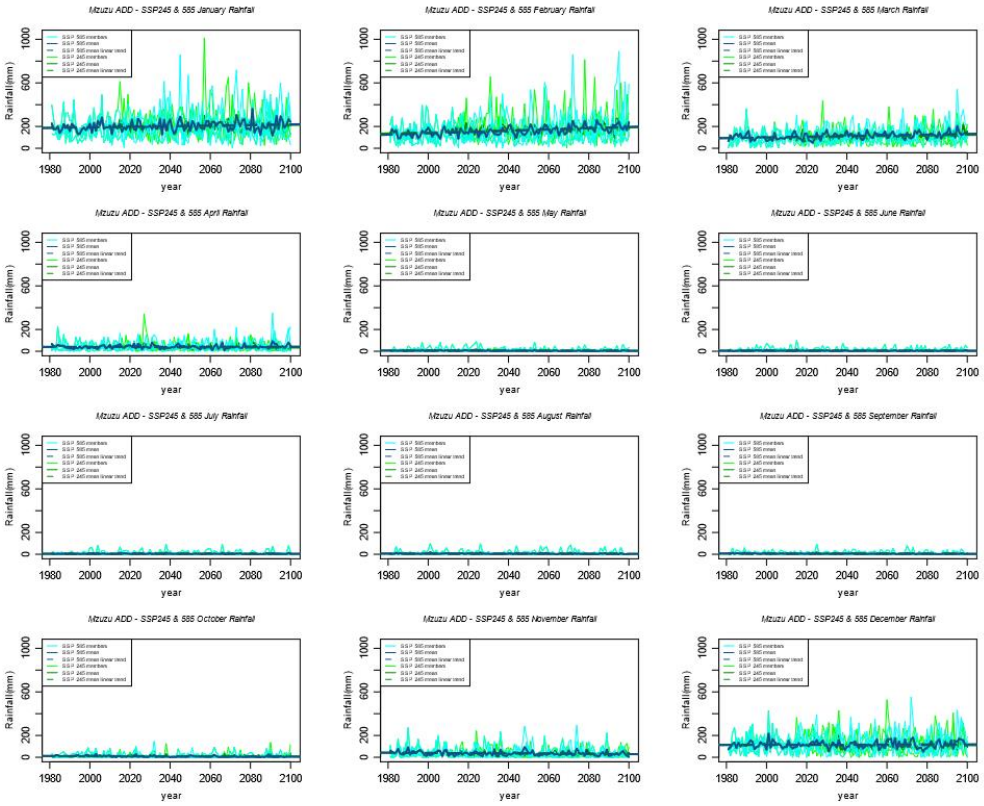

Figure 5- 5 Monthly rainfall projections in Mzuzu ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 11 Characteristics of the trends from the projected rainfall time series by month in Mzuzu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Mzuzu ADD SSP2.45							
Month	**Slope (mm/year)**	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.217931	0.026142	0.041224	0.217802	131.7 (112.7 - 155.7)	206.1 (132.3 - 256.6)	210.8 (159.1 - 293.6)
Feb	0.457893	6.29E-06	0.159355	0.185423	97.4 (69.2 - 113.8)	149.7 (88.3 - 183)	153.2 (105.6 - 186.6)
Mar	0.241999	0.001166	0.085815	0.170759	68.3 (48.2 - 92.7)	106.6 (80.8 - 142)	108.7 (84.1 - 149.2)
Apr	-0.05103	0.206363	0.013497	0.212526	28.5 (22.3 - 43.9)	37.9 (23.3 - 50.5)	37.3 (30.8 - 48)

May	-0.0184	0.03294	0.037973	0.235753	4 (0.5 - 22.2)	4.6 (1.4 - 19.4)	4.6 (1.4 - 19.6)
Jun	-0.00461	0.559987	0.002887	0.199081	3.3 (0.6 - 17.4)	4 (0.6 - 21)	3.9 (0.6 - 22.4)
Jul	-0.00342	0.663733	0.001607	0.204313	2.9 (0.5 - 14.1)	4.3 (0.8 - 22.3)	3.6 (0.7 - 21.5)
Aug	-0.01794	0.040761	0.034997	0.200233	3.6 (0.9 - 15.8)	4.3 (0.2 - 23.6)	4.5 (0.1 - 26.1)
Sep	-0.02565	0.000688	0.093388	0.16985	3.4 (0.7 - 13.2)	4.3 (0.4 - 22)	4.1 (0.4 - 23.3)
Oct	-0.03541	0.057477	0.030245	0.221025	6.8 (3.2 - 13.3)	7.1 (2.8 - 19.5)	8.6 (3.1 - 26.6)
Nov	-0.10288	0.02377	0.042567	0.191719	21.3 (11.5 - 41)	33.2 (15.9 - 52.5)	31.5 (18.9 - 55.6)
Dec	-0.03562	0.647401	0.001779	0.184572	77.9 (54.4 - 102)	105.4 (79.1 - 137.7)	104.2 (81.1 - 142)

Mzuzu ADD SSP5.85							
Month	**Slope (mm/year)**	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.279447	0.014368	0.049718	0.172675	133.5 (112.7 - 147.4)	204.8 (132.3 - 280.3)	213.2 (159.1 - 263.2)
Feb	0.607704	2.61E-11	0.314954	0.182836	91 (69.2 - 105)	142.3 (88.3 - 172.8)	157.6 (105.6 - 190.5)
Mar	0.321775	1.34E-05	0.149	0.170509	72.4 (48.2 - 97.1)	115.2 (80.8 - 151.7)	116 (84.1 - 159.2)
Apr	0.030639	0.458346	0.004669	0.179583	30.4 (20.9 - 38.7)	39.4 (25.4 - 49.4)	37.9 (23.4 - 50.9)

May	-0.02147	0.015245	0.048874	0.23465	4.4 (0.8 - 22.2)	4.3 (1.1 - 19.4)	3.8 (1 - 19.6)
Jun	-0.00462	0.572075	0.002713	0.203242	3.4 (0.8 - 17.4)	4.2 (1.1 - 21)	4 (0.7 - 22.4)
Jul	-0.00491	0.556843	0.002934	0.21549	3.3 (0.9 - 14.1)	4.1 (1 - 22.3)	3.5 (0.3 - 21.5)
Aug	-0.02141	0.016303	0.047918	0.198883	3.4 (0.7 - 15.8)	4.9 (0.1 - 23.6)	4.4 (0.2 - 26.1)
Sep	-0.02395	0.000582	0.0958	0.181153	3.1 (0 - 13.2)	4.1 (0.7 - 22)	4 (0.4 - 23.3)
Oct	-0.05403	0.000679	0.093581	0.18792	5.3 (2.5 - 13.3)	7.1 (1.8 - 19.5)	6.7 (1.7 - 26.6)
Nov	-0.10922	0.03083	0.038902	0.209988	20.3 (10.6 - 41)	34.3 (22.1 - 52.5)	33.2 (17.8 - 55.6)
Dec	0.060731	0.462878	0.004576	0.187389	78.8 (62.7 - 95.5)	104.7 (71 - 131.7)	108.2 (55.3 - 159.1)

5.1.2.1.3 Kasungu ADD

Kasungu ADD has many months with negative trends for rainfall except January and February for SSP2.45. Significant negative trends are noticed for June, September and November. For SSP5.85, the positive

trends are from December to March but significant ones for January and February, while significant negative trends are again noticed in June, September and November, Fig 5-6 and Tab 5-12.

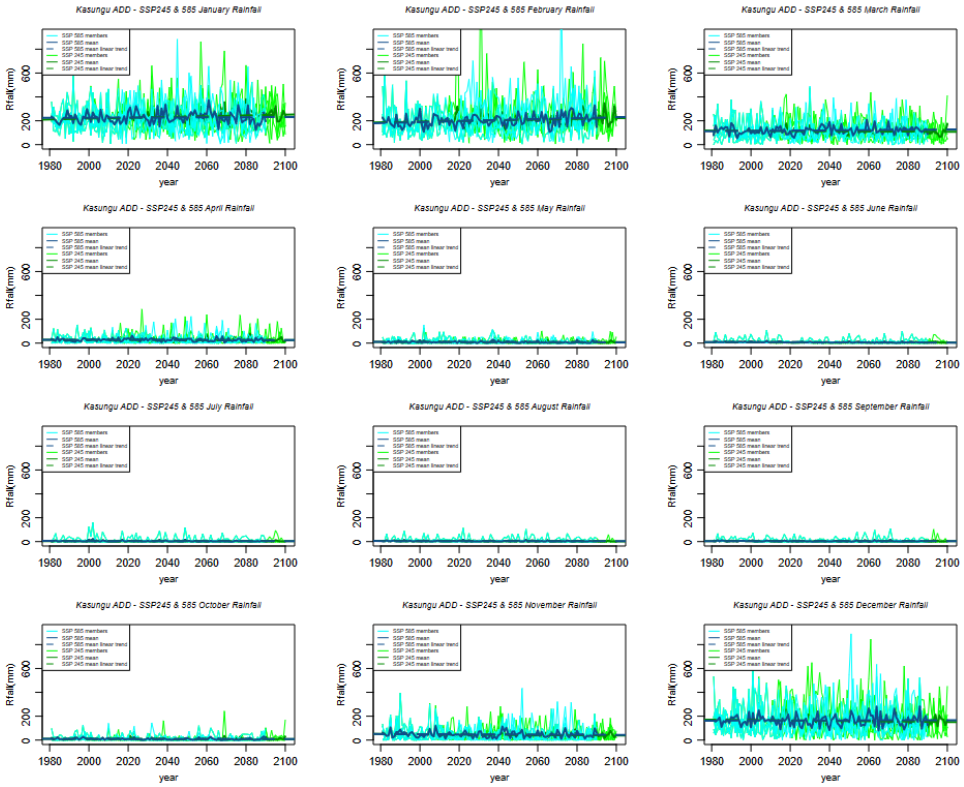

Figure 5- 6 Monthly rainfall projections in Kasungu ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 12 Characteristics of the trends from the projected rainfall time series by month Kasungu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

KASUNGU ADD SSP2.45							
Month	**slope**	**p-value**	**R^2**	**NRMSE**	**Range 2040(mm)**	**Range 2060(mm)**	**Range 2080(mm)**
Jan	0.335	0.004	0.068	0.184	144.111 (131.673 - 157.190)	225.577 (154.845 - 249.531)	234.648 (167.342 - 317.184)
Feb	0.295	0.02	0.045	0.195	128.933 (83.55 - 157.115)	191.802 (132.790 - 224.704)	191.044 (135.101 - 212.200)
Mar	-0.078	0.303	0.009	0.224	78.737 (45.534 - 117.244)	113.566 (88.339 - 129.101)	111.474 (75.995 - 129.383)
Apr	-0.005	0.889	0	0.169	19.774 (11.514 - 32.833)	25.338 (11.599 - 37.358)	25.720 (16.605 - 36.810)

May	-0.023	0.174	0.016	0.253	5.870 (2.485 - 18.114)	8.88708 (4.0263 - 30.036)	7.206 (3.768 - 19.909)
Jun	-0.031	0	0.113	0.186	4.338 (0.194 - 14.575)	6.267 (0.263 - 23.640)	5.5763 (0.289 - 25.499)
Jul	-0.01	0.278	0.01	0.174	2.5 (0.103 - 15.886)	3.848 (0.424 - 25.777)	3.377 (0.081 - 23.540)
Aug	-0.02	0.012	0.052	0.201	3.014 (0.290 - 16.096)	4.005 (0.112 - 24.879)	3.722 (0.094 - 24.315)
Sep	-0.014	0.016	0.029	0.214	2.446 (0.063 - 14.572)	3.377 (0.199 - 20.046)	3.888 (0.244 - 27.226)
Oct	-0.008	0.666	0.002	0.207	6.444 (2.408 - 16.499)	7.392 (2.786 - 23.280)	9.876 (2.311 - 31.541)
Nov	-0.102	0.051	0.032	0.185	28.812 (21.101 - 43.868)	43.612 (22.446 - 64.976)	42.535 (28.452 - 68.392)
Dec	-0.156	0.126	0.02	0.211	113.853 (74.434 - 153.539)	158.762 (126.048 - 206.539)	157.139 (119.011 - 197.677)
KASUNGU ADD SSP5.85							
Month	**slope**	**p-value**	**R^2**	**NRMSE**	**Range 2040(mm)**	**Range 2060(mm)**	**Range 2080(mm)**
Jan	0.54	0.704	0.001	0.186	150.794 (131.673 - 170.820)	235.580 (154.845 - 287.929)	240.461 (167.342 - 301.859)
Feb	0.412	0.003	0.081	0.198	124.3749 (83.55 - 151.936)	192.567 (132.790 - 229.213)	199.559 (135.101 - 243.840)
Mar	0.116	0.2	0.015	0.193	74.995 (45.534 - 92.663)	126.493 (88.339 - 151.670)	122.962 (75.995 - 141.949)
Apr	-0.023	0.51	0.004	0.207	20.566 (11.897 - 34.578)	26.956 (16.241 - 36.645)	24.563 (10.264 - 36.789)
May	-0.024	0.222	0.014	0.225	5.183 (1.713 - 18.114)	9.698 (5.469 - 30.036)	6.792 (1.997 - 19.909)
Jun	-0.039	0	0.145	0.187	4.726 (0.183 - 14.575)	6.0389 (0.476 - 23.640)	5.3286 (0.272 - 25.499)
Jul	-0.015	0.161	0.018	0.173	2.826 (0.318 - 15.886)	3.969 (0.139 - 25.777)	3.393 (0.129 - 23.540)

Aug	-0.013	0.156	0.019	0.203	2.701 (0.072 - 16.096)	4.438 (0.047 - 24.879)	3.926 (0.161 - 24.315)
Sep	-0.014	0.1	0.025	0.195	2.469 (0.093 - 14.572)	2.859 (0.254 - 20.046)	3.902 (0.018 - 27.226)
Oct	-0.023	0.242	0.013	0.219	5.606 (1.833 - 16.499)	7.795 (2.573 - 23.280)	7.181 (1.432 - 31.541)
Nov	-0.1055	0.445	0.005	0.217	30.045 (15.041 - 43.868)	46.618 (32.794 - 55.773)	45.719 (30.788 - 65.778)
Dec	0.028	0.834	0	0.218	103.158 (86.558 - 121.044)	164.439 (128.472 - 223.742)	169.599 (122.724 - 235.398)

5.1.2.1.4 Lilongwe ADD

The analysis of annual precipitation trends in Lilongwe ADD reveals varying patterns and statistically significant changes in different months under different scenarios. Under the SSP 2.45 scenario, the month of February shows a statistically significant positive trend in precipitation, with a slope of 0.271 mm/year (p-value = 0.021). November exhibits a statistically significant negative trend in precipitation, with a slope of -0.194 mm/year (p-value = 0.002). The remaining months (January, March, April, May, June, July, August, September, October, and December) do not show statistically significant trends in precipitation, Fig 5-7, Tab 5-13.

Under the SSP 5.85 scenario, the month of March displays a statistically significant positive trend in precipitation, with a slope of 0.264 mm/year (p-value = 0.016). September, October and November also demonstrates a statistically significant negative trend in precipitation. The remaining months (January, February, April, May, June, July, August, and December) do not exhibit statistically significant trends in precipitation, Fig 5-7, Tab 5-13.

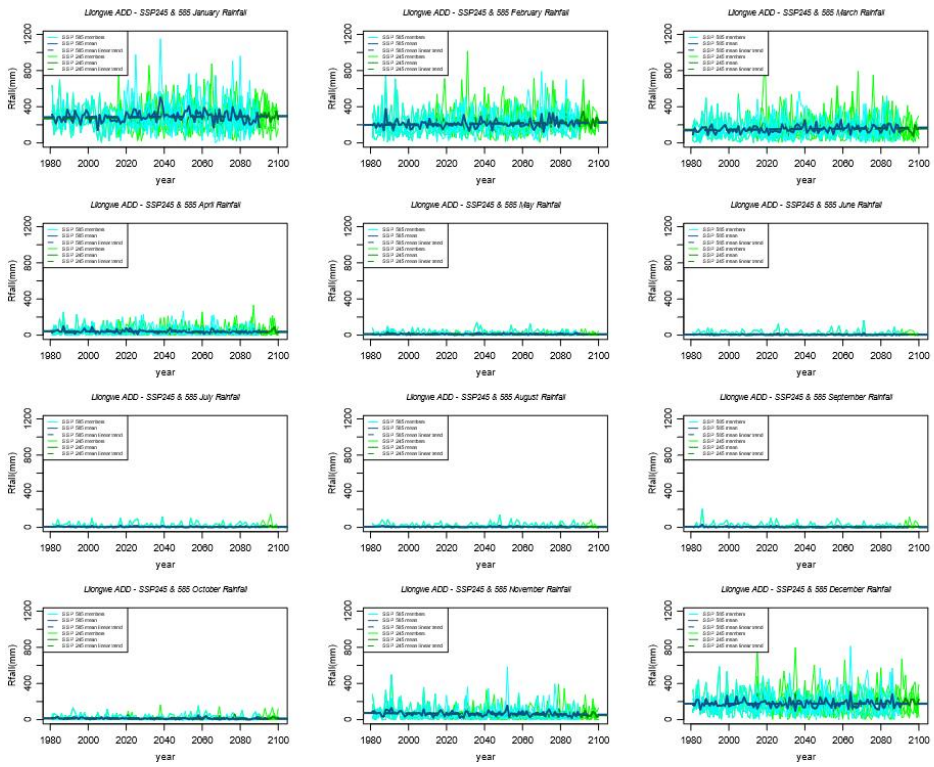

Figure 5- 7 Monthly rainfall projections in Lilongwe ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 13 Characteristics of the trends from the projected rainfall time series by month in Lilongwe ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Lilongwe ADD SSP2.45							
Month	**Slope (mm/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.216	0.103	0.103	0.179	174.2 (143.2 - 193.3)	287.8 (236.5 - 328.2)	283.1 (218.2 - 338.4)
Feb	0.271	0.021	0.021	0.174	141.1 (103 - 162.1)	206.5 (139.3 - 251.2)	216 (162.9 - 237.9)
Mar	0.094	0.364	0.364	0.169	105.7 (62.8 - 151.9)	150.2 (102 - 187.8)	159.9 (107.3 - 239.5)
Apr	-0.019	0.682	0.682	0.196	28.9 (20.6 - 41)	38.9 (25.9 - 55)	40.3 (26.8 - 51.3)
May	-0.022	0.138	0.138	0.174	6.6 (1.9 - 20.4)	10.8 (5.2 - 40.5)	10.4 (3.7 - 37.1)

Jun	-0.003	0.76	0.76	0.177	4.1 (0.5 - 24.1)	5.9 (0.9 - 27.8)	5.6 (0.7 - 30.3)
Jul	-0.008	0.426	0.426	0.207	4.8 (0.5 - 22.3)	6.2 (1.6 - 30.4)	5.8 (1.1 - 29.8)
Aug	-0.015	0.116	0.116	0.198	3.4 (0.9 - 16.1)	6.2 (1 - 33.7)	6.1 (0.8 - 32.6)
Sep	-0.022	0.039	0.039	0.138	3.4 (0.2 - 19.1)	4.5 (0.2 - 27.2)	4.4 (0.7 - 27.9)
Oct	-0.015	0.508	0.508	0.161	9 (1.9 - 16.8)	11.8 (4.9 - 31.4)	14.2 (4.9 - 37)
Nov	-0.194	0.002	0.002	0.211	39.2 (28.5 - 57.2)	59.5 (40.4 - 83.9)	58.4 (36.5 - 90.2)
Dec	0.01	0.923	0.923	0.202	120.5 (83.1 - 158.7)	171.3 (134.8 - 206.8)	172 (126.6 - 237.1)
Lilongwe ADD SSP5.85							
Month	**Slope (mm/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.082	0.646	0.002	0.16	188.4 (163.5 - 221.6)	316.3 (236.5 - 393.3)	309.2 (218.2 - 404.9)
Feb	0.18	0.166	0.018	0.167	136.3 (103 - 152.6)	214.4 (139.3 - 236)	210.9 (162.9 - 260.2)
Mar	0.264	0.016	0.052	0.211	96.3 (62.8 - 112.6)	159.7 (102 - 202)	157.9 (107.3 - 192.6)
Apr	-0.085	0.079	0.028	0.175	29.5 (19.5 - 40.4)	39 (25.3 - 48.2)	34.3 (21.2 - 43.1)
May	-0.008	0.688	0.002	0.19	6.3 (1.8 - 20.4)	11 (4.8 - 40.5)	9.7 (2.7 - 37.1)
Jun	-0.013	0.27	0.011	0.162	4.8 (0.6 - 24.1)	5.3 (0.7 - 27.8)	5.6 (0.5 - 30.3)
Jul	-0.014	0.216	0.014	0.193	5 (1.1 - 22.3)	6.3 (0.8 - 30.4)	5.6 (0.9 - 29.8)
Aug	-0.014	0.198	0.015	0.203	3.5 (0.8 - 16.1)	6.6 (1.2 - 33.7)	6.1 (1.1 - 32.6)

Sep	-0.029	0.011	0.058	0.128	3.4 (0.2 - 19.1)	4.3 (0.7 - 27.2)	4.4 (0.5 - 27.9)
Oct	-0.048	0.039	0.039	0.176	7.7 (3.5 - 16.8)	11.3 (2.8 - 31.4)	11.6 (2.2 - 37)
Nov	-0.145	0.053	0.034	0.176	41.3 (24.3 - 57.2)	66.5 (50.5 - 92.4)	67.8 (45.2 - 91.7)
Dec	-0.017	0.889	0	0.184	113.2 (97 - 135.6)	175.5 (142.1 - 221.7)	176.2 (136.4 - 228.3)

5.1.2.1.5 Salima ADD

Rainfall distribution over Salima shows that the months from December to April are the wet months with most of the rainfall falling between January and March. The analysis of monthly records indicate that January and March will be receiving more rains followed by December and February. Although the months of May to November may receive some rains, more rains are shown to be experienced in the far future as shown by Figure.5-8.

The trend analysis indicates positive trend during the rainfall season and negative trend during drier months. The significant positive trend is only in February for SSP5.85 and significant negative trend is in the month of November for SSP2.45, Tab 5-14.

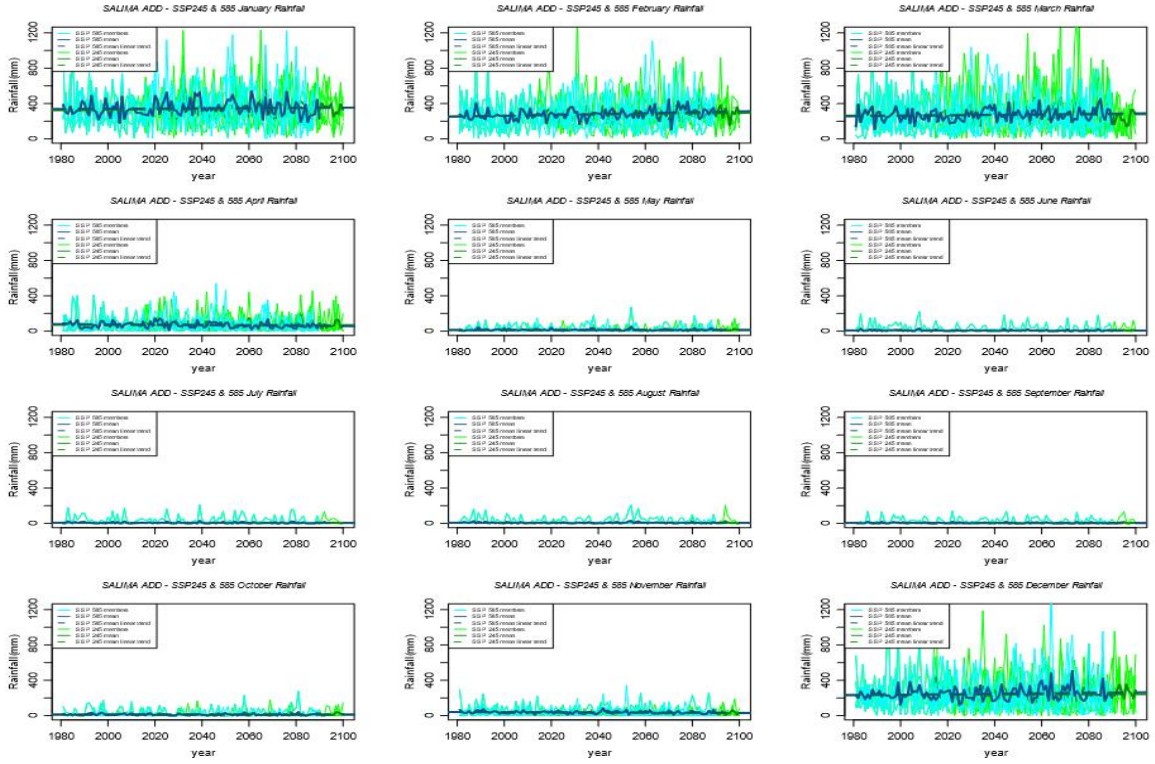

Figure 5- 6 Monthly rainfall projections in Salima ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 14 Characteristics of the trends from the projected rainfall time series by month in Salima ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Salima ADD SSP2.45							
Month	**slope**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.227	0.234	0.012	0.160	211.1 (179.4 - 223.3)	343.5 (281.4 - 378.8)	339.5 (270.8 - 377.4)
Feb	0.307	0.033	0.038	0.183	182.3 (139.9 - 205.5)	270.9 (178.4 - 313.4)	273.7 (204.7 - 298.9)
Mar	0.117	0.547	0.003	0.202	180.3 (104.5 - 252.7)	273.1 (202.8 - 322.2)	289.8 (167.5 - 421.6)
Apr	-0.019	0.813	0.000	0.187	51.6 (41.3 - 66.8)	68.5 (42.2 - 92.2)	65.2 (50.9 - 83.2)
May	0.000	0.995	0.000	0.202	7.8 (3.6 - 23.9)	14.4 (4.7 - 54.1)	12.6 (4.3 - 45.8)
Jun	-0.013	0.420	0.006	0.213	3.8 (0.4 - 23.2)	7 (0.4 - 44.7)	6.2 (0.4 - 40.1)
Jul	-0.016	0.306	0.009	0.218	4.4 (0.3 - 28.3)	6.6 (0.6 - 46.2)	6.8 (0.3 - 49.1)
Aug	-0.011	0.473	0.004	0.209	3.7 (0.4 - 20.5)	8.4 (0.4 - 56)	8.8 (0.6 - 58.6)
Sep	-0.007	0.529	0.003	0.233	3.3 (0 - 21.5)	5.4 (0 - 40)	4.7 (0.2 - 34.2)
Oct	0.005	0.837	0.000	0.246	7.1 (0.7 - 25.1)	11.3 (3.7 - 39.5)	13.7 (5.4 - 45.7)
Nov	-0.104	0.005	0.066	0.208	22.1 (13.8 - 44.5)	34.4 (17.9 - 71.4)	31.9 (15.4 - 72.8)
Dec	0.081	0.621	0.002	0.159	156.9 (118.3 - 209.1)	232.9 (210.5 - 286)	235.9 (191.2 - 277.9)
Salima ADD SSP5.85							

Month	slope	P-value	R^2	NRMSE	Mean, Range 2040 (mm)	Mean, Range 2060 (mm)	Mean, Range 2080 (mm)
Jan	0.118	0.637	0.002	0.229	228.5 (190.6 - 288.9)	370.4 (281.4 - 441.8)	372.3 (270.8 - 444.1)
Feb	0.500	0.003	0.077	0.160	189 (139.9 - 197.7)	281.3 (178.4 - 345.9)	292.5 (204.7 - 335.4)
Mar	0.287	0.162	0.018	0.195	165.5 (104.5 - 202.6)	289.8 (202.8 - 339.2)	271.8 (167.5 - 320.6)
Apr	-0.202	0.026	0.045	0.221	54.9 (42.2 - 67.4)	68.1 (50.6 - 82.5)	55.2 (29.5 - 69.4)
May	0.003	0.926	0.000	0.183	8.4 (3.3 - 23.9)	14.6 (7 - 54.1)	12.2 (3.3 - 45.8)
Jun	-0.024	0.191	0.016	0.216	4.3 (0.4 - 23.2)	7 (0.4 - 44.7)	6.2 (0.2 - 40.1)
Jul	-0.015	0.398	0.007	0.219	4.8 (0.6 - 28.3)	6.7 (0.3 - 46.2)	7 (0.2 - 49.1)
Aug	-0.011	0.482	0.005	0.205	3.7 (0.7 - 20.5)	8.6 (0.6 - 56)	8.8 (0.8 - 58.6)
Sep	-0.008	0.525	0.004	0.225	3.3 (0.1 - 21.5)	5.5 (0.2 - 40)	4.8 (0.1 - 34.2)
Oct	-0.005	0.858	0.000	0.243	6.7 (0.8 - 25.1)	11 (3.7 - 39.5)	11 (2.1 - 45.7)
Nov	-0.072	0.112	0.023	0.191	24.2 (11.4 - 44.5)	37.7 (22.1 - 71.4)	35.1 (19.1 - 72.8)
Dec	0.262	0.221	0.014	0.180	152.7 (133.4 - 187)	250.3 (224.5 - 339.7)	270.1 (221.1 - 367.8)

5.1.2.1.6 Shire Valley ADD

Rainfall distribution over Salima shows that the months from November to April are the wet months with most of the rainfall falling between december and March. The analysis of monthly records indicate that December to February will be receiving more rains. Although the months of May to November may receive some rains, less are shown to be experienced in the far future as shown by Figure.5-9.

The trend analysis indicates positive trend during the rainfall season and negative trend during drier months. The significant positive trend is only in December for SSP5.85 and significant negative trend is in the months of October and November for SSP2.45, Tab 5-15.

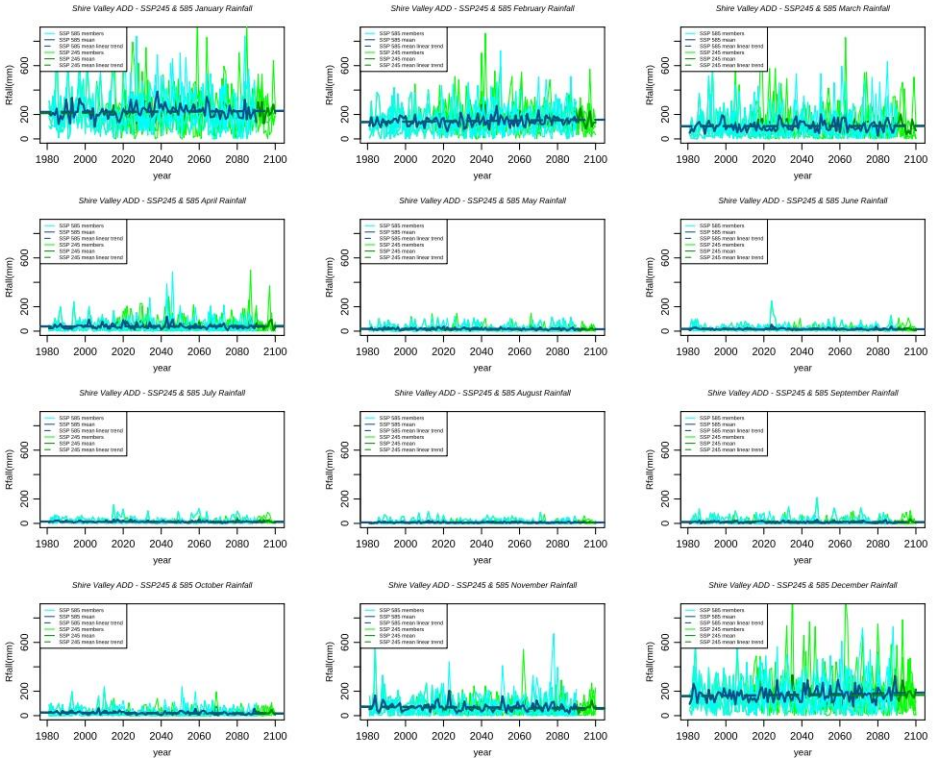

Figure 5- 7 Monthly rainfall projections in Shire Valley ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 15 Characteristics of the trends from the projected rainfall time series by month in Shire Valley ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Shire Valley ADD SSP2.45							
Month	**Slope (mm/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.1582	0.2393	0.0117	0.1991	209.1 (126.5 - 280.1)	220.1 (176.9 - 248.6)	225.5 (160.1 - 274.4)
Feb	0.1454	0.1926	0.0143	0.1818	149.9 (106.8 - 195)	155.0 (117.2 - 195.7)	151.6 (131.7 - 189.8)
Mar	-0.0079	0.9338	0.0001	0.2077	108.4 (59.8 - 161.9)	99.9 (65.2 - 121.4)	106.2 (73.1 - 152.1)

Apr	0.0509	0.3018	0.009	0.1827	42.9 (35.4 - 59.4)	38.4 (27.3 - 53.8)	40.6 (29.6 - 56.3)
May	-0.0252	0.1822	0.015	0.2111	17.7 (9.5 - 38.9)	16.4 (11.6 - 36.2)	15.6 (8.7 - 35.4)
Jun	-0.0194	0.258	0.0108	0.1474	17.8 (10.3 - 37.9)	15.3 (10.5 - 26.3)	15.4 (10 - 32.1)
Jul	0.0031	0.8297	0.0004	0.1832	13.8 (8.8 - 33.8)	12.8 (9.7 - 29.9)	14.6 (10 - 35.2)
Aug	-0.0038	0.7395	0.0009	0.2088	7.4 (3.2 - 21.7)	8.3 (3.7 - 28)	7.4 (3.6 - 19.2)
Sep	-0.008	0.6565	0.0017	0.1963	10.5 (6.5 - 26.9)	10.4 (3.4 - 36.5)	10.6 (4.8 - 35.4)
Oct	-0.0498	0.0863	0.0247	0.1724	20.5 (10.4 - 29.4)	19.4 (11.8 - 29.4)	21.1 (9.9 - 42.1)
Nov	-0.1343	0.051	0.0319	0.1651	62.6 (52.3 - 77.1)	58.1 (41.7 - 73)	58.2 (31.6 - 77.9)
Dec	0.0632	0.5942	0.0024	0.1754	168.3 (142.3 - 206.3)	164.1 (116.8 - 206.3)	162.3 (104 - 247.4)
Shire Valley ADD SSP5.85							
Month	**Slope (mm/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.0533	0.7295	0.0011	0.176	232.4 (169.3 - 272.9)	249.4 (177.9 - 328)	227.1 (160.1 - 317.3)
Feb	0.1597	0.1461	0.0195	0.1717	142.1 (111.4 - 158.1)	149.7 (125.7 - 190.3)	150.7 (116.3 - 185.1)
Mar	0.0476	0.6828	0.0016	0.217	103.5 (77.9 - 128.5)	110.5 (85.8 - 145)	105.2 (73.1 - 138)
Apr	-0.0212	0.7124	0.0013	0.1708	40.2 (26.4 - 52.7)	40.6 (32.4 - 52.3)	35.1 (28 - 44)
May	-0.0199	0.3997	0.0066	0.2288	18.6 (13 - 38.9)	17.3 (12.1 - 36.2)	16.2 (7 - 35.4)
Jun	-0.0197	0.3522	0.008	0.1514	18.4 (10.7 - 37.9)	15.9 (9.6 - 29.1)	16.4 (9.4 - 32.1)
Jul	-0.0357	0.0397	0.0386	0.1885	15.6 (9.2 - 33.8)	12.9 (6.9 - 29.9)	12.0 (7.5 - 35.2)
Aug	-0.0011	0.9267	0.0001	0.2086	7.5 (3 - 21.7)	8.0 (3.9 - 28)	7.2 (3 - 19.2)
Sep	-0.0122	0.536	0.0036	0.2374	10.0 (4.6 - 26.9)	10.1 (3.5 - 36.5)	9.9 (2.7 - 35.4)

Oct	-0.0754	0.0314	0.0421	0.1991	19.9 (9.8 - 29.4)	19.7 (10.4 - 31)	20.5 (7 - 36.4)
Nov	-0.0992	0.2933	0.0102	0.1668	70.0 (46.4 - 108.3)	66.1 (44.6 - 95.1)	72.3 (50.6 - 98.4)
Dec	0.2482	0.0983	0.0251	0.1959	159.9 (113 - 204.6)	178.4 (115.7 - 347.7)	176.3 (100.7 - 316.4)

5.1.2.1.7 Machinga ADD

Rainfall distribution over Salima shows that the months from December to April are the wet months with most of the rainfall falling between January and March. The analysis of monthly records indicate that January and March will be receiving more rains followed by December and February. Although the months of May to November may receive some rains, more rains are shown to be experienced in the far future as shown by Figure.5-10

The trend analysis indicates positive trend during the rainfall season and negative trend during drier months. The significant positive trend is only in February for SSP5.85 and significant negative trend is in the month of November for SSP2.45, Tab 5-16.

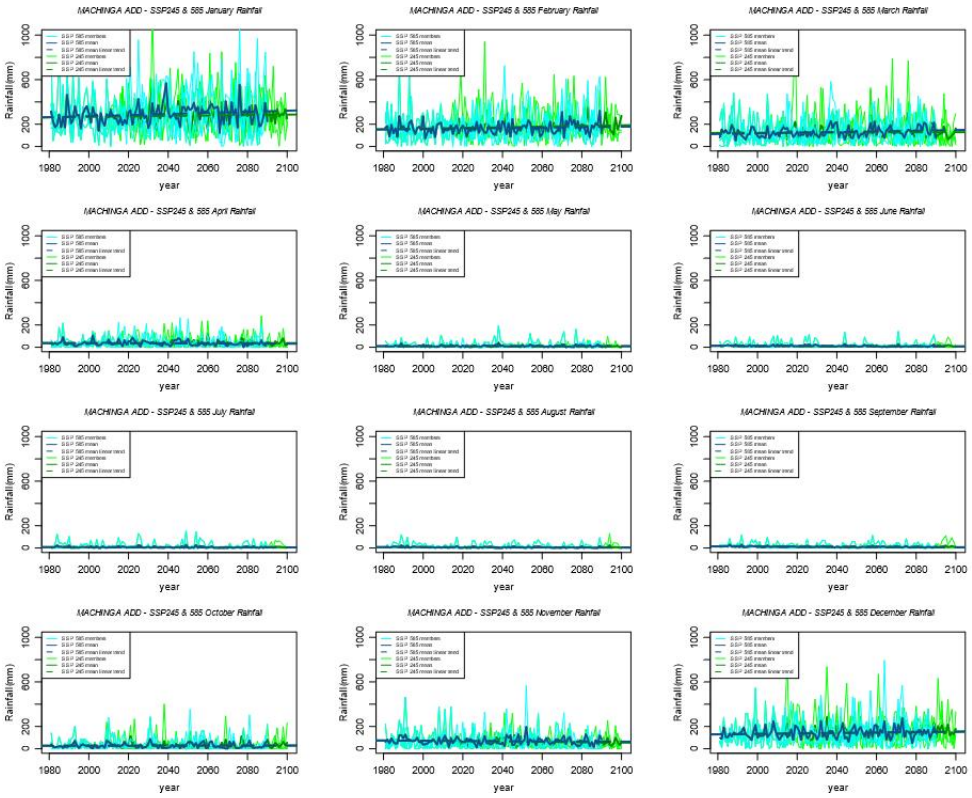

Figure 5- 8 Monthly rainfall projections in Machinga ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 16 Characteristics of the trends from the projected rainfall time series by month in Machinga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Machinga ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	0.203	0.301	0.009	0.183	169 (149.3 - 184.6)	285 (223.5 - 322.7)	268.9 (196.5 - 302.8)
Feb	0.289	0.026	0.041	0.176	112.7 (83.7 - 132.4)	164.5 (126.6 - 197.9)	164.2 (139.4 - 189.6)
Mar	0.054	0.658	0.002	0.182	87 (50.8 - 123.4)	123.9 (83.5 - 148.6)	131 (92.2 - 196.5)
Apr	0.019	0.706	0.001	0.184	24.2 (17.7 - 28.6)	40.2 (29.6 - 52.0)	36.9 (26.3 - 45.1)
May	-0.008	0.682	0.001	0.169	4.9 (1.7 - 11.4)	10.7 (3.3 - 39.2)	10.3 (3.6 - 36.1)
Jun	-0.031	0.040	0.035	0.223	8.3 (2.2 - 25.5)	9.7 (0.2 - 21.8)	8.8 (0.2 - 23.3)
Jul	-0.013	0.365	0.007	0.201	5.3 (0.1 - 22.2)	7.2 (0.9 - 30.3)	6.1 (0.2 - 28.6)
Aug	-0.026	0.034	0.037	0.187	3.6 (0.2 - 15.9)	6.5 (0.5 - 29.1)	5.5 (0.2 - 24.0)
Sep	-0.052	0.000	0.122	0.176	6.5 (2.5 - 14.7)	9.9 (0.2 - 31.1)	9.3 (0.8 - 31.1)
Oct	0.013	0.821	0.000	0.200	21.6 (11.3 - 27.5)	30.4 (16.7 - 54.1)	31 (18.2 - 50.8)
Nov	-0.171	0.015	0.049	0.232	41.8 (26.4 - 61.1)	70.6 (57.2 - 82.9)	62.4 (35.1 - 83.6)
Dec	0.179	0.119	0.020	0.184	90.5 (67.0 - 121.2)	137.5 (113.6 - 166.0)	138.5 (98.4 - 169.6)
Machinga ADD SSP5.85							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	0.487	0.042	0.038	0.175	177.9 (151.9 - 218.5)	321.6 (223.5 - 403.9)	317 (196.5 - 413.3)
Feb	0.207	0.167	0.018	0.197	101.9	166.2	170.6

					(83.7 - 112.0)	(126.6 - 206.0)	(139.4 - 192.5)
Mar	0.301	0.013	0.055	0.226	80 (50.8 - 101.2)	132.9 (100.1 - 172.4)	132.3 (99.2 - 164.5)
Apr	-0.061	0.300	0.010	0.182	28.7 (22.0 - 38.0)	36.1 (29.0 - 42.1)	28.5 (24.4 - 33.5)
May	0.004	0.863	0.000	0.202	5.6 (2.6 - 11.4)	11.7 (3.0 - 39.2)	10.1 (2.4 - 36.1)
Jun	-0.055	0.002	0.083	0.210	9.8 (4.3 - 25.5)	10.1 (4.9 - 21.8)	8.6 (2.9 - 23.3)
Jul	-0.018	0.291	0.010	0.212	5.8 (0.2 - 22.2)	7.2 (0.1 - 30.3)	6.4 (0.1 - 28.6)
Aug	-0.034	0.011	0.058	0.202	3.9 (0.3 - 15.9)	6.9 (0.6 - 29.1)	5.7 (0.4 - 24.0)
Sep	-0.074	0.000	0.206	0.168	7 (1.0 - 14.7)	8.9 (0.8 - 31.1)	9.2 (0.5 - 31.1)
Oct	0.015	0.810	0.001	0.231	18.4 (10.3 - 26.5)	30.4 (20.8 - 54.1)	29.3 (16.9 - 49.4)
Nov	-0.072	0.443	0.005	0.165	44.7 (22.8 - 61.1)	70.9 (57.8 - 91.5)	68.9 (55.0 - 90.0)
Dec	0.211	0.123	0.022	0.199	88.4 (75.9 - 101.8)	146.7 (116.8 - 197.0)	151.5 (116.4 - 204.4)

5.1.2.1.8 Blantyre ADD

The trend of monthly rainfall does not clearly indicate an increase or decrease.

Rainfall distribution in Blantyre ADD shows that the months from December to March are the wet months with highest of the rainfall falling in January, Fig 5-11. The trend analysis generally indicates positive trend during the rainfall season and negative trend during drier months. The significant positive trend is only in February and significant negative trend is in the months of May, June and November for SSP2.45. While for SSp5.85, the significant positive trend is also in February and negative trends in May, Jun, Jul, Aug, September, October and November, Tab 5-17.

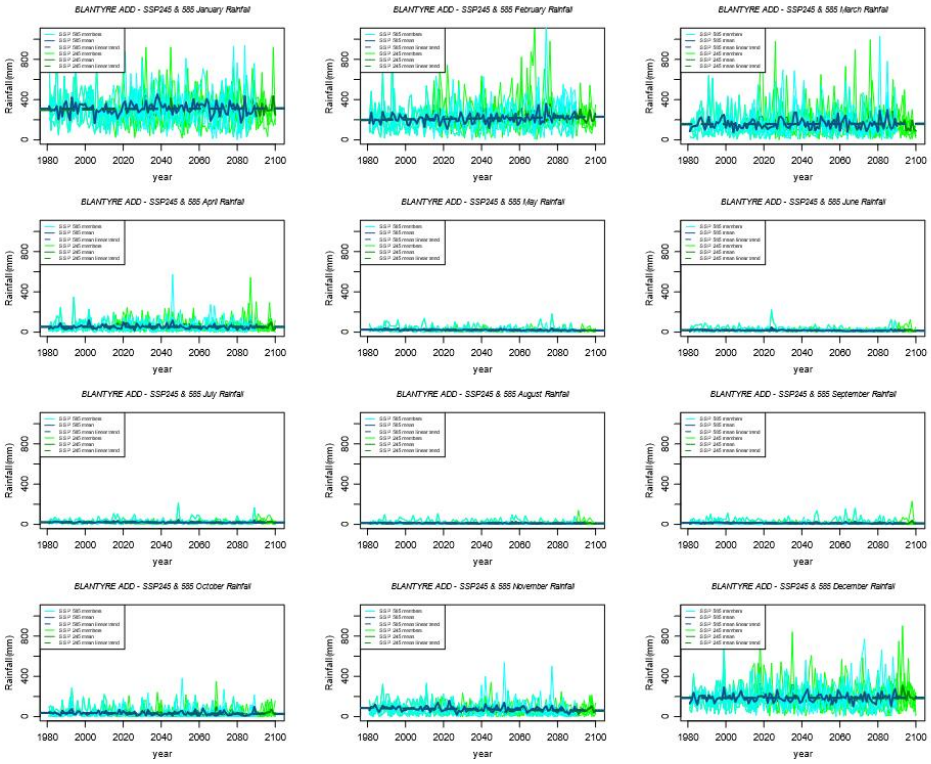

Figure 5- 9 Monthly rainfall projections in Blantyre ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 17 Characteristics of the trends from the projected rainfall time series by month in Blantyre ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Blantyre ADD SSP2.45 Rainfall							
Month	**slope**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	0.165	0.255	0.011	0.190	169 (149.3 - 184.6)	285 (223.5 - 322.7)	268.9 (196.5 - 302.8)
Feb	0.245	0.050	0.032	0.207	112.7 (83.7 - 132.4)	164.5 (126.6 - 197.9)	164.2 (139.4 - 189.6)
Mar	-0.029	0.801	0.001	0.207	87 (50.8 - 123.4)	123.9 (83.5 - 148.6)	131 (92.2 - 196.5)
Apr	0.023	0.639	0.002	0.182	24.2 (17.7 - 28.6)	40.2 (29.6 - 52)	36.9 (26.3 - 45.1)
May	-0.068	0.000	0.173	0.163	4.9 (1.7 - 11.4)	10.7 (3.3 - 39.2)	10.3 (3.6 - 36.1)

Jun	-0.028	0.040	0.035	0.134	8.3 (2.2 - 25.5)	9.7 (0.2 - 21.8)	8.8 (0.2 - 23.3)
Jul	0.000	0.986	0.000	0.152	5.3 (0.1 - 22.2)	7.2 (0.9 - 30.3)	6.1 (0.2 - 28.6)
Aug	-0.019	0.082	0.025	0.200	3.6 (0.2 - 15.9)	6.5 (0.5 - 29.1)	5.5 (0.2 - 24)
Sep	-0.031	0.032	0.038	0.156	6.5 (2.5 - 14.7)	9.9 (0.2 - 31.1)	9.3 (0.8 - 31.1)
Oct	-0.056	0.186	0.015	0.183	21.6 (11.3 - 27.5)	30.4 (16.7 - 54.1)	31 (18.2 - 50.8)
Nov	-0.231	0.000	0.138	0.200	41.8 (26.4 - 61.1)	70.6 (57.2 - 82.9)	62.4 (35.1 - 83.6)
Dec	-0.062	0.546	0.003	0.185	90.5 (67 - 121.2)	137.5 (113.6 - 166)	138.5 (98.4 - 169.9)
Blantyre ADD SSP5.85 Rainfall							
Month	**slope**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Jan	-0.001	0.994	0.000	0.195	177.9 (151.9 - 218.5)	321.6 (223.5 - 403.9)	317 (196.5 - 413.3)
Feb	0.268	0.036	0.040	0.166	101.9 (83.7 - 112)	166.2 (126.6 - 206)	170.6 (139.4 - 192.5)
Mar	0.078	0.597	0.003	0.217	80 (50.8 - 101.2)	132.9 (100.1 - 172.4)	132.3 (99.2 - 164.5)
Apr	-0.027	0.636	0.002	0.185	28.7 (22 - 38)	36.1 (29 - 42.1)	28.5 (24.4 - 33.5)
May	-0.065	0.000	0.121	0.203	5.6 (2.6 - 11.4)	11.7 (3 - 39.2)	10.1 (2.4 - 36.1)
Jun	-0.059	0.000	0.133	0.129	9.8 (4.3 - 25.5)	10.1 (4.9 - 21.8)	8.6 (2.9 - 23.3)

Jul	-0.041	0.016	0.052	0.175	5.8 (0.2 - 22.2)	7.2 (0.1 - 30.3)	6.4 (0.1 - 28.6)
Aug	-0.041	0.001	0.104	0.205	3.9 (0.3 - 15.9)	6.9 (0.6 - 29.1)	5.7 (0.4 - 24)
Sep	-0.050	0.001	0.095	0.205	7 (1 - 14.7)	8.9 (0.8 - 31.1)	9.2 (0.5 - 31.1)
Oct	-0.103	0.058	0.033	0.193	18.4 (10.3 - 26.5)	30.4 (20.8 - 54.1)	29.3 (16.9 - 49.4)
Nov	-0.189	0.010	0.060	0.172	44.7 (22.8 - 61.1)	70.9 (57.8 - 91.5)	68.9 (55 - 90)
Dec	0.043	0.708	0.001	0.200	88.4 (75.9 - 101.8)	146.7 (116.8 - 197)	151.5 (116.4 - 204.4)

5.1.2.2 Annual Rainfall

5.1.2.2.1 Karonga ADD

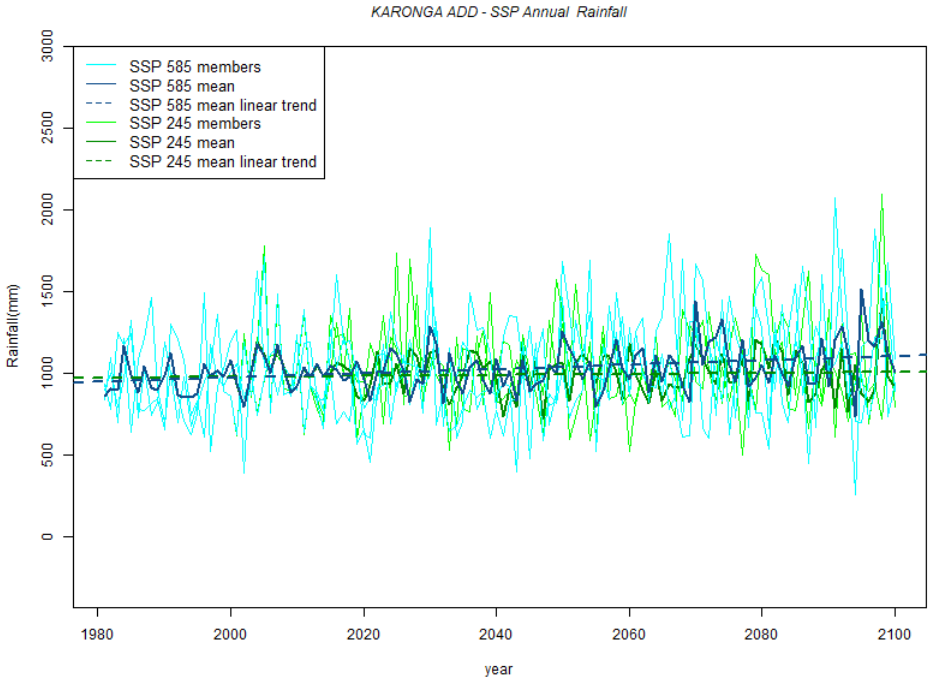

Figure 5- 10 Annual rainfall projections in Karonga ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 18 Characteristics of the trends from the projected annual rainfall time series in Karonga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Karonga ADD SSP2.45							
	Slope (mm/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Karonga	0.303	0.360	0.007	0.166	998.6 (942.9 - 1066.7)	982.5 (917.6 - 1072.3)	1008 (929.6 - 1099)
Karonga ADD SSP5.85							
	slope	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Karonga	1.306	0.000	0.111	0.164	1011.7 (947.1 - 1081.3)	994.5 (900.7 - 1090.2)	1056.3 (834.7 - 1205.6)

5.1.2.2.2 Mzuzu ADD

Figure 5- 11 Annual rainfall projections in Mzuzu ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

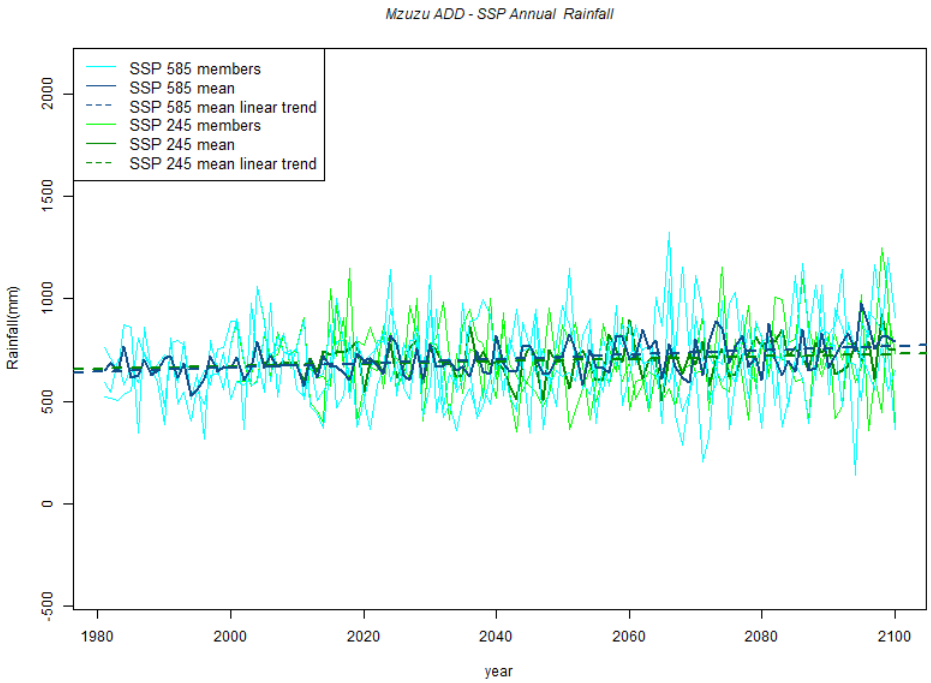

Table 5- 19 Characteristics of the trends from the projected annual rainfall time series in Mzuzu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

SSP2.45

	Slope (mm/year)	P-value	R^2	NRMSE (%)	Mean, Range 2040 (mm)	Mean, Range 2060 (mm)	Mean, Range 2080 (mm)
Mzuzu	0.622864	0.002247	0.076375	0.179479	692.18 (607.02 - 784.59)	676.16 (606.95 - 788.95)	695.13 (613.8 - 814.42)
SSP5.85							
	slope	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Mzuzu	1.060675	2.40E-07	0.203129	0.161668	676.94 (634.25 - 739.46)	679.9 (585.34 - 784.7)	713.86 (534.04 - 913.1)

5.1.2.2.3 Kasungu ADD

Figure 5- 12 Annual rainfall projections in Kasungu ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

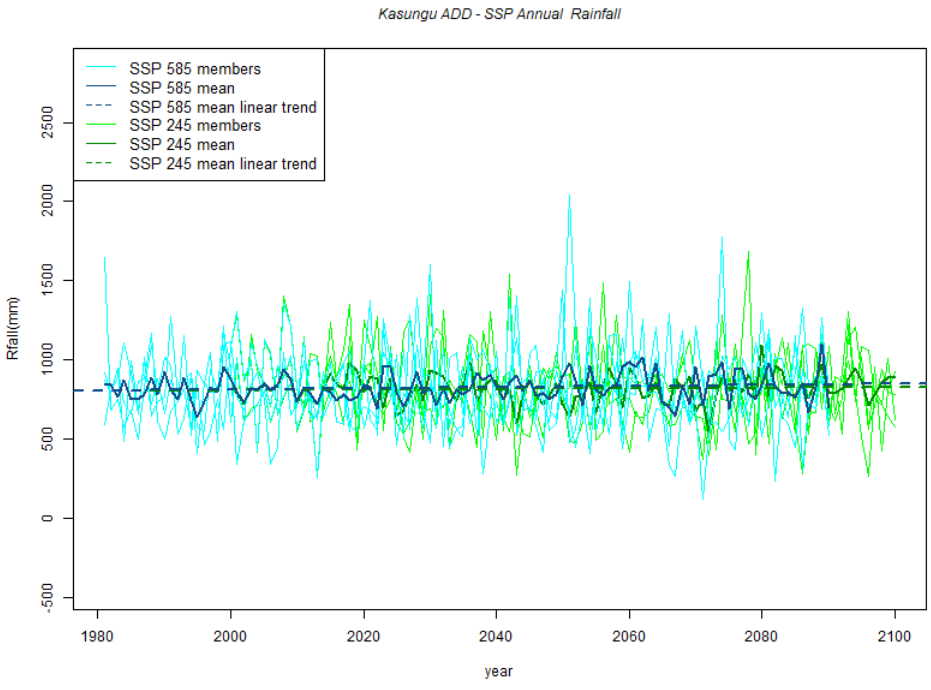

Table 5- 20 Characteristics of the trends from the projected annual rainfall time series in Kasungu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Kasungu ADD SSP2.45

	Slope (mm/year)	P-value	R^2	NRMSE (%)	Mean, Range 2040 (mm)	Mean, Range 2060 (mm)	Mean, Range 2080 (mm)
Kasungu	0.182941	0.43217	0.005237	0.160645	823.1 (761.1 - 920.3)	798.6 (715.1 - 948.6)	802.6 (724.1 - 915.2)
Kasungu ADD SSP5.85							
	slope	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Kasungu	0.403715	0.130596	0.021035	0.18969	797 (725.6 - 866.4)	834.8 (733.5 - 955.9)	844.6 (690.6 - 1041.5)

5.1.2.2.4 Lilongwe ADD

In **SSP2.45**, the slope is 0.293 mm/year, indicating a positive trend in precipitation. However, the p-value of 0.222 suggests that the observed trend may not be statistically significant. The R^2 value of 0.013 indicates that only a small portion of the variation in precipitation can be explained by the model, while the NRMSE value of 0.208 represents the overall accuracy of the model.

In the second scenario (SSP5.85), the slope is reduced to 0.153 mm/year, indicating a slightly lower positive trend in precipitation compared to the first scenario. The p-value of 0.586 suggests that the observed trend is not statistically significant. The R^2 value of 0.003 indicates a very weak relationship between the variables, and the NRMSE value of 0.168 represents a slightly improved accuracy compared to the first scenario.

Figure 5- 13 Annual rainfall projections in Lilongwe ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

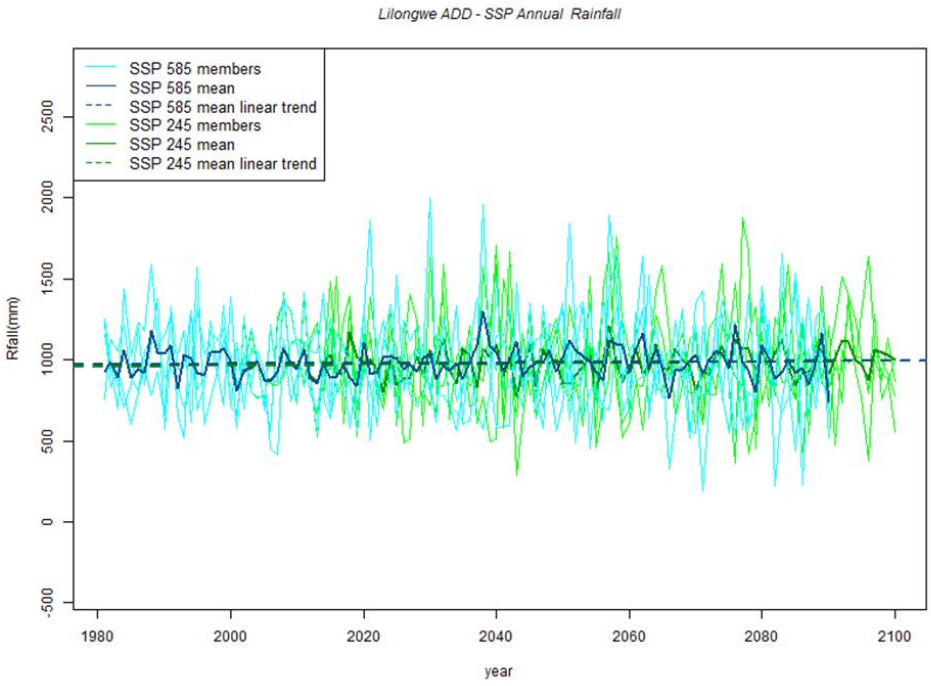

Table 5- 21 Characteristics of the trends from the projected annual rainfall time series in Lilongwe ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Lilongwe ADD SSP2.45							
	Slope (mm/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Lilongwe	0.293	0.222	0.013	0.208	968.3 (879.1 - 1109.5)	968.3 (868.5 - 1091.7)	978.9 (876.4 - 1062.4)
Lilongwe ADD SSP5.85							
	Slope (mm/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Lilongwe	0.153	0.586	0.003	0.168	957.1 (878.5 - 1009.6)	1014.1 (916.9 - 1102.8)	994.8 (865.6 - 1044)

5.1.2.2.5 Salima ADD

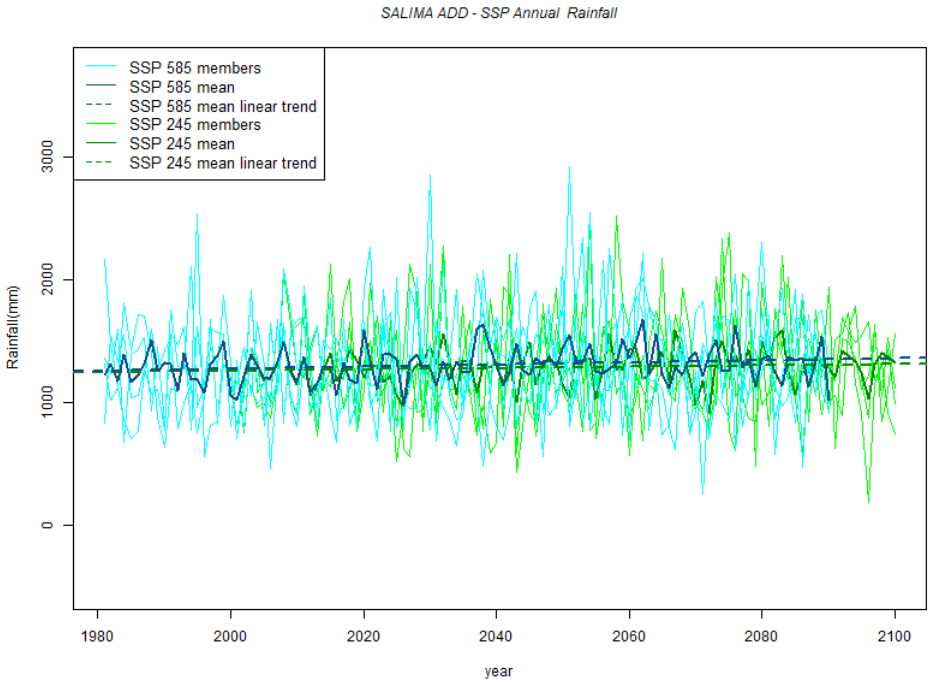

Figure 5- 14 -Annual rainfall projections in Salima ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 22 Characteristics of the trends from the projected annual rainfall time series in Salima ADD (linear models) for SSP2.45 and SSP5.85.

Salima ADD SSP2.45							
	Slope (mm/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Salima	0.568	0.127	0.020	0.207	1263 (1112.7 - 1462.7)	1276.1 (1179.7 - 1378)	1289 (1182 - 1380.1)
Salima ADD SSP5.85							
	slope	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**

Salima	0.831	0.049	0.035	0.199	1263.2 (1113.3 - 1363.7)	1349.9 (1242.7 - 1453.2)	1347.2 (1205.2 - 1556.4)

5.1.2.2.6 Shire Valley ADD

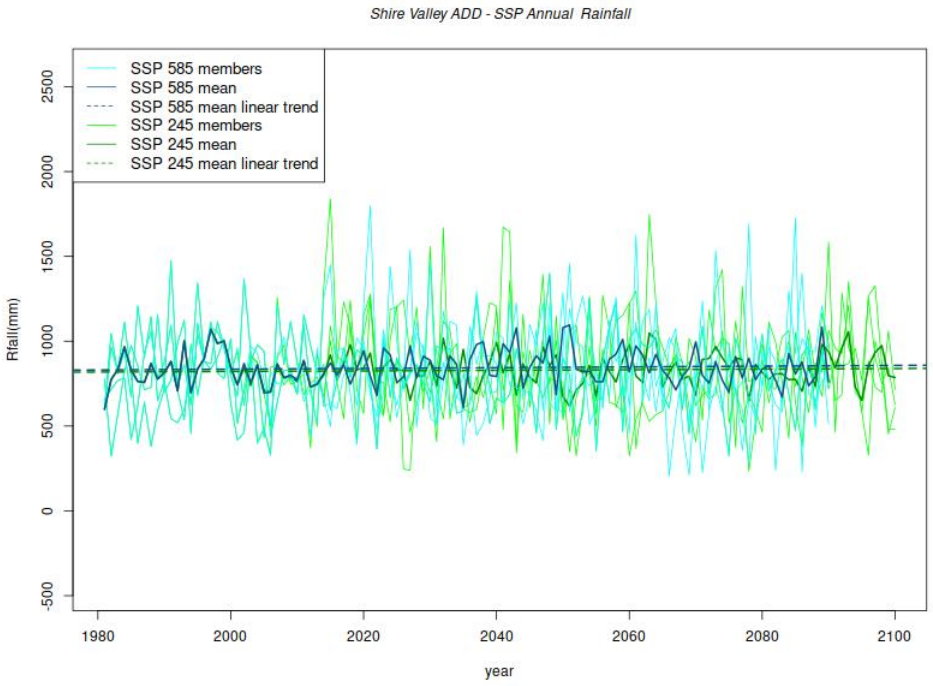

Figure 5- 15 Annual rainfall projections for in Shire Valley ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 23 Characteristics of the trends from the projected annual rainfall time series in Shire Valley ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Shire Valley ADD SSP2.45							
	Slope (mm/ year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Shire Valley	0.1726	0.5192	0.0035	0.2135	828.9 (678.5 - 914.5)	818.3 (729.1-888.9)	829.1 (737.5 -940.9)
Shire Valley SSP5.85							
	slope	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**

Shire Valley	0.2245	0.4738	0.0048	0.2077	838.1 (775.5 -979.7)	878.6 (725.7-1104.3)	849.0 (720.5-1000.2)

5.1.2.2.7 Machinga ADD

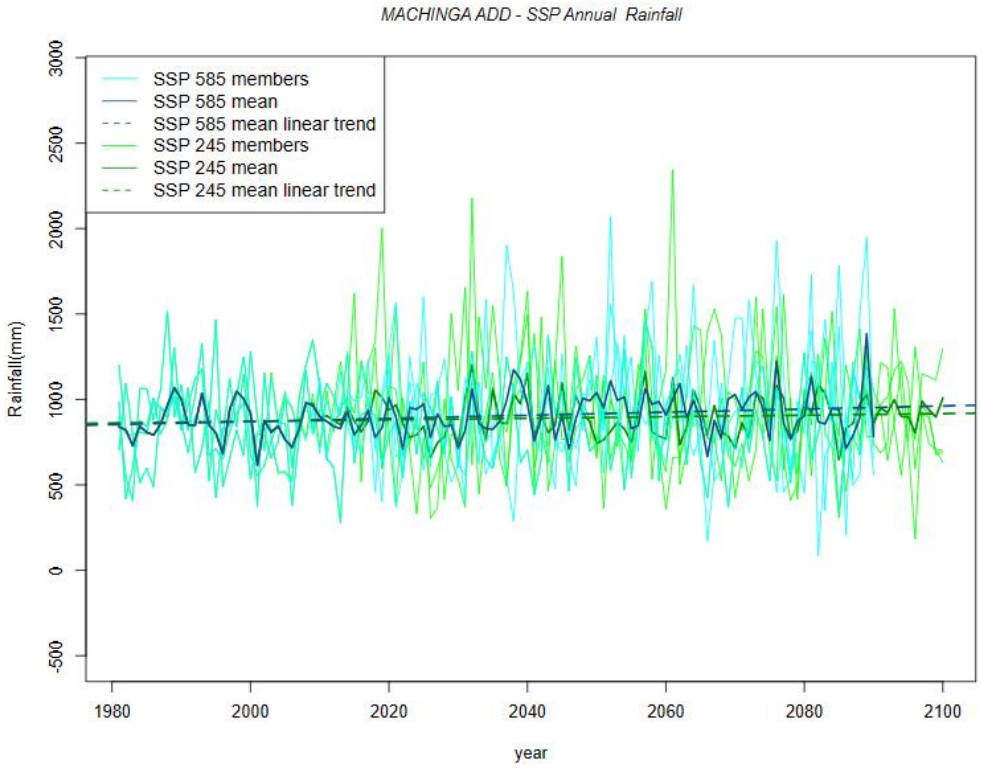

Figure 5- 16 Annual rainfall projections in Machinga ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 24 Characteristics of the trends from the projected annual rainfall time series in Machinga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Machinga ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Machinga	0.456	0.135	0.019	0.196	869.2 (809.4 - 976.1)	904.6 (810.9 - 992.2)	880.1 (827.1 - 940.2)
Machinga ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range**	**Mean, Range**	**Mean, Range**

					2040 (°C)	2040 (°C)	2040 (°C)
Machinga	0.910	0.014	0.055	0.156	857.2 (769.4 - 933.7)	945.4 (888.4 - 1002.8)	929.8 (858.3 - 996.5)

5.1.2.2.8 Blantyre ADD

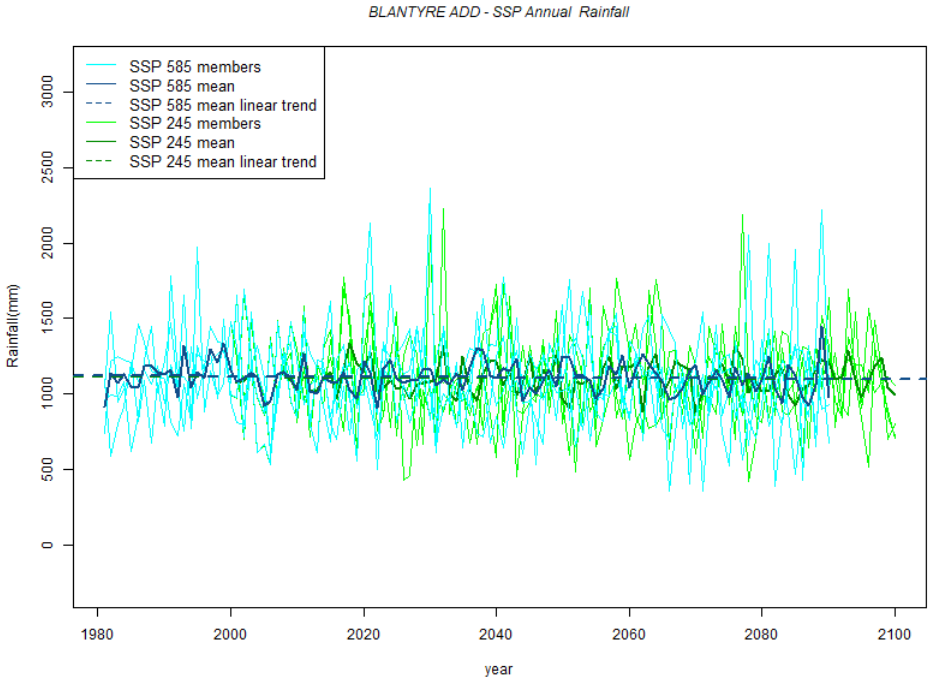

Figure 5- 17 Annual rainfall projections in Blantyre ADD for both SSP2.45 (green) and SSP5.85 (blue). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 25 Characteristics of the trends from the projected annual rainfall time series in Blantyre ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Blantyre ADD SSP2.45							
	Slope (mm/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Blantyre	-0.092	0.742	0.001	0.228	1111.2 (965 - 1285)	1101.8 (1042.8 - 1172.5)	1095.3 (1009.3 - 1169.2)
SSP5.85							
	slope	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Blantyre	-0.186	0.538	0.004	0.184	1103.4 (984.9 - 1204.4)	1133.5 (987 - 1306.3)	1109 (967.9 - 1247)

5.1.2.3 **Probability of occurrence of rainfall greater than 150mm in 24 hours** (Proxy of stormy conditions)

Table 5- 26 Probability of exceedance of rainfall greater than 150mm in 24 hours

ADD	2020	2040	2060	2080
	Mean, Range	Mean, Range	Mean, Range	Mean, Range
Karonga				
Mzuzu				
Kasungu				
Salima				
Lilongwe				
Blantyre				
Shire Valley				
Machinga				

5.1.2.4 **Probability of occurrence of rainfall greater than 100mm in 24 hours** (Proxy of flash floods)

Table 5- 27 Probability of exceedance of rainfall greater than 100mm in 24 hours

ADD	2020	2040	2060	2080
	Mean, Range	Mean, Range	Mean, Range	Mean, Range
Karonga				
Mzuzu				
Kasungu				
Salima				
Lilongwe				
Blantyre				
Shire Valley				
Machinga				

5.2 Maximum Temperature

5.2.1 Current Maximum Temperature

5.2.1.1 Seasonal Variations

The seasonal maximum temperature according to the models from 1991-2020 is presented in Fig. 5-20. It is clearly shown that the Shire Valley ADD is the hottest which is followed by Machinga and Karonga ADDs. Lilongwe ADD is the coolest. The seasonal variations also show that the months of October and November are the hottest while June and July are the coolest months. There is a big gap between Lilongwe ADD and the rest of the ADDs.

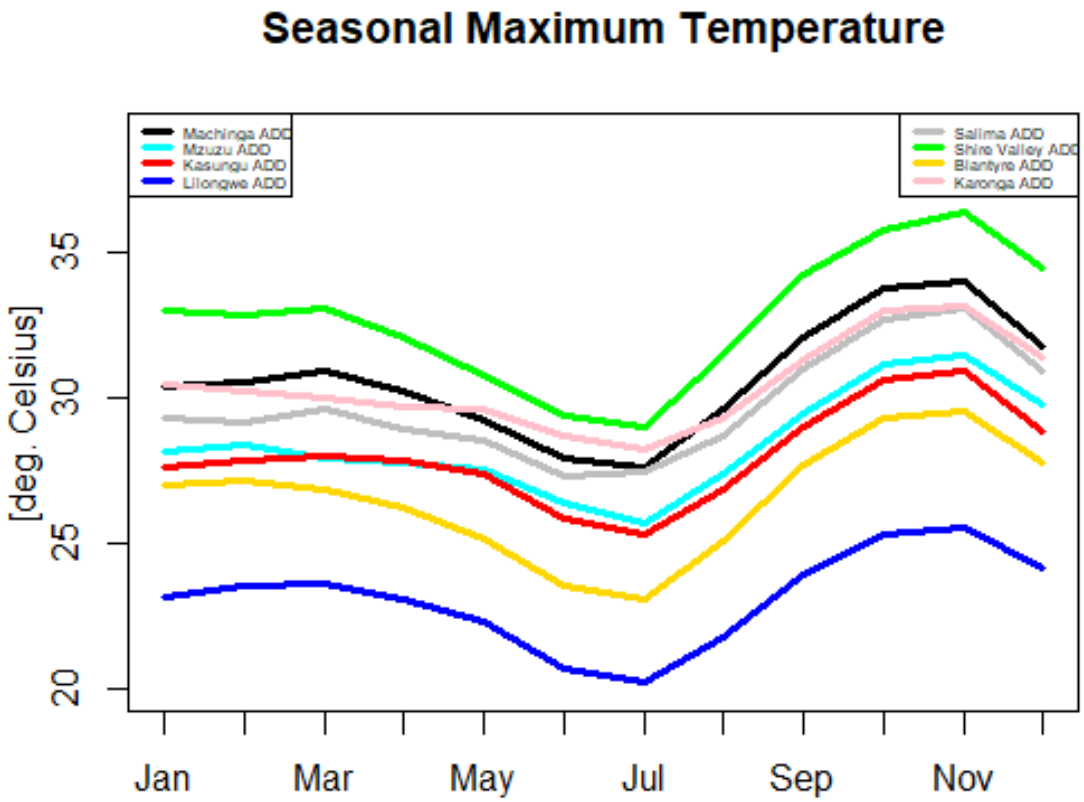

Figure 5- 18 Current seasonal variations of the monthly maximum temperature in eight ADDs

5.2.1.2 Monthly Maximum Temperature

The comparison of maximum temperature for the 8 ADDs per month during 1991-2020 are presented in Fig. 5-21. Like the seasonal variations, the hottest ADD is still the Shire Valley and the coolest is Lilongwe ADD for all the months. The monthly trend characteristics for all the ADDs are presented in Tab. 5-28 to Tab. 5-35. It is shown that the maximum temperature is significantly increasing in all the ADDs at the rate between +0.01 to +0.06 degrees Celsius per year for all the months. The hottest month of November has the highest increasing trend while February has the lowest trend in many ADD except Shire Valley ADD and Blantyre ADD which have the lowest increasing trend in June.

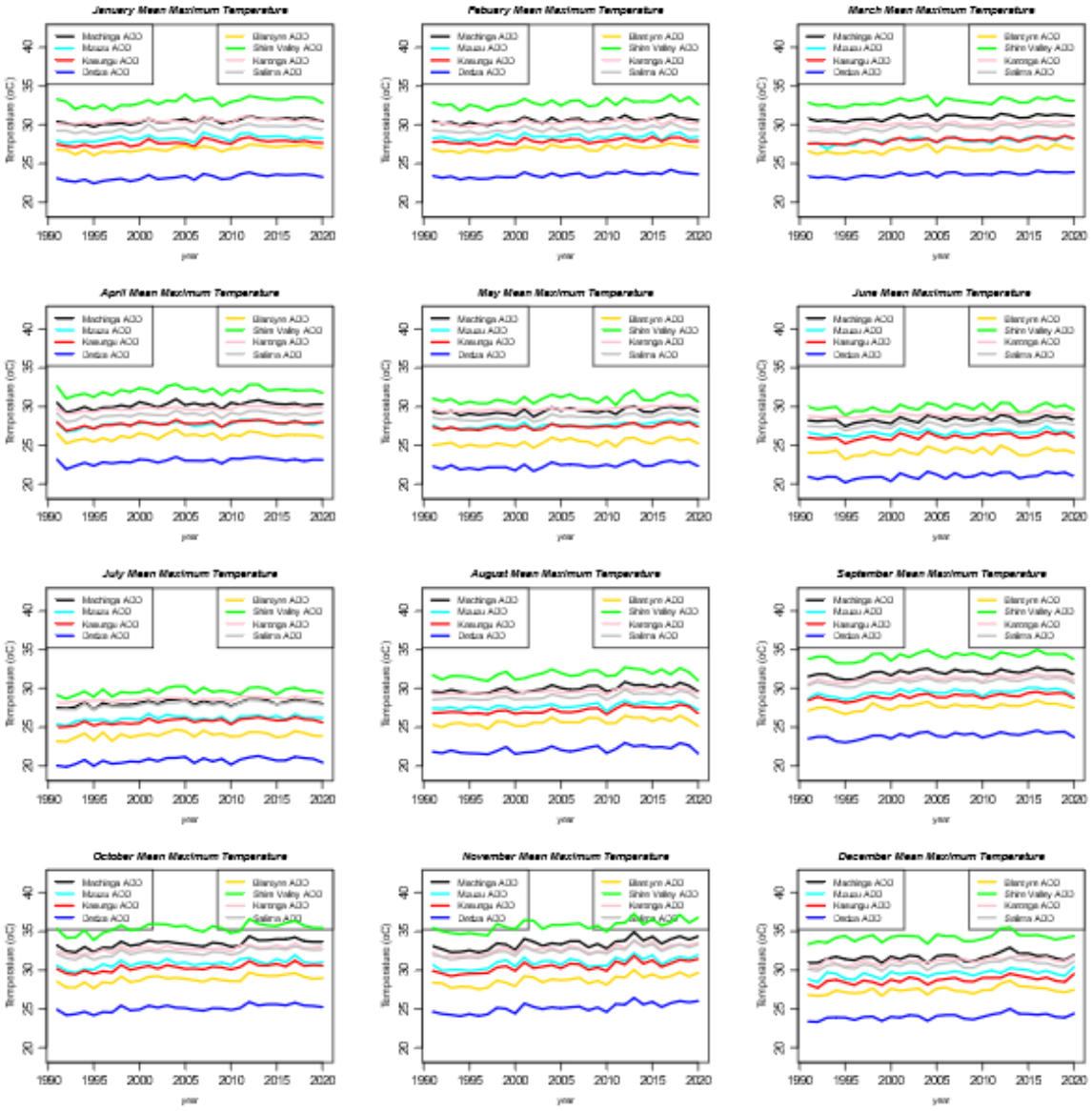

Figure 5- 19 Current (1991-2020) monthly mean maximum temperature in eight ADDs. The trend characteristics are presented in the tables below.

*Table 5- 28 Characteristics of the trends from the current time series of maximum temperature by month in **Karonga ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.02	0.00	0.33	0.21	30.5
Feb	0.01	0.01	0.21	0.21	30.3
Mar	0.03	0.00	0.56	0.17	30.1
Apr	0.02	0.00	0.47	0.17	29.7
May	0.02	0.00	0.67	0.15	29.7
Jun	0.02	0.00	0.51	0.16	28.9
Jul	0.02	0.00	0.55	0.18	28.6
Aug	0.02	0.00	0.53	0.21	29.6
Sep	0.03	0.00	0.50	0.18	31.3
Oct	0.03	0.00	0.52	0.16	32.7
Nov	0.05	0.00	0.58	0.19	32.7
Dec	0.03	0.00	0.53	0.18	31.2

*Table 5- 29 Characteristics of the trends from the current time series of maximum temperature by month in **Mzuzu ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.02	0.00	0.26	0.21	28.3
Feb	0.01	0.03	0.16	0.25	28.4
Mar	0.03	0.00	0.38	0.18	28.0
Apr	0.02	0.00	0.31	0.20	27.7
May	0.03	0.00	0.58	0.17	27.6
Jun	0.02	0.01	0.24	0.20	26.6
Jul	0.02	0.00	0.29	0.20	26.1
Aug	0.02	0.00	0.31	0.21	27.7
Sep	0.03	0.00	0.39	0.21	29.5
Oct	0.04	0.00	0.43	0.16	30.8
Nov	0.05	0.00	0.52	0.20	31.0
Dec	0.03	0.00	0.40	0.18	29.5

*Table 5- 30 Characteristics of the trends from the current time series of maximum temperature by month in **Kasungu ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.02	0.00	0.36	0.22	27.7
Feb	0.02	0.00	0.34	0.21	27.9
Mar	0.03	0.00	0.54	0.19	28.0
Apr	0.02	0.00	0.36	0.19	27.8
May	0.02	0.00	0.45	0.21	27.4
Jun	0.02	0.00	0.30	0.19	26.1
Jul	0.03	0.00	0.48	0.19	25.7
Aug	0.03	0.00	0.43	0.22	27.1
Sep	0.03	0.00	0.47	0.18	28.9
Oct	0.04	0.00	0.53	0.16	30.3
Nov	0.06	0.00	0.63	0.15	30.4
Dec	0.03	0.00	0.40	0.17	28.7

*Table 5- 31 Characteristics of the trends from the current time series of maximum temperature by month in **Lilongwe ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0	0.55	0.17	23.2
Feb	0.03	0	0.53	0.17	23.5
Mar	0.03	0	0.61	0.16	23.6
Apr	0.02	0	0.36	0.17	23
May	0.03	0	0.41	0.2	22.4
Jun	0.02	0	0.29	0.21	21
Jul	0.02	0	0.33	0.22	20.7
Aug	0.03	0	0.38	0.23	22.1
Sep	0.03	0	0.44	0.19	23.9
Oct	0.04	0	0.54	0.17	25.1
Nov	0.06	0	0.67	0.15	25.1
Dec	0.03	0	0.38	0.17	24

*Table 5- 32 Characteristics of the trends from the current time series of maximum temperature by month in **Salima ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.42	0.20	29.5
Feb	0.02	0.00	0.37	0.18	29.4
Mar	0.03	0.00	0.55	0.19	29.6
Apr	0.02	0.00	0.30	0.19	28.9
May	0.03	0.00	0.48	0.18	28.6
Jun	0.02	0.00	0.35	0.19	27.6
Jul	0.03	0.00	0.47	0.21	27.9
Aug	0.03	0.00	0.49	0.20	28.9
Sep	0.03	0.00	0.48	0.18	30.9
Oct	0.04	0.00	0.58	0.17	32.3
Nov	0.06	0.00	0.63	0.15	32.5
Dec	0.03	0.00	0.29	0.21	30.7

*Table 5- 33 Characteristics of the trends from the current time series of maximum temperature by month in **Shire Valley ADD** significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.04	0.00	0.36	0.20	33.0
Feb	0.03	0.00	0.33	0.19	32.8
Mar	0.03	0.00	0.33	0.22	33.0
Apr	0.02	0.07	0.11	0.23	32.1
May	0.03	0.01	0.21	0.22	31.0
Jun	0.01	0.13	0.08	0.25	29.8
Jul	0.02	0.01	0.20	0.23	29.6
Aug	0.03	0.01	0.25	0.24	31.8
Sep	0.02	0.01	0.22	0.23	34.2
Oct	0.04	0.00	0.32	0.19	35.4
Nov	0.06	0.00	0.49	0.18	35.7
Dec	0.02	0.02	0.18	0.20	34.2

*Table 5- 34 Characteristics of the trends from the current time series of maximum temperature by month in **Machinga ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.51	0.17	30.5
Feb	0.03	0.00	0.42	0.19	30.5
Mar	0.02	0.00	0.47	0.21	30.9
Apr	0.02	0.01	0.24	0.20	30.2
May	0.02	0.00	0.33	0.22	29.4
Jun	0.02	0.01	0.22	0.21	28.3
Jul	0.02	0.00	0.30	0.22	28.1
Aug	0.03	0.00	0.44	0.21	29.9
Sep	0.03	0.00	0.36	0.20	32.0
Oct	0.04	0.00	0.50	0.17	33.4
Nov	0.06	0.00	0.57	0.17	33.4
Dec	0.02	0.01	0.22	0.20	31.6

*Table 5- 35 Characteristics of the trends from the current time series of maximum temperature by month in **Blantyre ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.55	0.17	26.9
Feb	0.03	0.00	0.50	0.18	27.0
Mar	0.02	0.00	0.36	0.20	26.8
Apr	0.02	0.01	0.20	0.20	26.2
May	0.03	0.00	0.30	0.24	25.4
Jun	0.01	0.09	0.10	0.21	24.2
Jul	0.02	0.03	0.17	0.24	24.0
Aug	0.03	0.00	0.34	0.21	25.7
Sep	0.03	0.00	0.33	0.18	27.6
Oct	0.04	0.00	0.48	0.18	28.8
Nov	0.06	0.00	0.59	0.16	28.7
Dec	0.03	0.00	0.28	0.19	27.4

5.2.1.3 **Annual Mean Maximum Temperature**

The annual maximum temperature is also portraying the increasing trend in all the 8 ADDs. The trend characteristics are shared in Tab. 5-36. All the ADD have the uniform significant positive annual trend of maximum temperature of +0.03 degrees Celsius per year from 1991-2020.

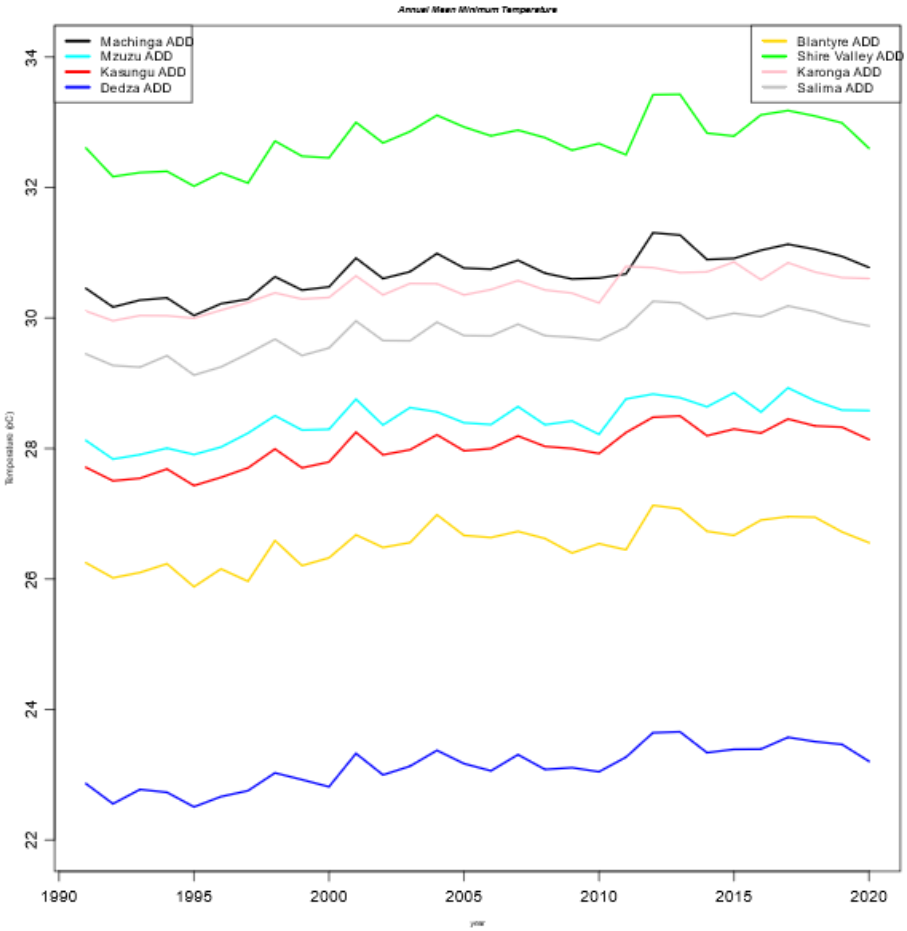

Figure 5- 20 Current (1991-2020) annual mean maximum temperature in eight ADDs

Table 5- 36 Characteristics of the trends from the current time series of annual maximum temperature in eight target ADDs (linear models), significant changes are presented in bold.

ADD	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Machinga	**0.03**	**0.00**	**0.63**	**0.15**	**30.7**
Mzuzu	**0.03**	**0.00**	**0.62**	**0.17**	**28.4**
Karonga	**0.03**	**0.00**	**0.71**	**0.16**	**30.4**
Kasungu	**0.03**	**0.00**	**0.72**	**0.15**	**28.0**
Salima	**0.03**	**0.00**	**0.72**	**0.14**	**29.7**
Lilongwe	**0.03**	**0.00**	**0.70**	**0.15**	**23.1**
Blantyre	**0.03**	**0.00**	**0.57**	**0.17**	**26.5**
Shire Valley	**0.03**	**0.00**	**0.46**	**0.19**	**32.7**

5.2.2 **Maximum Temperature Projections**

5.2.2.1 **Monthly Maximum Temperature**

5.2.2.1.1 Karonga ADD

The maximum temperature projection for Karonga ADD is presented in Fig. 5-23 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-37. The monthly increasing trends are significant and are ranging from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

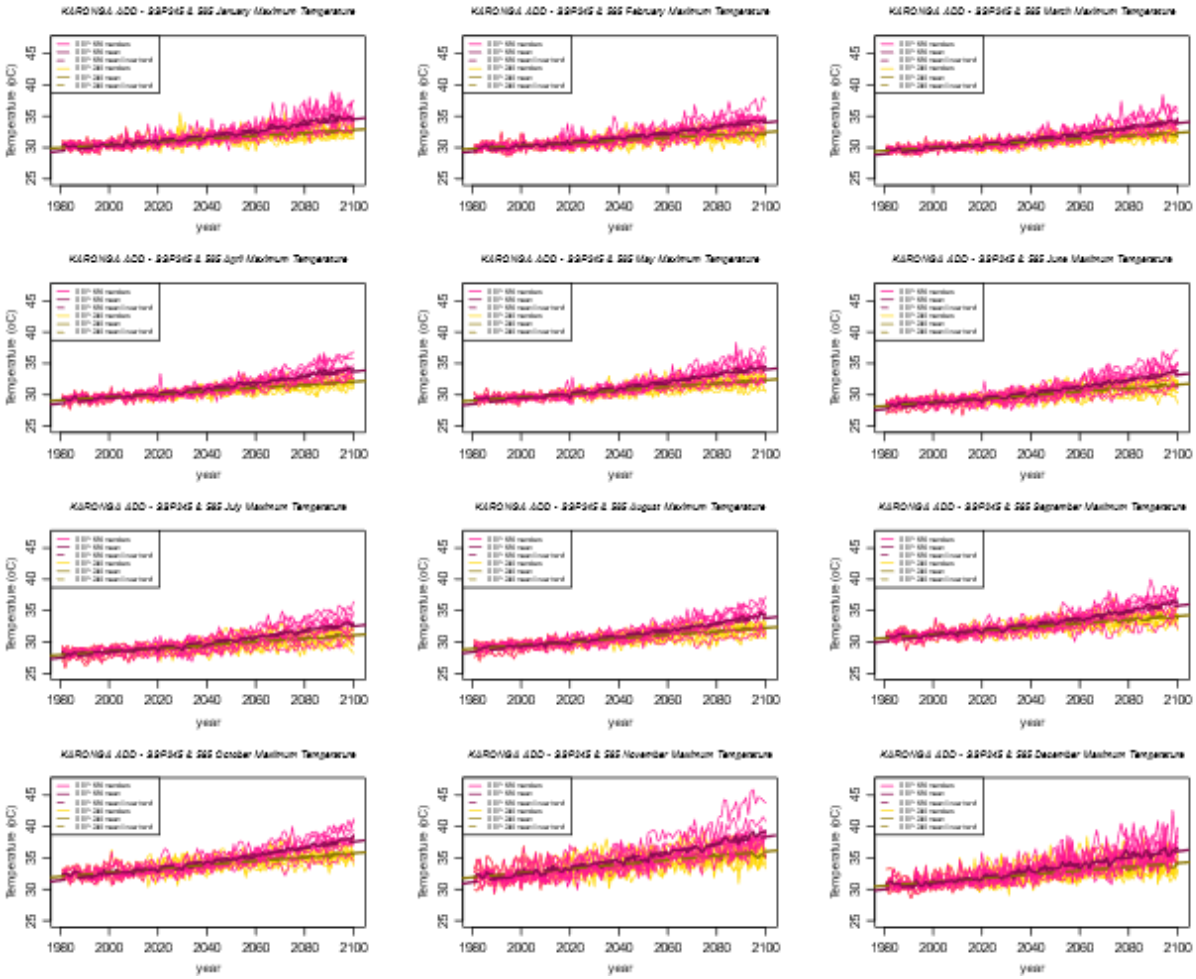

Figure 5- 21 Monthly maximum temperature projections in Karonga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 37 Characteristics of the trends from the projected maximum temperature time series by month in Karonga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Karonga ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.024**	**0.000**	**0.918**	**0.086**	31 (30.7 - 31.8)	31.6 (31 - 32.3)	32.1 (31.1 - 33.1)

Feb	**0.022**	**0.000**	**0.909**	**0.082**	30.7 (30.5 - 31.1)	31.4 (30.8 - 32.1)	31.9 (31.2 - 33)
Mar	**0.024**	**0.000**	**0.948**	**0.064**	30.5 (30.1 - 30.9)	31.1 (30.7 - 31.7)	31.6 (30.9 - 32.6)
Apr	**0.025**	**0.000**	**0.950**	**0.063**	30.2 (30 - 30.6)	30.8 (30.4 - 31.6)	31.3 (30.4 - 32.2)
May	**0.027**	**0.000**	**0.952**	**0.066**	30.3 (30 - 30.5)	30.9 (30.3 - 31.8)	31.5 (30.4 - 32.6)
Jun	**0.028**	**0.000**	**0.947**	**0.064**	29.4 (28.9 - 29.9)	30.1 (29.4 - 31.2)	30.8 (29.5 - 32)
Jul	**0.026**	**0.000**	**0.947**	**0.061**	29 (28.2 - 29.6)	29.7 (28.6 - 30.9)	30.3 (29.2 - 31.8)
Aug	**0.028**	**0.000**	**0.963**	**0.054**	30.2 (29.6 - 30.7)	30.8 (30 - 31.7)	31.3 (30.2 - 32.4)
Sep	**0.029**	**0.000**	**0.946**	**0.065**	31.9 (31.3 - 32.7)	32.6 (31.7 - 33.3)	33.2 (32 - 34.2)
Oct	**0.031**	**0.000**	**0.939**	**0.070**	33.3 (32.5 - 34.3)	34.1 (33.3 - 34.9)	34.8 (33.4 - 36)
Nov	**0.034**	**0.000**	**0.901**	**0.089**	33.5 (32.3 - 35.4)	34.2 (33.1 - 35.6)	35.1 (33.9 - 36.7)
Dec	**0.030**	**0.000**	**0.893**	**0.088**	31.9 (30.9 - 33.5)	32.7 (31.7 - 34)	33.3 (32.1 - 35.2)
Karonga ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	**0.042**	**0.000**	**0.928**	**0.077**	31.1 (30.7 - 31.8)	31.8 (31.2 - 32.6)	32.9 (31.9 - 34.1)
Feb	**0.039**	**0.000**	**0.946**	**0.068**	31 (30.4 - 31.4)	31.7 (30.8 - 32.5)	32.6 (31.3 - 33.9)

Mar	**0.041**	**0.000**	**0.948**	**0.066**	30.5 (30.2 - 30.9)	31.3 (30.8 - 32.1)	32.4 (31.5 - 33.7)
Apr	**0.042**	**0.000**	**0.939**	**0.070**	30.2 (30 - 30.8)	31 (30.6 - 31.8)	32.1 (31.2 - 33.2)
May	**0.046**	**0.000**	**0.948**	**0.070**	30.3 (29.9 - 30.9)	31.2 (30.6 - 31.9)	32.3 (31.1 - 33.4)
Jun	**0.045**	**0.000**	**0.950**	**0.063**	29.5 (28.7 - 30.3)	30.4 (29.5 - 31.2)	31.5 (29.9 - 32.9)
Jul	**0.042**	**0.000**	**0.945**	**0.066**	29.1 (28.1 - 29.9)	29.9 (28.8 - 31)	31 (29 - 32.5)
Aug	**0.045**	**0.000**	**0.954**	**0.058**	30.2 (29.5 - 30.9)	31.1 (30.1 - 31.9)	32.1 (30.1 - 33.3)
Sep	**0.048**	**0.000**	**0.939**	**0.070**	32 (31.1 - 32.7)	32.8 (31.5 - 33.7)	34 (31.9 - 35.4)
Oct	**0.051**	**0.000**	**0.950**	**0.061**	33.4 (32.7 - 34.5)	34.4 (33.4 - 35.5)	35.7 (33.9 - 37.3)
Nov	**0.060**	**0.000**	**0.945**	**0.066**	33.7 (32.6 - 35.1)	34.7 (33.4 - 36.7)	36.1 (34.4 - 38.9)
Dec	**0.050**	**0.000**	**0.938**	**0.070**	32.1 (31.2 - 33.1)	33.2 (31.9 - 34.4)	34.3 (33.1 - 36.1)

5.2.2.1.2 Mzuzu ADD

The maximum temperature projection for Mzuzu ADD is presented in Fig. 5-24 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in maximum temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-38. The monthly increasing trends are significant and are ranging from +0.02 to +0.04 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.05 degrees Celsius per year.

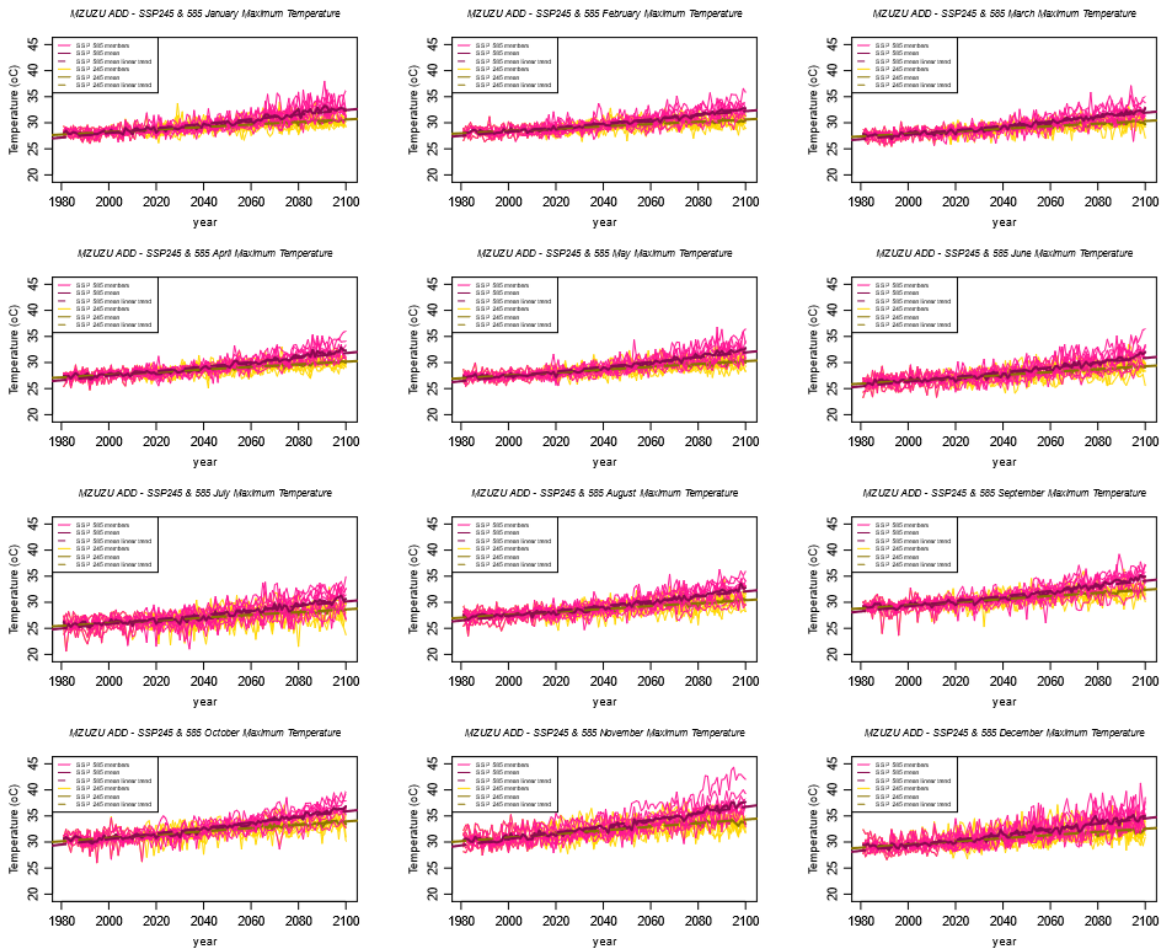

Figure 5- 22 Monthly maximum temperature projections in Mzuzu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 38 Characteristics of the trends from the projected maximum temperature time series by month in Mzuzu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Mzuzu ADD SSP2.45							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.024**	**0**	**0.881**	**0.098**	28.8 (28.5 - 29.5)	29.3 (28.8 - 30)	29.9 (28.9 - 31)
Feb	**0.022**	**0**	**0.873**	**0.095**	28.8 (28.2 - 29.3)	29.5 (28.9 - 30.2)	30 (29.3 - 31)
Mar	**0.025**	**0**	**0.897**	**0.079**	28.4 (28.1 - 28.8)	29 (28.6 - 29.5)	29.6 (28.9 - 30.5)
Apr	**0.025**	**0**	**0.901**	**0.081**	28.2 (27.9 - 28.7)	28.9 (28.4 - 29.7)	29.4 (28.6 - 30.2)

May	**0.027**	**0**	**0.911**	**0.085**	28.2 (27.9 - 28.5)	28.8 (28.2 - 29.8)	29.4 (28.3 - 30.5)
Jun	**0.028**	**0**	**0.882**	**0.087**	27.1 (26.6 - 27.8)	27.8 (27.1 - 29.2)	28.4 (27.2 - 29.8)
Jul	**0.026**	**0**	**0.831**	**0.099**	26.5 (25.5 - 27.3)	27.2 (26 - 28.7)	27.9 (26.5 - 29.6)
Aug	**0.028**	**0**	**0.902**	**0.08**	28.3 (27.6 - 28.9)	28.9 (27.9 - 29.9)	29.5 (28.1 - 30.6)
Sep	**0.03**	**0**	**0.906**	**0.081**	30.1 (29.6 - 30.8)	30.8 (30 - 31.5)	31.4 (30.2 - 32.5)
Oct	**0.032**	**0**	**0.889**	**0.088**	31.5 (30.6 - 32.4)	32.3 (31.4 - 33.1)	32.9 (31.5 - 34.1)
Nov	**0.035**	**0**	**0.883**	**0.097**	31.8 (30.5 - 33.7)	32.5 (31.3 - 33.9)	33.3 (32 - 35)
Dec	**0.03**	**0**	**0.857**	**0.095**	30.2 (29.1 - 31.9)	31 (30.1 - 32.4)	31.6 (30.4 - 33.5)

Mzuzu ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.04**	**0.00**	**0.91**	**0.08**	28.9 (28.5 - 29.6)	29.6 (29 - 30.4)	30.8 (29.8 - 31.9)
Feb	**0.04**	**0.00**	**0.94**	**0.07**	29.1 (28.3 - 29.8)	29.9 (28.9 - 30.8)	30.7 (29.4 - 32.1)
Mar	**0.04**	**0.00**	**0.93**	**0.07**	28.5 (28.1 - 28.8)	29.3 (28.6 - 30.1)	30.4 (29.4 - 31.6)
Apr	**0.04**	**0.00**	**0.92**	**0.07**	28.3 (28 - 28.9)	29.1 (28.6 - 29.8)	30.2 (29.3 - 31.4)
May	**0.05**	**0.00**	**0.93**	**0.07**	28.2 (27.9 - 28.9)	29.1 (28.5 - 29.9)	30.2 (29 - 31.4)

Jun	**0.05**	**0.00**	**0.92**	**0.07**	27.2 (26.4 - 27.9)	28.1 (27.2 - 29.1)	29.2 (27.6 - 30.8)
Jul	**0.04**	**0.00**	**0.89**	**0.08**	26.6 (25.4 - 27.5)	27.4 (26.2 - 28.6)	28.6 (26.5 - 30.3)
Aug	**0.05**	**0.00**	**0.93**	**0.06**	28.3 (27.5 - 29.1)	29.2 (28.3 - 30.2)	30.3 (28.3 - 31.6)
Sep	**0.05**	**0.00**	**0.92**	**0.07**	30.2 (29.4 - 30.8)	31.1 (29.7 - 31.9)	32.3 (30.1 - 33.5)
Oct	**0.05**	**0.00**	**0.93**	**0.07**	31.6 (30.8 - 32.7)	32.7 (31.6 - 33.6)	33.9 (32.1 - 35.5)
Nov	**0.06**	**0.00**	**0.93**	**0.07**	32 (31 - 33.4)	33 (31.5 - 35)	34.4 (32.6 - 37.2)
Dec	**0.05**	**0.00**	**0.92**	**0.08**	30.4 (29.7 - 31.5)	31.6 (30.3 - 32.9)	32.7 (31.5 - 34.6)

5.2.2.1.3 Kasungu ADD

The maximum temperature projection for Kasungu ADD is presented in Fig. 5-25 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in maximum temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-39. The monthly increasing trends are significant and are

ranging from +0.03 to +0.04 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

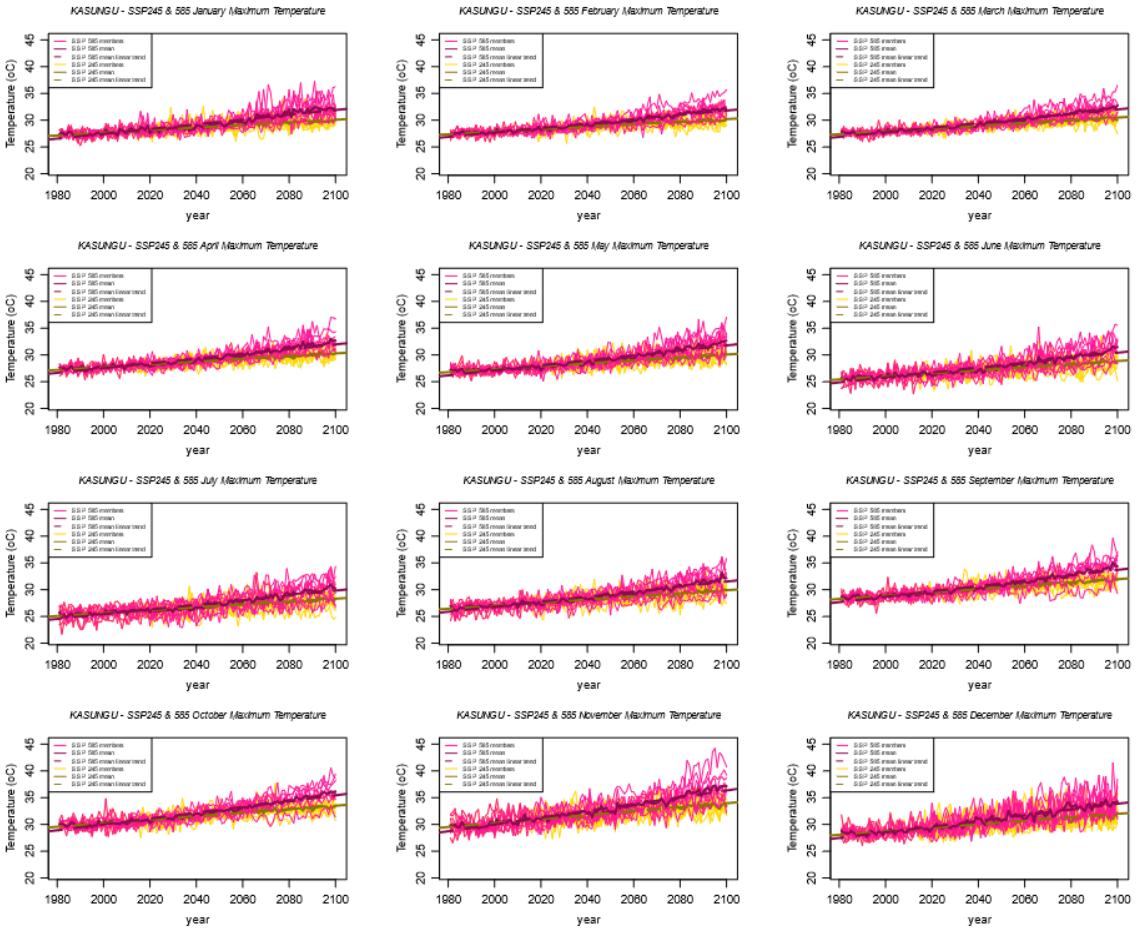

Figure 5- 23 Monthly maximum temperature projections in Kasungu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 39 Characteristics of the trends from the projected maximum temperature time series by month in Kasungu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Kasungu ADD SSP2.45							
Month	**Slope (^{O}C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	**0.024**	**0**	**0.898**	**0.088**	**28.2 (24.7 - 31.3)**	**28.8 (25.1 - 32)**	**29.4 (25.6 - 32.8)**
Feb	**0.024**	**0**	**0.918**	**0.086**	**28.4 (25.1 - 31.3)**	**29 (25.5 - 32)**	**29.5 (26 - 32.6)**
Mar	**0.026**	**0**	**0.933**	**0.075**	**28.5 (25.3 - 31)**	**29.1 (25.9 - 31.8)**	**29.7 (26.4 - 32.5)**

Apr	**0.026**	**0**	**0.917**	**0.073**	**28.3 (25.2 - 31)**	**29 (25.8 - 31.9)**	**29.5 (26.3 - 32.4)**
May	**0.027**	**0**	**0.914**	**0.082**	**28 (25 - 30.9)**	**28.6 (25.5 - 31.8)**	**29.2 (26.1 - 32.5)**
Jun	**0.029**	**0**	**0.903**	**0.08**	**26.6 (23.4 - 29.8)**	**27.3 (23.9 - 30.6)**	**27.9 (24.5 - 31.5)**
Jul	**0.027**	**0**	**0.885**	**0.084**	**26.2 (22.7 - 29.4)**	**26.9 (23.2 - 30.3)**	**27.5 (23.8 - 31.3)**
Aug	**0.029**	**0**	**0.908**	**0.079**	**27.8 (24.5 - 30.9)**	**28.4 (25 - 31.6)**	**28.9 (25.3 - 32.3)**
Sep	**0.031**	**0**	**0.935**	**0.072**	**29.6 (26.4 - 32.6)**	**30.4 (27.2 - 33.4)**	**31 (27.7 - 34.1)**
Oct	**0.033**	**0**	**0.925**	**0.08**	**31 (27.2 - 34.2)**	**31.9 (28.3 - 35.1)**	**32.5 (28.8 - 35.7)**
Nov	**0.037**	**0**	**0.901**	**0.088**	**31.3 (26.7 - 35.2)**	**31.9 (27.2 - 36)**	**32.9 (27.9 - 37)**
Dec	**0.033**	**0**	**0.879**	**0.089**	**29.5 (25.3 - 33.9)**	**30.3 (25.9 - 35.3)**	**31 (26.4 - 36.3)**
Kasungu ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	**0.045**	**0**	**0.906**	**0.092**	**28.3 (24.8 - 31.5)**	**29 (25.3 - 32.3)**	**30.3 (26.3 - 34.3)**
Feb	**0.041**	**0**	**0.948**	**0.067**	**28.5 (25.1 - 31.6)**	**29.3 (25.8 - 32.4)**	**30.3 (26.5 - 33.7)**
Mar	**0.043**	**0**	**0.949**	**0.064**	**28.5 (25.4 - 31.1)**	**29.4 (26.2 - 32.1)**	**30.5 (27 - 33.6)**
Apr	**0.044**	**0**	**0.927**	**0.07**	**28.4 (25.3 - 31.1)**	**29.2 (26.1 - 32)**	**30.4 (27 - 33.5)**
May	**0.047**	**0**	**0.928**	**0.075**	**28 (25.2 - 30.9)**	**28.9 (25.9 - 32)**	**30 (26.8 - 33.6)**

Jun	**0.046**	**0**	**0.92**	**0.074**	**26.7 (23.3 - 29.9)**	**27.5 (24.2 - 30.8)**	**28.7 (25 - 32.5)**
Jul	**0.044**	**0**	**0.919**	**0.072**	**26.2 (22.7 - 29.5)**	**27 (23.3 - 30.4)**	**28.2 (24.2 - 32.1)**
Aug	**0.047**	**0**	**0.937**	**0.06**	**27.8 (24.4 - 30.9)**	**28.6 (25.1 - 32)**	**29.7 (25.8 - 33.4)**
Sep	**0.05**	**0**	**0.941**	**0.063**	**29.6 (26.5 - 32.6)**	**30.6 (27.4 - 33.7)**	**31.8 (28.1 - 35.2)**
Oct	**0.054**	**0**	**0.952**	**0.063**	**31.1 (27.4 - 34.2)**	**32.1 (28.6 - 35.4)**	**33.5 (29.7 - 36.8)**
Nov	**0.063**	**0**	**0.938**	**0.07**	**31.4 (27 - 35.2)**	**32.5 (27.7 - 36.5)**	**33.9 (28.6 - 38.3)**
Dec	**0.053**	**0**	**0.922**	**0.077**	**29.6 (25.5 - 34.1)**	**30.8 (26.3 - 35.8)**	**32 (27.1 - 37.3)**

5.2.2.1.4 Lilongwe ADD

The maximum temperature projection for Lilongwe ADD is presented in Fig. 5-26 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in maximum temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-40. The monthly increasing trends are significant and are

ranging from +0.02 to +0.04 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.07 degrees Celsius per year.

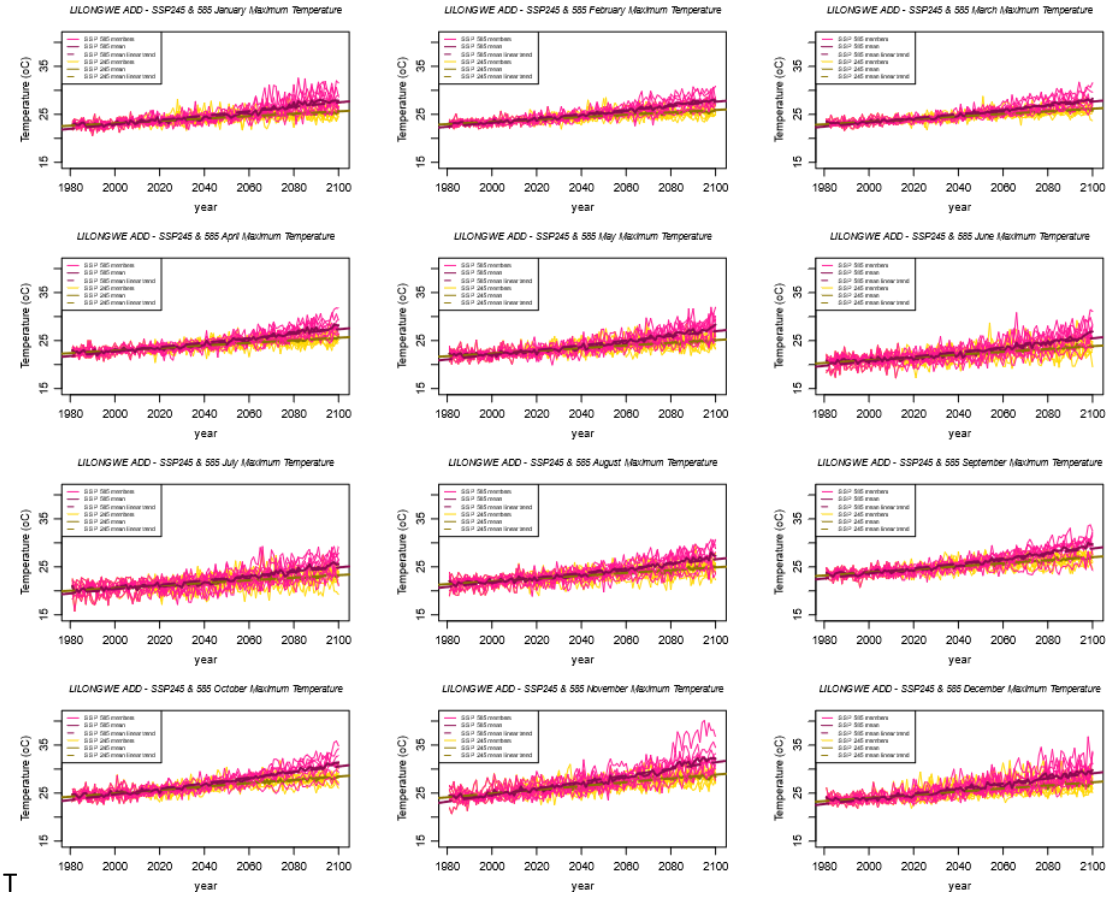

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Figure 5- 24 Monthly maximum temperature projections in Lilongwe ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 40 Characteristics of the trends from the projected maximum temperature time series by month in Lilongwe ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Lilongwe ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.02**	**0.0**	**0.9**	**0.09**	23.8 (23.4 - 24.3)	24.3 (23.8 - 25.3)	24.9 (24.1 - 26.1)
Feb	**0.02**	**0.0**	**0.92**	**0.08**	24.1 (23.6 - 24.5)	24.7 (24 - 25.3)	25.3 (24.6 - 26.2)
Mar	**0.03**	**0.0**	**0.94**	**0.07**	24.1 (23.7 - 24.6)	24.7 (24.3 - 25.2)	25.3 (24.7 - 26.5)
Apr	**0.03**	**0.0**	**0.92**	**0.07**	23.5 (23.2 - 23.8)	24.2 (23.7 - 25)	24.8 (24.2 - 25.5)
May	**0.03**	**0.0**	**0.9**	**0.09**	23 (22.7 - 23.3)	23.7 (23.3 - 24.7)	24.2 (23.2 - 25.4)
Jun	**0.03**	**0.0**	**0.89**	**0.09**	21.6 (20.8 - 22.4)	22.3 (21.3 - 23.5)	22.9 (21.3 - 24.3)

Jul	**0.03**	**0.0**	**0.85**	**0.1**	21.1 (19.9 - 22.1)	21.9 (20.4 - 23.1)	22.5 (20.8 - 24.2)
Aug	**0.03**	**0.0**	**0.9**	**0.08**	22.8 (21.9 - 23.5)	23.4 (22.2 - 24.4)	23.9 (22.2 - 24.9)
Sep	**0.03**	**0.0**	**0.93**	**0.07**	24.6 (23.9 - 25.2)	25.4 (24.6 - 26)	26 (24.8 - 26.8)
Oct	**0.04**	**0.0**	**0.94**	**0.07**	25.8 (25 - 26.4)	26.7 (25.9 - 27.4)	27.4 (26 - 28.3)
Nov	**0.04**	**0.0**	**0.92**	**0.08**	26 (24.7 - 27.6)	26.6 (25.7 - 27.8)	27.7 (26.6 - 29.2)
Dec	**0.03**	**0.0**	**0.91**	**0.08**	24.8 (23.7 - 26.5)	25.6 (24.5 - 26.9)	26.3 (24.9 - 28.3)

Lilongwe ADD SSP5.85

Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.05**	**0.0**	**0.91**	**0.09**	23.8 (23.5 - 24.3)	24.5 (23.9 - 25.3)	25.7 (24.6 - 27.2)
Feb	**0.04**	**0.0**	**0.95**	**0.07**	24.2 (23.7 - 24.7)	25.1 (24.2 - 25.9)	26.1 (24.7 - 27.5)
Mar	**0.04**	**0.0**	**0.95**	**0.06**	24.1 (23.9 - 24.4)	25 (24.5 - 25.7)	26.1 (25.1 - 27.4)
Apr	**0.05**	**0.0**	**0.92**	**0.07**	23.6 (23.3 - 24.1)	24.4 (24 - 25.3)	25.7 (24.6 - 27)
May	**0.05**	**0.0**	**0.92**	**0.08**	23 (22.1 - 23.8)	23.9 (22.8 - 25)	25.1 (24 - 26.6)
Jun	**0.05**	**0.0**	**0.91**	**0.08**	21.6 (20.5 - 22.4)	22.5 (21 - 23.7)	23.7 (22.1 - 25.5)
Jul	**0.05**	**0.0**	**0.9**	**0.08**	21.2 (19.8 - 22.1)	22 (20.3 - 23.3)	23.2 (21.7 - 25.1)
Aug	**0.05**	**0.0**	**0.93**	**0.06**	22.7 (21.7 - 23.5)	23.6 (22.5 - 24.8)	24.8 (22.8 - 26.3)
Sep	**0.05**	**0.0**	**0.94**	**0.06**	24.6 (23.9 - 25)	25.7 (24.3 - 26.3)	26.9 (24.4 - 28)
Oct	**0.06**	**0.0**	**0.96**	**0.06**	25.9 (25.4 - 26.5)	27 (25.9 - 28.1)	28.4 (26.2 - 29.6)
Nov	**0.07**	**0.0**	**0.94**	**0.07**	26.1 (25.1 - 27.3)	27.2 (25.5 - 28.9)	28.7 (26.5 - 30.7)
Dec	**0.05**	**0.0**	**0.94**	**0.07**	24.9 (24.1 - 26)	26 (25.1 - 27.5)	27.2 (25.7 - 29.3)

5.2.2.1.5 Salima ADD

The maximum temperature projection for Salima ADD is presented in Fig. 5-27 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in maximum temperature than SSP2.45 more especially during end century. The trend characteristics for

both scenarios are presented in Tab. 5-41. The monthly increasing trends are significant and are ranging from +0.02 to +0.04 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

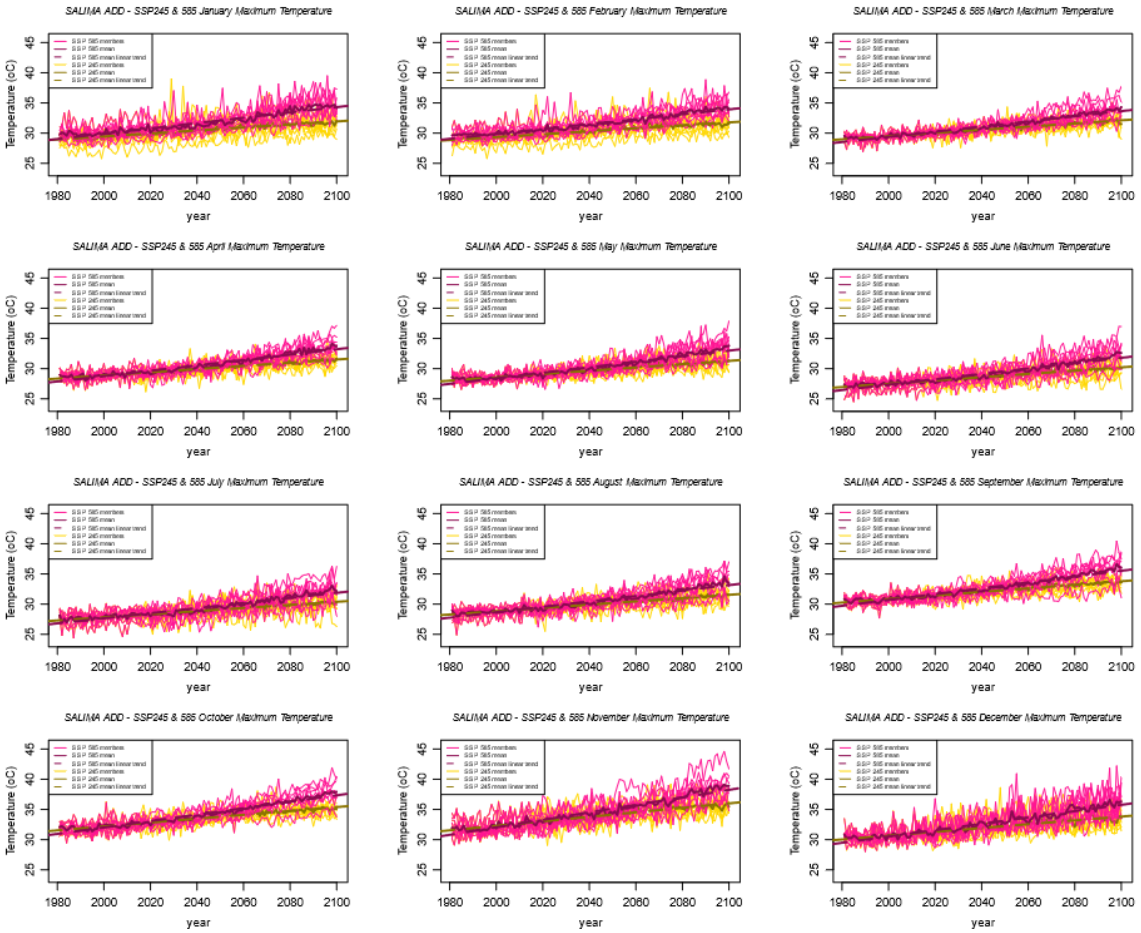


Figure 5- 25 Monthly maximum temperature projections in Salima ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 41 Characteristics of the trends from the projected maximum temperature time series by month in Salima ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Salima ADD SSP2.45							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	0.02	0.00	0.86	0.10	30.1 (27.7 - 32.5)	30.6 (28.6 - 32.7)	31.2 (29.3 - 33.2)
Feb	0.02	0.00	0.90	0.09	30.3 (29.6 - 32.1)	30.9 (30.2 - 32.6)	31.5 (30.7 - 33.1)
Mar	0.03	0.00	0.92	0.08	30.1 (29.6 - 30.4)	30.7 (30.5 - 31.3)	31.3 (30.7 - 32.3)

Apr	0.03	0.00	0.92	0.07	29.5 (29 - 30.1)	30.1 (29.4 - 30.8)	30.7 (29.6 - 31.2)
May	0.03	0.00	0.92	0.08	29.2 (28.8 - 29.6)	29.8 (29.1 - 31)	30.4 (29.5 - 31.8)
Jun	0.03	0.00	0.92	0.08	28.1 (27.4 - 29)	28.8 (27.9 - 30.1)	29.4 (27.8 - 30.8)
Jul	0.03	0.00	0.87	0.09	28.4 (27.2 - 29)	29 (27.6 - 30.4)	29.6 (28 - 31.4)
Aug	0.03	0.00	0.91	0.08	29.6 (28.9 - 30.3)	30.1 (29.2 - 31.2)	30.6 (29.2 - 31.7)
Sep	0.03	0.00	0.94	0.07	31.6 (30.8 - 32.2)	32.3 (31.5 - 33)	32.8 (31.7 - 34.1)
Oct	0.03	0.00	0.93	0.08	32.9 (31.9 - 33.9)	33.8 (33 - 34.7)	34.4 (33.2 - 36)
Nov	0.04	0.00	0.91	0.08	33.3 (31.8 - 35)	34 (32.7 - 35.3)	34.9 (33.7 - 36.7)
Dec	0.03	0.00	0.87	0.10	31.4 (30 - 32.9)	32.3 (30.9 - 33.6)	32.9 (31.6 - 34.5)
Salima ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	0.04	0.00	0.91	0.09	30.8 (29.2 - 32.3)	31.5 (30.1 - 32.7)	32.6 (31 - 33.7)
Feb	0.04	0.00	0.94	0.07	30.9 (29.8 - 32.6)	31.7 (30.3 - 33)	32.6 (30.8 - 33.6)
Mar	0.04	0.00	0.95	0.06	30.2 (29.8 - 30.5)	31 (30.6 - 31.8)	32.1 (31.2 - 33.5)
Apr	0.04	0.00	0.93	0.07	29.6 (29.1 - 30.1)	30.5 (29.7 - 31.1)	31.6 (30.2 - 32.8)

May	0.05	0.00	0.94	0.07	29.3 (28.6 - 30.1)	30.2 (29.5 - 31.3)	31.3 (30.1 - 32.9)
Jun	0.04	0.00	0.93	0.07	28.2 (27.2 - 29.1)	29 (28 - 30.3)	30.2 (28.6 - 32)
Jul	0.04	0.00	0.92	0.07	28.4 (26.9 - 29.4)	29.2 (27.5 - 30.6)	30.3 (28.6 - 32.1)
Aug	0.04	0.00	0.94	0.06	29.6 (28.6 - 30.3)	30.4 (29.5 - 31.3)	31.5 (29.7 - 32.9)
Sep	0.05	0.00	0.95	0.06	31.6 (30.9 - 32.3)	32.6 (31.2 - 33.7)	33.7 (31.3 - 35)
Oct	0.05	0.00	0.96	0.06	33.1 (32.3 - 34.3)	34.1 (33 - 35.4)	35.4 (33.3 - 37)
Nov	0.06	0.00	0.94	0.07	33.4 (32.4 - 35)	34.5 (32.7 - 36.9)	35.8 (33.8 - 38.7)
Dec	0.05	0.00	0.92	0.08	31.6 (30.5 - 32.9)	32.7 (31.4 - 33.9)	33.9 (32.4 - 35.7)

5.2.2.1.6 Shire Valley ADD

The maximum temperature projection for Shire Valley ADD is presented in Fig. 5-28 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in maximum temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-42 The monthly increasing trends are significant and are ranging from +0.03 to +0.04 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.05 to +0.07 degrees Celsius per year.

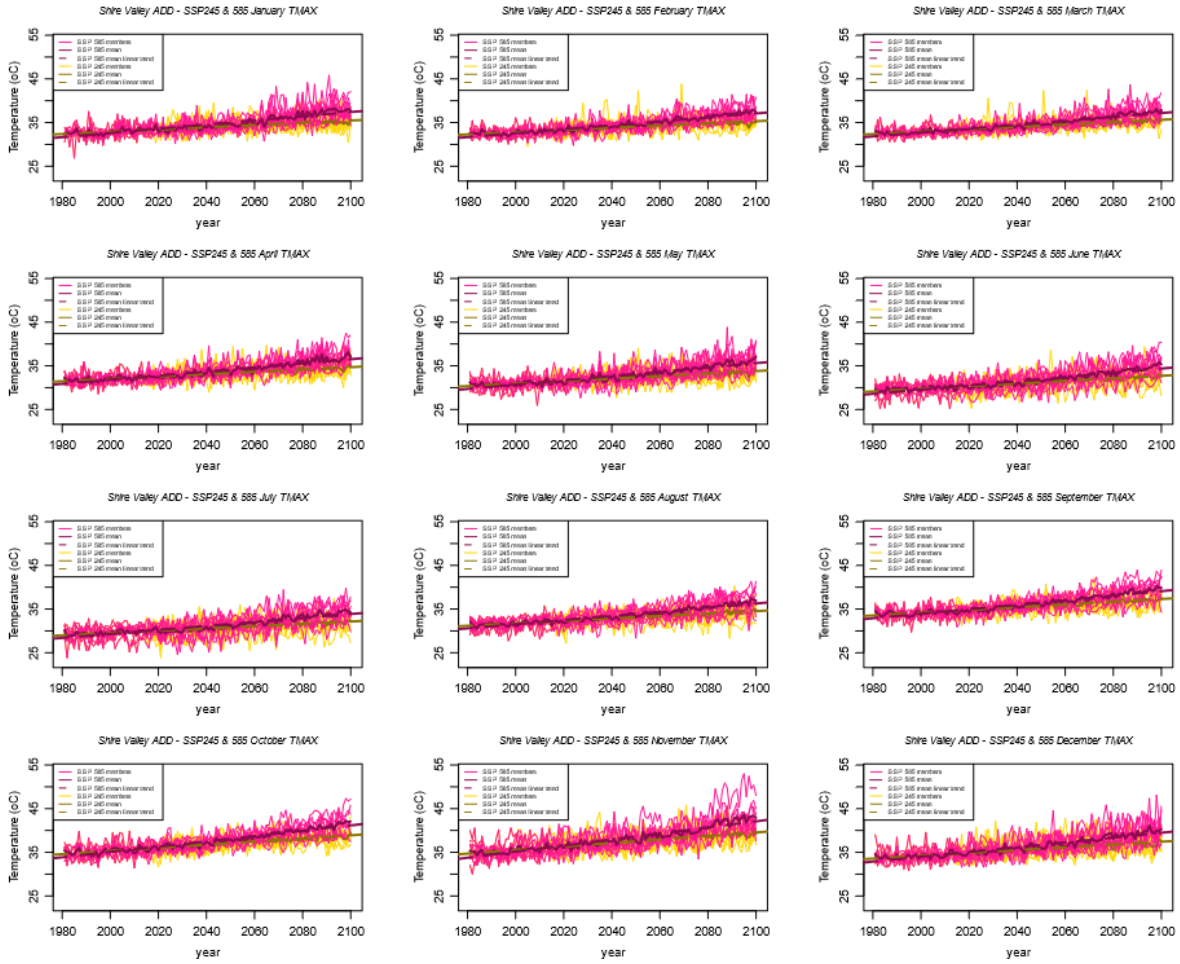


Figure 5- 26 Monthly maximum temperature projections in Shire Valley ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 42 Characteristics of the trends from the projected maximum temperature time series by month in Shire Valley ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Shire Valley ADD SSP2.45							
Month	**Slope (OC/ year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	0.026	0	0.819	0.106	33.6 (33 - 34.4)	34.1 (33.3 - 35.1)	34.7 (33.8 - 36)
Feb	0.025	0	0.787	0.115	33.4 (33.1 - 34)	34.0 (33.4 - 34.6)	34.6 (33.9 - 35.5)
Mar	0.027	0	0.838	0.109	33.5 (33.1 - 34.1)	34.2 (33.8 - 34.9)	34.8 (34 - 35.8)
Apr	0.027	0	0.818	0.104	32.6 (32.2 - 33)	33.4 (32.9 - 34.1)	33.9 (33.1 - 34.5)
May	0.029	0	0.815	0.108	31.6 (31 - 32.1)	32.3 (31.5 - 33.6)	32.9 (31.5 - 34.3)
Jun	0.03	0	0.833	0.105	30.3	31.1	31.8

					(29.2 - 31.2)	(29.8 - 32.2)	(29.7 - 33)
Jul	0.026	0	0.786	0.125	30.0 (28.2 - 31.4)	30.8 (28.7 - 32)	31.4 (29.2 - 33)
Aug	0.028	0	0.833	0.099	32.5 (31.7 - 33.4)	33.1 (32 - 34)	33.6 (31.5 - 34.8)
Sep	0.032	0	0.86	0.101	34.9 (34.1 - 35.6)	35.7 (34.8 - 36.6)	36.3 (35 - 37.7)
Oct	0.036	0	0.872	0.089	36.1 (35.3 - 36.7)	37.1 (36.1 - 37.9)	37.8 (36.3 - 39.5)
Nov	0.04	0	0.862	0.093	36.7 (35 - 39)	37.3 (36.1 - 38.3)	38.3 (36.7 - 40)
Dec	0.032	0	0.823	0.111	35.0 (33.9 - 37)	35.8 (34.6 - 37.2)	36.5 (34.7 - 38.5)
Shire Valley ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	0.048	0	0.867	0.1	33.6 (33.3 - 34.1)	34.3 (33.5 - 35.2)	35.6 (34.2 - 37.3)
Feb	0.045	0	0.907	0.083	33.6 (33.1 - 34)	34.4 (33.6 - 35)	35.4 (34.1 - 36.9)
Mar	0.045	0	0.913	0.081	33.6 (33.3 - 33.8)	34.4 (33.7 - 35.2)	35.5 (34.5 - 36.9)
Apr	0.047	0	0.88	0.085	32.7 (32.1 - 33.2)	33.6 (32.9 - 34.7)	34.8 (33.7 - 36.2)
May	0.049	0	0.88	0.09	31.6 (30.5 - 32.4)	32.6 (31 - 33.9)	33.8 (32.2 - 35.4)
Jun	0.048	0	0.892	0.082	30.4 (29.1 - 31.2)	31.4 (29.5 - 32.7)	32.6 (30.3 - 34.4)
Jul	0.046	0	0.878	0.094	30.1 (28.4 - 31.4)	30.9 (28.8 - 32.4)	32.2 (30.4 - 34.1)
Aug	0.047	0	0.918	0.072	32.5 (31.3 - 33.5)	33.4 (32.3 - 34.5)	34.5 (32.9 - 36)
Sep	0.052	0	0.915	0.078	34.9 (34.2 - 35.4)	36.0 (34.7 - 36.8)	37.2 (35 - 38.4)
Oct	0.061	0	0.928	0.071	36.3 (35.8 - 37)	37.4 (36.3 - 38.5)	38.9 (36.9 - 40.7)
Nov	0.07	0	0.905	0.083	36.7 (35.6 - 38.3)	37.8 (35.8 - 40.2)	39.2 (37 - 42.1)
Dec	0.055	0	0.897	0.083	35.1 (34.1 - 36.5)	36.1 (35.2 - 37.6)	37.4 (35.8 - 39.3)

5.2.2.1.7 Machinga ADD

The maximum temperature projection for Machinga ADD is presented in Fig. 5-29 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in maximum temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-43. The monthly increasing trends are significant and are ranging from +0.02 to +0.04 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.07 degrees Celsius per year.

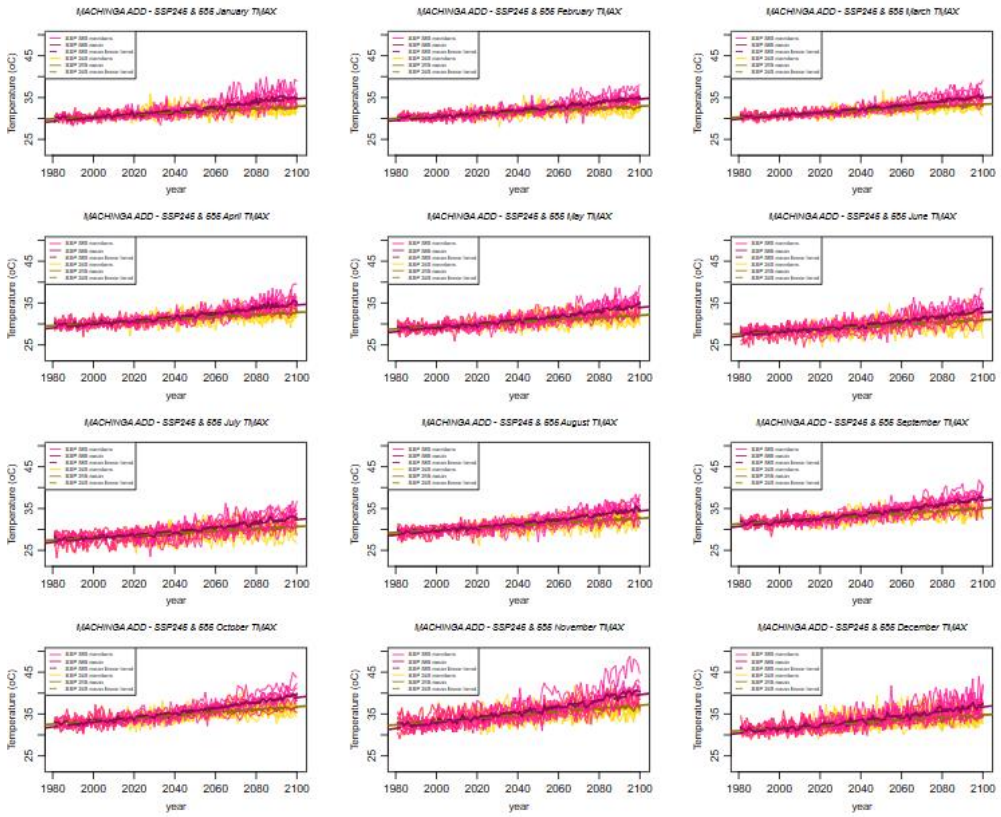


Figure 5- 27 Monthly maximum temperature projections in Machinga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 43 Characteristics of the trends from the projected maximum temperature time series by month in Machinga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Machinga ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.025**	**0**	**0.895**	**0.089**	**31 (27.4 - 34.3)**	**31.6 (27.9 - 35)**	**32.1 (28.2 - 35.7)**
Feb	**0.024**	**0**	**0.895**	**0.091**	**31.1 (27.4 - 34.3)**	**31.7 (27.8 - 35.1)**	**32.2 (28.3 - 35.8)**

Mar	**0.026**	**0**	**0.912**	**0.085**	**31.4 (28.1 - 34.3)**	**32 (28.7 - 35.1)**	**32.6 (29.1 - 35.9)**
Apr	**0.026**	**0**	**0.885**	**0.084**	**30.7 (27.1 - 33.9)**	**31.4 (27.6 - 35.1)**	**31.9 (28.1 - 35.7)**
May	**0.027**	**0**	**0.89**	**0.095**	**30 (26.5 - 33.3)**	**30.6 (26.9 - 34.2)**	**31.2 (27.4 - 34.9)**
Jun	**0.028**	**0**	**0.881**	**0.093**	**28.8 (24.9 - 32.4)**	**29.5 (25.6 - 33.3)**	**30.1 (26.2 - 34.2)**
Jul	**0.027**	**0**	**0.851**	**0.102**	**28.6 (24.3 - 32.3)**	**29.3 (24.8 - 33.2)**	**29.9 (25.5 - 34.1)**
Aug	**0.028**	**0**	**0.886**	**0.089**	**30.6 (26.7 - 33.8)**	**31.1 (27.2 - 34.5)**	**31.6 (27.6 - 35.2)**
Sep	**0.031**	**0**	**0.915**	**0.083**	**32.7 (28.4 - 36)**	**33.4 (29.3 - 36.7)**	**34 (29.9 - 37.5)**
Oct	**0.035**	**0**	**0.915**	**0.082**	**34.1 (29.4 - 37.8)**	**35 (30.5 - 38.7)**	**35.7 (31.1 - 39.4)**
Nov	**0.039**	**0**	**0.889**	**0.091**	**34.3 (29.1 - 38.8)**	**34.9 (29.6 - 39.6)**	**35.9 (30.4 - 40.7)**
Dec	**0.031**	**0**	**0.862**	**0.104**	**32.4 (28 - 37)**	**33.2 (28.6 - 38.3)**	**33.8 (29.1 - 39.3)**
Machinga ADD SSP5.85							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	**0.045**	**0**	**0.906**	**0.089**	**31.1 (27.4 - 34.3)**	**31.7 (27.9 - 35.3)**	**32.9 (28.9 - 37)**
Feb	**0.043**	**0**	**0.942**	**0.07**	**31.2 (27.5 - 34.5)**	**32.1 (28.2 - 35.4)**	**33 (28.9 - 36.7)**
Mar	**0.043**	**0**	**0.946**	**0.066**	**31.5 (28.2 - 34.3)**	**32.3 (29 - 35.3)**	**33.4 (29.8 - 36.8)**
Apr	**0.046**	**0**	**0.912**	**0.078**	**30.8 (27.1 - 34)**	**31.7 (28 - 35)**	**32.9 (29 - 36.5)**
May	**0.048**	**0**	**0.922**	**0.076**	**30 (26.5 - 33.4)**	**30.9 (27.3 - 34.5)**	**32.1 (28.3 - 35.9)**

Jun	**0.047**	**0**	**0.92**	**0.074**	**28.9 (25 - 32.6)**	**29.8 (25.9 - 33.6)**	**31 (26.8 - 35.1)**
Jul	**0.045**	**0**	**0.913**	**0.078**	**28.7 (24.4 - 32.4)**	**29.5 (25.1 - 33.4)**	**30.7 (26.2 - 35)**
Aug	**0.048**	**0**	**0.94**	**0.062**	**30.6 (26.6 - 33.8)**	**31.5 (27.5 - 34.9)**	**32.6 (28.4 - 36.4)**
Sep	**0.052**	**0**	**0.939**	**0.067**	**32.7 (28.6 - 35.9)**	**33.8 (29.6 - 37.1)**	**35 (30.7 - 38.6)**
Oct	**0.059**	**0**	**0.954**	**0.06**	**34.3 (29.7 - 37.9)**	**35.4 (30.8 - 39)**	**36.8 (32.3 - 40.6)**
Nov	**0.067**	**0**	**0.928**	**0.077**	**34.4 (29.3 - 38.8)**	**35.5 (30 - 40.4)**	**36.9 (31 - 42.3)**
Dec	**0.053**	**0**	**0.917**	**0.079**	**32.5 (28.2 - 37.1)**	**33.6 (29 - 38.5)**	**34.8 (29.9 - 40.2)**

5.2.2.1.8 Blantyre ADD

The projections for maximum temperature shows an increasing trend in Blantyre ADD for both SSP2.45 and SSP5.85 scenarios as presented in Fig. 5-30. The rate of increase is much higher for SSP5.85 scenario than for SSP2.45 scenario for all the months of the year.

As presented in Tab. 5-44, there is a significant increasing trend of maximum temperature in all the months of the year across the two scenarios. The rate of increase is ranging from +0.024 to 0.041

degrees Celsius per year in the SSP2.45 scenario, whereas +0.044 to +0.070 degrees Celsius per year in the SSP5.85 scenario.

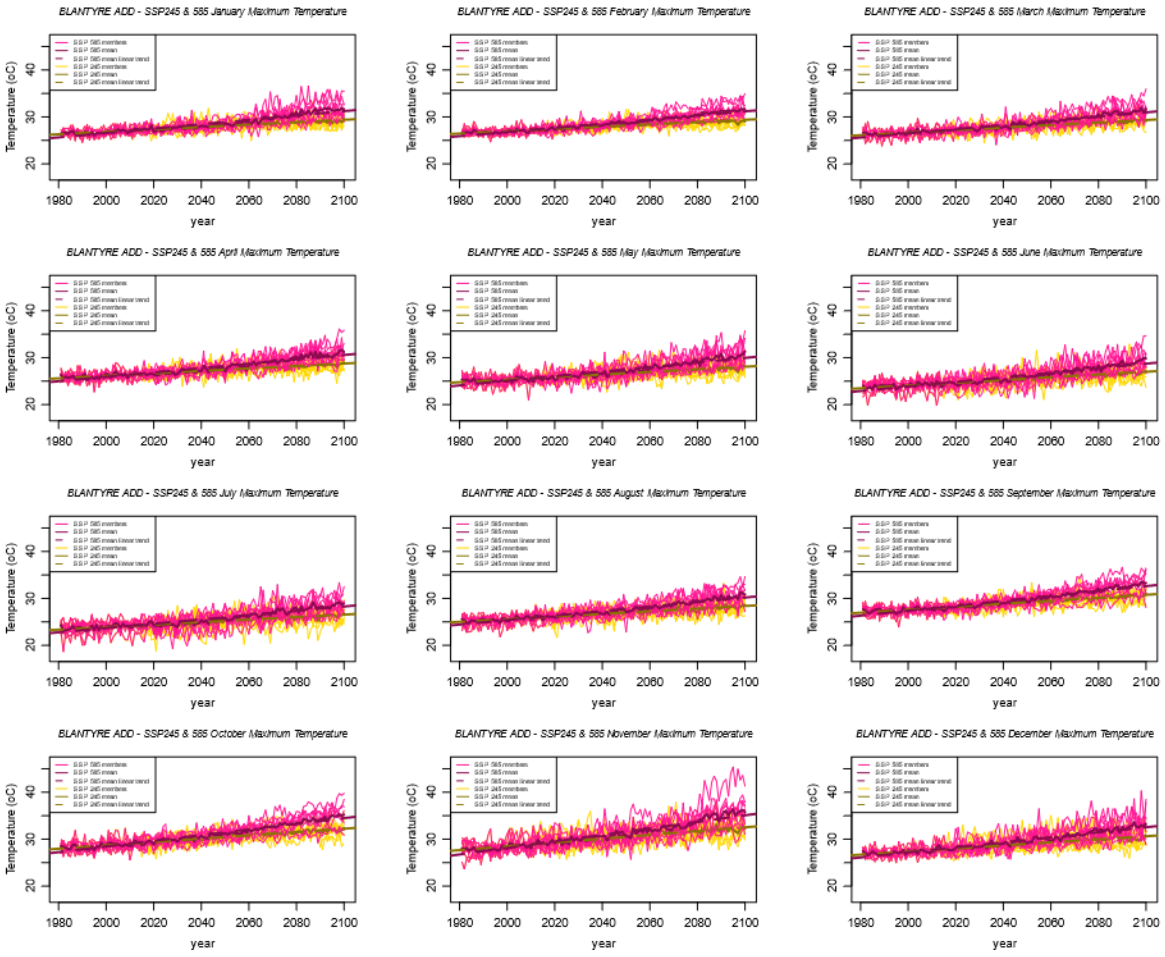


Figure 5- 28 Monthly maximum temperature projections in Blantyre ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 44 Characteristics of the trends from the projected maximum temperature time series by month in Blantyre ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Blantyre ADD SSP2.45							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^oC)**	**Mean, Range 2060 (^oC)**	**Mean, Range 2080 (^oC)**
Jan	0.026	0.000	0.915	0.076	27.5 (27.1 - 28.3)	28 (27.4 - 29)	28.6 (27.9 - 29.8)
Feb	0.024	0.000	0.902	0.086	27.6 (27.2 - 28.2)	28.2 (27.6 - 28.8)	28.8 (28 - 29.8)
Mar	0.027	0.000	0.895	0.091	27.2 (26.8 - 27.8)	27.9 (27.5 - 28.7)	28.5 (27.8 - 29.5)
Apr	0.026	0.000	0.881	0.089	26.7 (26.5 - 27.1)	27.4 (27 - 28.3)	27.9 (27.1 - 28.8)
May	0.027	0.000	0.860	0.102	26 (25.5 - 26.5)	26.7 (26 - 27.9)	27.2 (26 - 28.6)
Jun	0.029	0.000	0.856	0.098	24.7 (23.6 - 25.5)	25.4 (24.2 - 26.6)	26.1 (25.1 - 27.4)
Jul	0.027	0.000	0.816	0.116	24.4 (22.6 - 25.3)	25.1 (23.1 - 26.3)	25.8 (23.6 - 27.4)
Aug	0.028	0.000	0.865	0.096	26.4 (25.4 - 27)	26.9 (26.2 - 27.9)	27.4 (26.6 - 28.4)
Sep	0.032	0.000	0.907	0.082	28.3 (27.6 - 28.8)	29.1 (28.2 - 30)	29.8 (28.5 - 31.1)
Oct	0.036	0.000	0.915	0.078	29.5 (28.8 - 30.2)	30.4 (29.5 - 31.3)	31.2 (29.7 - 32.8)
Nov	0.041	0.000	0.898	0.082	29.6 (28.3 - 31.9)	30.3 (28.6 - 31.4)	31.3 (29.6 - 32.8)
Dec	0.033	0.000	0.896	0.091	28.2 (27.1 - 30)	28.9 (28 - 30.3)	29.7 (28.2 - 31.5)
Blantyre ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^oC)**	**Mean, Range 2060 (^oC)**	**Mean, Range 2080 (^oC)**
Jan	0.047	0.000	0.910	0.088	27.5 (27.3 - 28)	28.2 (27.4 - 29.1)	29.4 (28.3 - 31)

Feb	0.044	0.000	0.948	0.067	27.8 (27.3 - 28.3)	28.6 (27.8 - 29.2)	29.6 (28.4 - 31.1)
Mar	0.045	0.000	0.931	0.072	27.4 (27.1 - 27.7)	28.2 (27.5 - 29.1)	29.3 (28.3 - 30.8)
Apr	0.047	0.000	0.905	0.082	26.7 (26.3 - 27.4)	27.6 (27 - 28.7)	28.9 (27.8 - 30.3)
May	0.049	0.000	0.901	0.083	26 (25 - 26.8)	26.9 (25.5 - 28.2)	28.1 (27.2 - 29.8)
Jun	0.049	0.000	0.909	0.079	24.7 (23.4 - 25.5)	25.6 (23.9 - 26.8)	27 (25.8 - 28.7)
Jul	0.046	0.000	0.898	0.087	24.5 (22.8 - 25.4)	25.3 (23.2 - 26.4)	26.6 (25 - 28.2)
Aug	0.048	0.000	0.936	0.065	26.4 (25.1 - 27.1)	27.2 (26.2 - 28.2)	28.4 (26.8 - 29.7)
Sep	0.052	0.000	0.936	0.069	28.3 (27.7 - 28.8)	29.4 (28.1 - 30)	30.7 (28.5 - 31.8)
Oct	0.060	0.000	0.949	0.063	29.7 (28.7 - 30.4)	30.8 (29.4 - 31.8)	32.3 (30.3 - 34.1)
Nov	0.070	0.000	0.926	0.076	29.7 (28.9 - 31.1)	30.8 (29.1 - 33)	32.2 (30 - 34.9)
Dec	0.054	0.000	0.937	0.068	28.3 (27.5 - 29.6)	29.3 (28.3 - 30.7)	30.6 (29 - 32.5)

5.2.2.2 **Annual Maximum Temperature**

5.2.2.2.1 Karonga ADD

The annual maximum temperature trends are shown in Fig. 5-31 for Karonga ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-45. The annual maximum temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual maximum temperature increases by +1.3 and +1.5 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual maximum temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.7 degrees Celsius for SSP5.85.

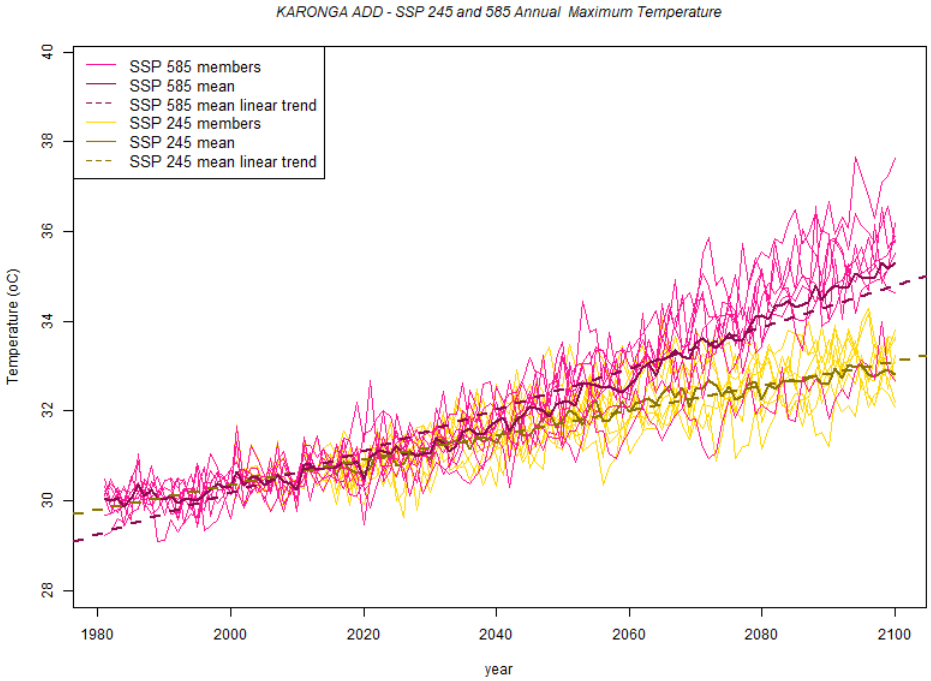


Figure 5- 29 Annual maximum temperature projections in Karonga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 45 Characteristics of the trends from the projected annual maximum temperature time series in Karonga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Karonga ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Karonga	**0.027**	**0.000**	**0.969**	**0.054**	31.0 (30.7 - 31.2)	31.7 (31.1 - 32.4)	32.3 (31.5 - 33.2)
Karonga SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**
Karonga	**0.046**	**0.000**	**0.959**	**0.061**	31.1 (30.7 - 31.5)	32.0 (31.1 - 32.5)	33.1 (31.7 - 34.0)

5.2.2.2.2 Mzuzu ADD

The annual maximum temperature trends are shown in Fig. 5-32 for Mzuzu ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-46. The annual maximum temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual maximum temperature increases by +1.3 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual maximum temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.8 degrees Celsius for SSP5.85.

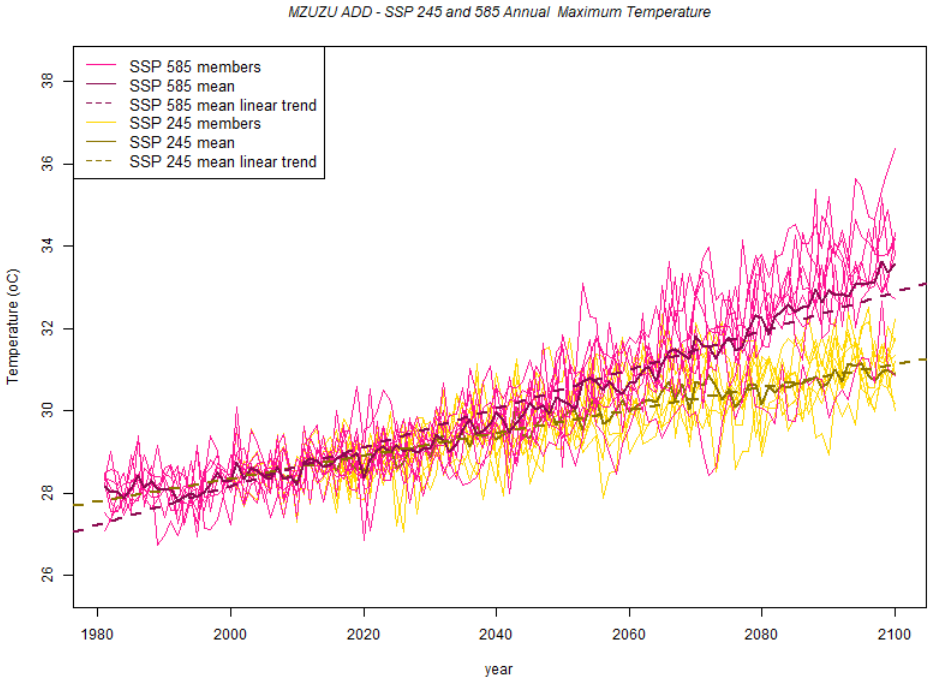


Figure 5- 30 Annual maximum temperature projections in Mzuzu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 46 Characteristics of the trends from the projected annual maximum temperature time series in Mzuzu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Mzuzu ADD SSP2.45							
	Slope (OC/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Mzuzu	**0.028**	**0**	**0.95**	**0.066**	29 (28.7 - 29.2)	29.7 (29.1 - 30.5)	30.3 (29.5 - 31.2)
Mzuzu ADD SSP5.85							
	Slope (OC/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Mzuzu	**0.05**	**0.00**	**0.95**	**0.06**	29.1 (28.7 - 29.5)	30 (29.2 - 30.6)	31.2 (29.7 - 32.2)

5.2.2.2.3 Kasungu ADD

The annual maximum temperature trends are shown in Fig. 5-33 for Kasungu ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-47. The annual maximum temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s)

with reference from 1991-2020 period. While during the mid-century (2060s) the annual maximum temperature increases by +1.3 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual maximum temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.8 degrees Celsius for SSP5.85.

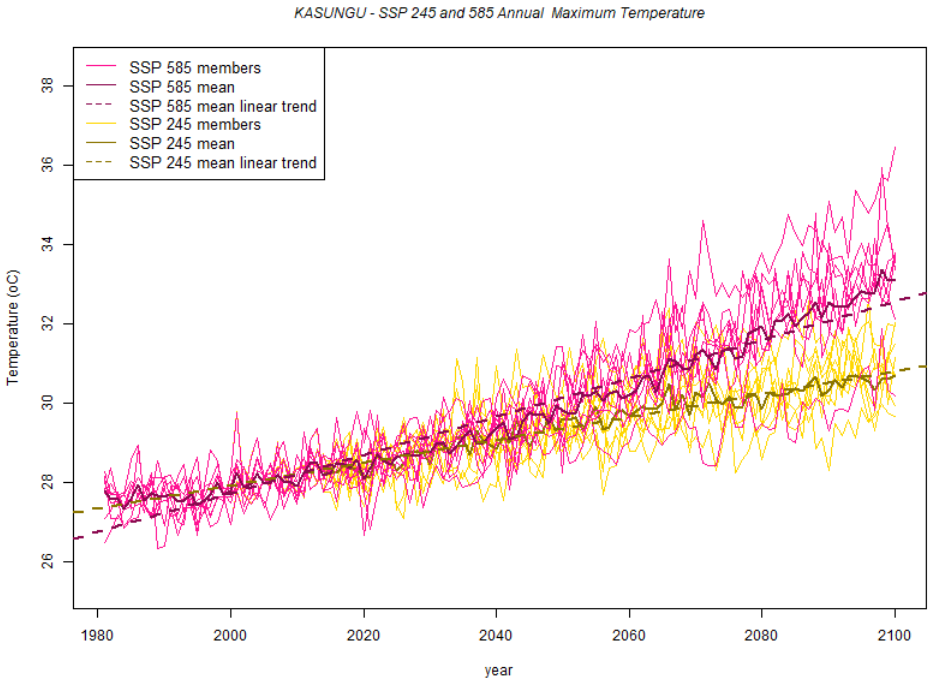


Figure 5- 31 Annual maximum temperature projections in Kasungu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 47 Characteristics of the trends from the projected annual maximum temperature time series in Kasungu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Kasungu ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Kasungu	**0.029**	**0**	**0.961**	**0.059**	**28.6 (25.1 - 31.8)**	**29.3 (25.7 - 32.7)**	**29.9 (26.2 - 33.4)**
Kasungu ADD							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Kasungu	**0.048**	**0**	**0.955**	**0.06**	**28.7 (25.2 - 31.9)**	**29.6 (26 - 33)**	**30.8 (26.8 - 34.5)**

5.2.2.2.4 Lilongwe ADD

The annual maximum temperature trends are shown in Fig. 5-34 for Lilongwe ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-48. The annual maximum temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual maximum temperature increases by +1.3 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual maximum temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.8 degrees Celsius for SSP5.85.

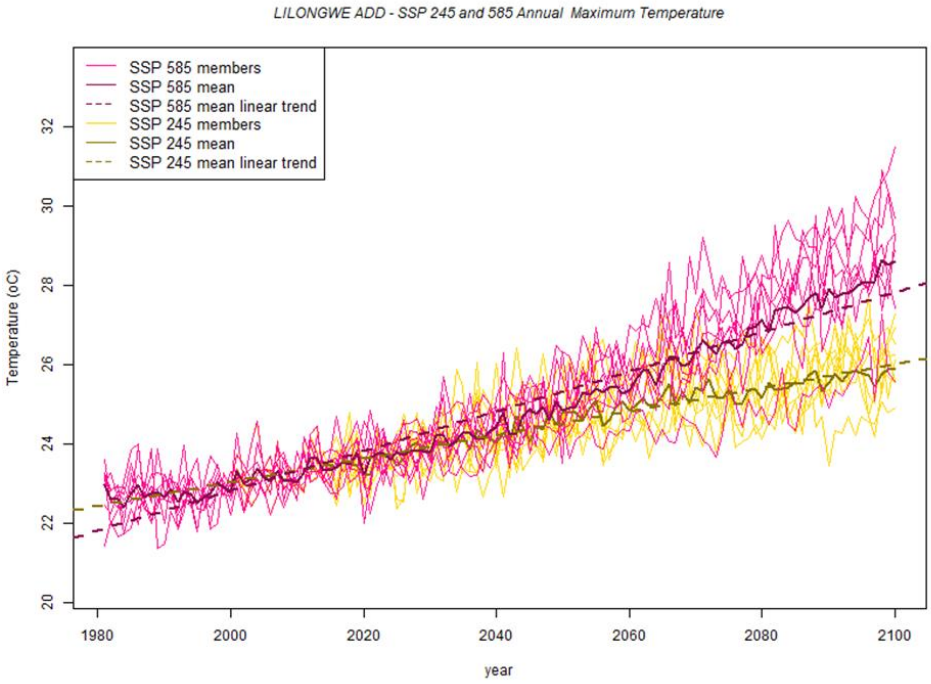


Figure 5- 32 Annual maximum temperature projections in Lilongwe ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 48 Characteristics of the trends from the projected annual maximum temperature time series in Lilongwe ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Lilongwe ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Lilongwe	**0.03**	**0**	**0.96**	**0.06**	23.7 (23.4 - 24.1)	24.5 (24 - 25.4)	25.1 (24.2 - 26.2)
Lilongwe ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Lilongwe	**0.05**	**0**	**0.95**	**0.06**	23.8 (23.5 - 24.2)	24.7 (24 - 25.5)	25.9 (24.4 - 27.2)

5.2.2.2.5 Salima ADD

The annual maximum temperature trends are shown in Fig. 5-35 for Salima ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-49. The annual maximum temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.8 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual maximum temperature increases by +1.3 and +1.7 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual maximum temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.9 degrees Celsius for SSP5.85.

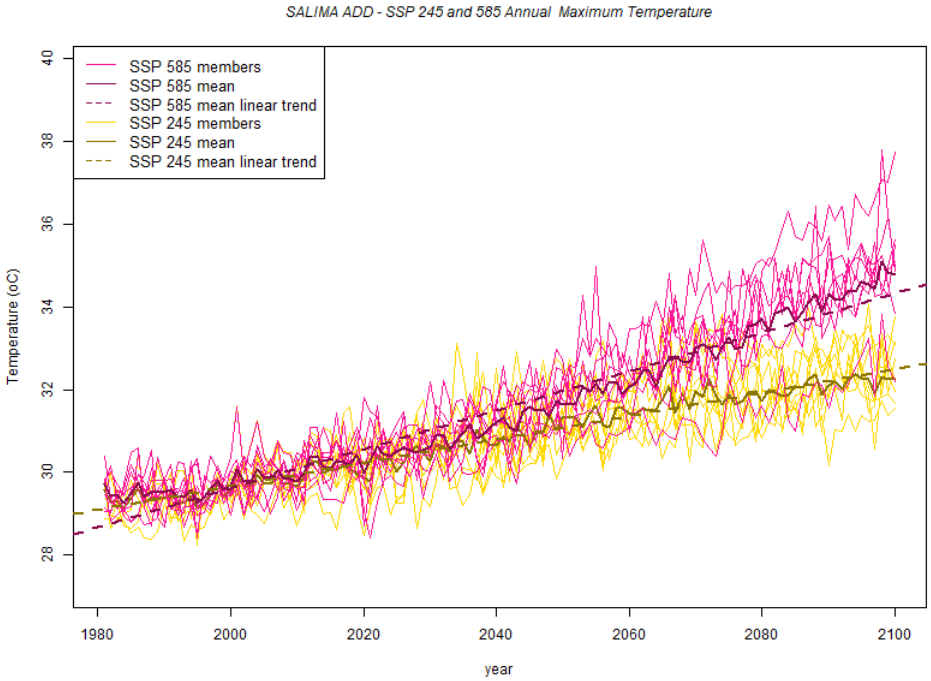


Figure 5- 33 Annual maximum temperature projections in Salima ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 49 Characteristics of the trends from the projected annual maximum temperature time series in Salima ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Salima ADD SSP2.45							
	Slope (OC/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Salima	0.03	0.00	0.96	0.06	30.4 (29.6 - 30.6)	31 (30.5 - 31.9)	31.6 (30.8 - 32.6)
Salima ADD SSP5.85							
	Slope (OC/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**

Salima	0.05	0.00	0.96	0.06	30.5 (30 - 30.9)	31.4 (30.7 - 32.1)	32.6 (31.1 - 33.8)

5.2.2.2.6 Shire Valley ADD

The annual maximum temperature trends are shown in Fig. 5-36 for Shire Valley ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-50. The annual maximum temperature increases by +0.7 degrees Celsius for both SSP2.45 (ensemble mean) and SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual maximum temperature increases by +1.4 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual maximum temperature increase during the end-century (2080s) is by +2.0 degrees Celsius for SSP2.45 and +2.9 degrees Celsius for SSP5.85.

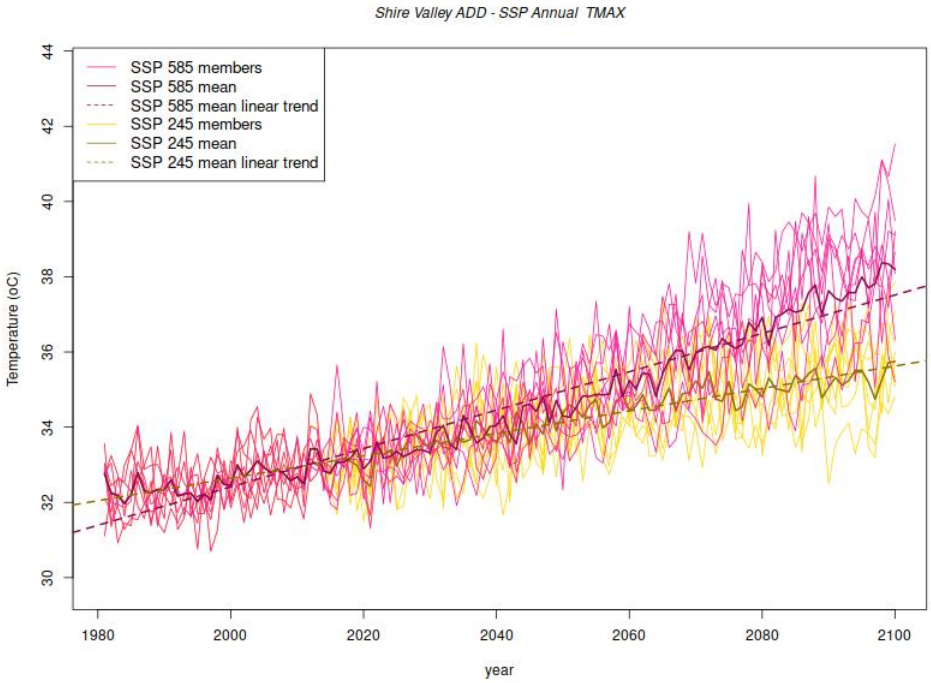


Figure 5- 34 Annual maximum temperature projections in Shire Valley ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 50 Characteristics of the trends from the projected annual maximum temperature time series in Shire Valley ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Shire Valley SSP2.45							
	Slope (°C/ year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Shire Valley	0.0298	0	0.9256	0.0777	33.3 (33 - 33.7)	34.1 (33.5 - 34.9)	34.7 (33.8 - 35.7)
Shire Valley SSP5.85							

	Slope (°C/year)	P-value	R^2	NRMSE	Mean, Range 2040 (°C)	Mean, Range 2040 (°C)	Mean, Range 2040 (°C)
Shire Valley	0.051	0	0.9376	0.0712	33.4 (33.1 - 33.8)	34.3 (33.7 - 35.1)	35.6 (34.2 - 36.9)

5.2.2.2.7 Machinga ADD

The annual maximum temperature trends are shown in Fig. 5-37 for Machinga ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-51. The annual maximum temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and 0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual maximum temperature increases by +1.3 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual maximum temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.8 degrees Celsius for SSP5.85.

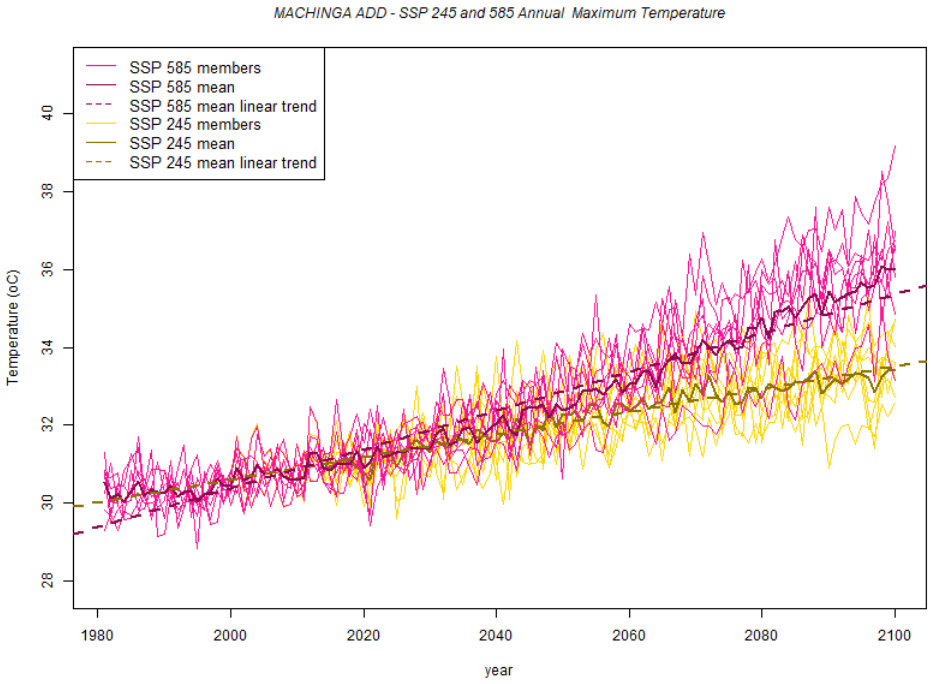


Figure 5- 35 Annual maximum temperature projections in Machinga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 51 Characteristics of the trends from the projected annual maximum temperature time series in Machinga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Machinga ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Machinga	**0.029**	**0**	**0.954**	**0.065**	**31.3 (27.3 - 34.9)**	**32 (27.9 - 35.7)**	**32.6 (28.4 - 36.5)**
Machinga 1T SSP2.45							

	Slope (°C/year)	P-value	R^2	NRMSE (%)	Mean, Range 2040 (°C)	Mean, Range 2060 (°C)	Mean, Range 2080 (°C)
Machinga	**0.05**	**0**	**0.953**	**0.063**	**31.4 (27.4 - 34.9)**	**32.3 (28.2 - 36)**	**33.5 (29.2 - 37.6)**

5.2.2.2.8 Blantyre ADD

The trend of annual maximum temperature is positive and increasing as shown in Fig. 5-38 for Blantyre ADD. The rate of increase is about +0.03 degrees Celsius per year under the SSP2.45 scenario while +0.05 degrees Celsius per year under SSP5.85.

The annual maximum temperature increases by +0.7 degrees Celsius for both SSP2.45 (ensemble mean) and SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual maximum temperature increases by +1.4 and +1.7 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual maximum temperature increase during the end-century (2080s) is by +2.0 degrees Celsius for SSP2.45 and +2.9 degrees Celsius for SSP5.85.

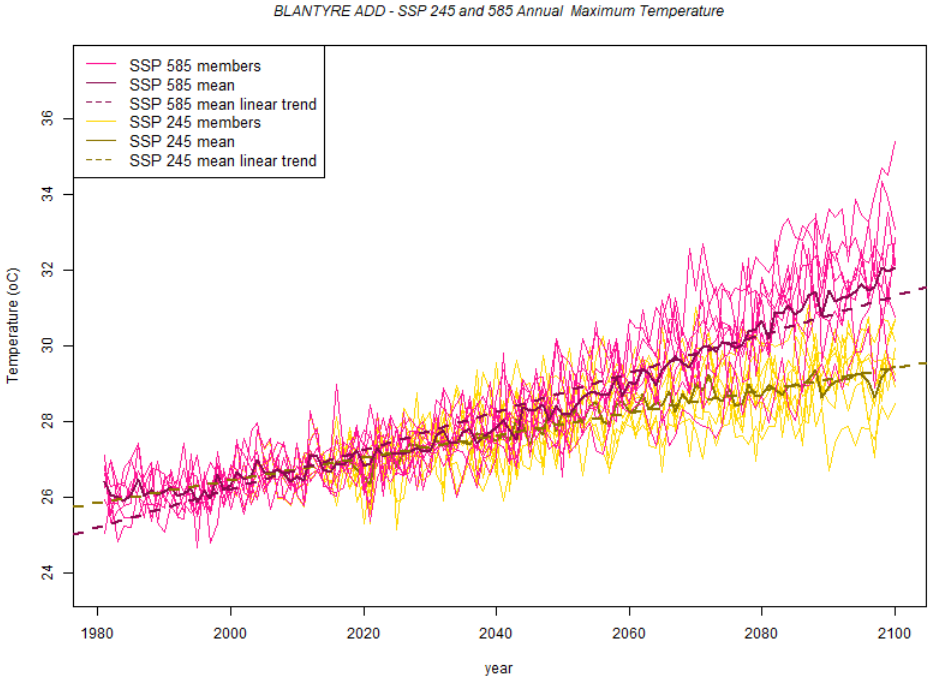


Figure 5- 36 Annual maximum temperature projections in Blantyre ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 52 Characteristics of the trends from the projected annual maximum temperature time series in Blantyre ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Blantyre ADD SSP2.45							
	Slope (OC/year)	P-value	R^2	NRMSE (%)	Mean, Range 2040 (°C)	Mean, Range 2060 (°C)	Mean, Range 2080 (°C)

Blantyre	0.03	0.00	0.95	0.07	27.1 (26.8 - 27.5)	27.9 (27.3 - 28.8)	28.5 (27.6 - 29.6)
Blantyre ADD SSP5.85							
	Slope (OC/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Blantyre	0.051	0.00	0.949	0.066	27.2 (27 - 27.7)	28.2 (27.5 - 29)	29.4 (28.1 - 30.8)

5.2.3 Probability of occurrence of temperature greater than 35 degrees Celsius

Table 5- 53 The probability of exceedance of maximum temperature greater than 35 degrees Celsius at 8 ADDS for SSP2.45 and SSP5.85 (proxy to heatwaves).

SSP2.45				
ADD	**2020**	**2040**	**2060**	**2080**
	Mean, Range	**Mean, Range**	**Mean, Range**	**Mean, Range**
Karonga				
Mzuzu				
Kasungu				
Salima				
Lilongwe				
Blantyre				
Shire Valley				
Machinga				
SSP5.85				
Karonga				
Mzuzu				
Kasungu				
Salima				
Lilongwe				
Blantyre				
Shire Valley				

Machinga				

5.3 Minimum Temperature

5.3.1 Current Minimum Temperature

5.3.1.1 Seasonal Variations

The seasonal minimum temperature according to the models from 1991-2020 is presented in Fig. 5-39. It is clearly shown that the Lilongwe ADD is the coldest which is followed by Mzuzu ADD. Karonga ADD is warmest in winter (May, June and July) and Shire Valley ADD is warmest in summer (September, October, November, December, January, February and March). The ADDs are clearly demarcated where the Salima ADD, Shire Valley ADD, Karonga ADD and Machinga ADD have similar minimum temperatures while Mzuzu ADD, Kasungu ADD and Blantyre ADD have also similar minimum temperature conditions.

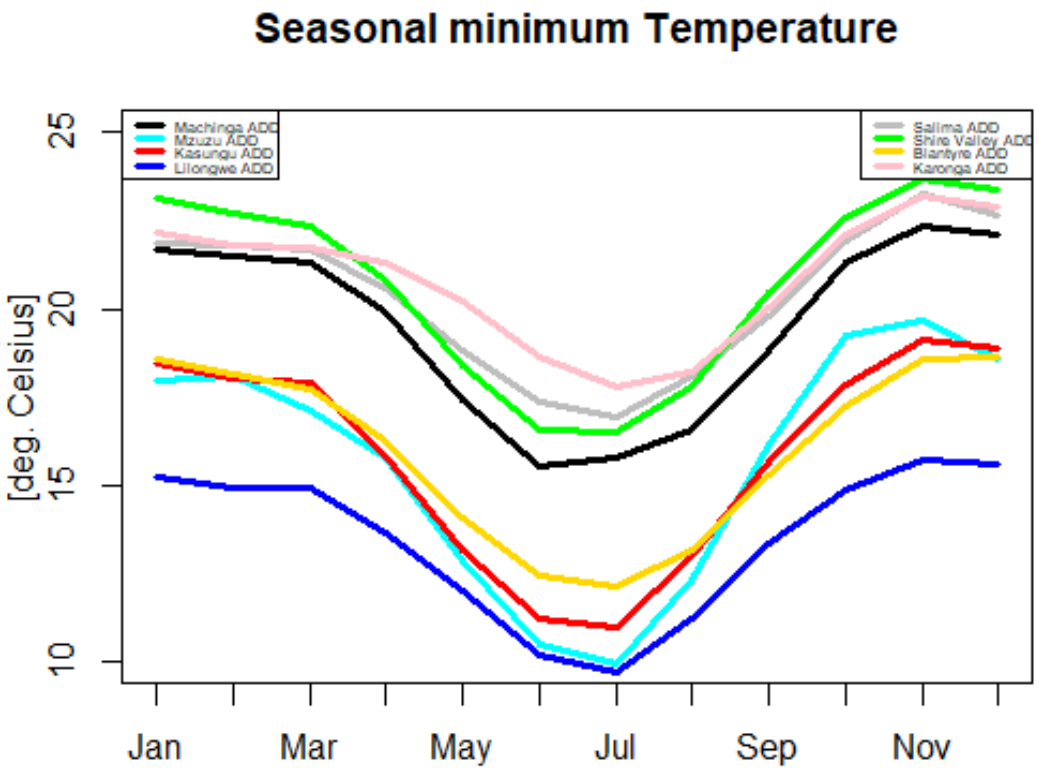


Figure 5- 37 Current (1991-2020) seasonal variations of the monthly minimum temperature in eight ADDs

5.3.1.2 Monthly Minimum Temperature

The comparison of minimum temperature for the 8 ADDs per month during 1991-2020 are presented in Fig. 5-40. Like the seasonal variations, the warmest ADD is still the Shire Valley followed by Karonga ADD, Salima ADD and Machinga ADD from September to March. While the coolest still remains Lilongwe ADD. The monthly trend characteristics for all the ADDs are presented in Tab. 5-54 to Tab. 5-61. It is shown that the minimum temperature is significantly increasing in all the ADDs at the rate between +0.02 and +0.05 degrees Celsius per year for all the months. The hottest month of November

has the highest increasing trend in all the ADDs. The lowest trend is generally in June in many of the ADDs.

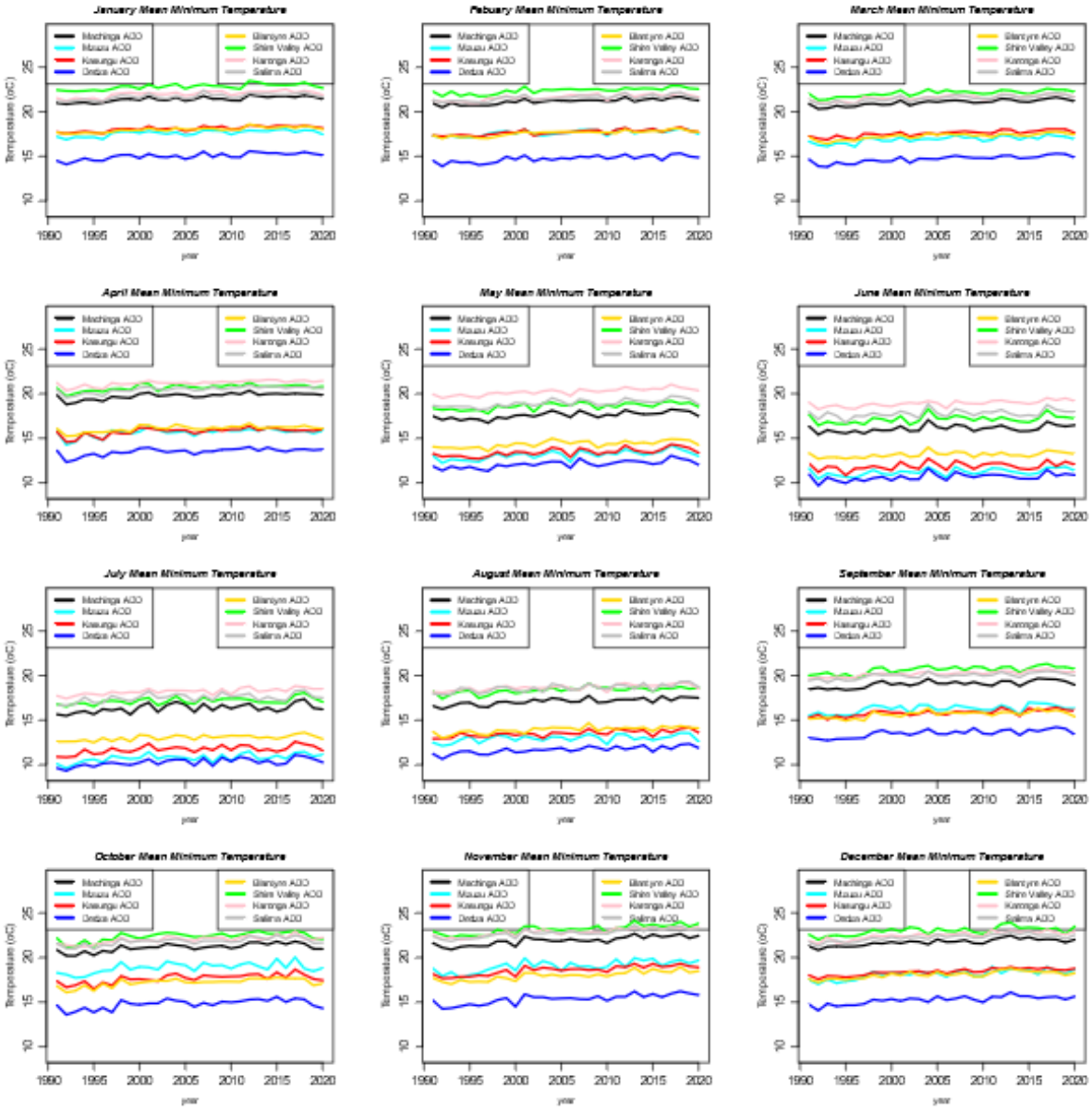


Figure 5- 38 Current- (1991-2020) monthly mean minimum temperature in the eight ADDs

*Table 5- 54 Characteristics of the trends from the current time series of minimum temperature by month in **Karonga ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.53	0.17	22.0
Feb	0.03	0.00	0.55	0.19	21.6
Mar	0.03	0.00	0.58	0.17	21.6
Apr	0.03	0.00	0.55	0.16	21.2
May	0.03	0.00	0.69	0.13	20.2
Jun	0.03	0.00	0.50	0.18	18.9
Jul	0.03	0.00	0.54	0.16	18.2
Aug	0.03	0.00	0.47	0.21	18.7
Sep	0.03	0.00	0.71	0.14	20.2
Oct	0.03	0.00	0.53	0.16	22.0
Nov	0.04	0.00	0.74	0.15	22.9
Dec	0.04	0.00	0.68	0.15	22.5

*Table 5- 55 Characteristics of the trends from the current time series of minimum temperature by month in **Mzuzu ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.48	0.20	17.6
Feb	0.02	0.00	0.43	0.23	17.6
Mar	0.03	0.00	0.48	0.18	16.9
Apr	0.03	0.00	0.25	0.18	15.6
May	0.04	0.00	0.43	0.18	13.1
Jun	0.02	0.01	0.24	0.24	11.2
Jul	0.03	0.00	0.35	0.19	10.8
Aug	0.02	0.02	0.19	0.24	13.0
Sep	0.03	0.00	0.30	0.25	16.3
Oct	0.03	0.00	0.27	0.20	18.9
Nov	0.05	0.00	0.49	0.19	19.0
Dec	0.04	0.00	0.55	0.17	18.1

*Table 5- 56 Characteristics of the trends from the current time series of minimum temperature by month in **Kasungu ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.63	0.17	18.1
Feb	0.03	0.00	0.58	0.17	17.7
Mar	0.03	0.00	0.66	0.16	17.6
Apr	0.03	0.00	0.38	0.19	15.7
May	0.03	0.00	0.44	0.20	13.4
Jun	0.02	0.05	0.13	0.21	11.9
Jul	0.03	0.00	0.36	0.20	11.7
Aug	0.03	0.00	0.50	0.19	13.5
Sep	0.03	0.00	0.54	0.17	15.8
Oct	0.04	0.00	0.44	0.17	17.6
Nov	0.05	0.00	0.70	0.16	18.6
Dec	0.04	0.00	0.77	0.12	18.4

*Table 5- 57 Characteristics of the trends from the current time series of minimum temperature by month in **Lilongwe ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.54	0.16	15.0
Feb	0.03	0.00	0.53	0.17	14.7
Mar	0.04	0.00	0.65	0.15	14.7
Apr	0.03	0.00	0.39	0.18	13.5
May	0.03	0.00	0.50	0.16	12.1
Jun	0.02	0.01	0.22	0.19	10.6
Jul	0.03	0.00	0.39	0.18	10.3
Aug	0.03	0.00	0.60	0.14	11.7
Sep	0.03	0.00	0.51	0.19	13.5
Oct	0.03	0.00	0.35	0.20	14.8
Nov	0.05	0.00	0.64	0.16	15.4
Dec	0.04	0.00	0.60	0.13	15.2

Table 5- 58 Characteristics of the trends from the current time series of minimum temperature by month in Salima ADD, significant changes are presented in bold.

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.49	0.19	21.7
Feb	0.02	0.00	0.48	0.20	21.6
Mar	0.03	0.00	0.60	0.17	21.5
Apr	0.03	0.00	0.55	0.16	20.5
May	0.03	0.00	0.47	0.19	18.9
Jun	0.02	0.04	0.15	0.19	17.8
Jul	0.03	0.01	0.25	0.23	17.5
Aug	0.03	0.00	0.43	0.21	18.6
Sep	0.03	0.00	0.49	0.18	20.0
Oct	0.03	0.00	0.43	0.19	21.8
Nov	0.04	0.00	0.69	0.14	22.8
Dec	0.03	0.00	0.61	0.15	22.2

*Table 5- 59 Characteristics of the trends from the current time series of minimum temperature by month in **Shire Valley ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.02	0.00	0.45	0.20	22.8
Feb	0.03	0.00	0.57	0.18	22.4
Mar	0.03	0.00	0.54	0.18	22.1
Apr	0.02	0.00	0.38	0.17	20.7
May	0.03	0.00	0.40	0.20	18.6
Jun	0.02	0.05	0.13	0.22	17.1
Jul	0.02	0.00	0.26	0.20	17.1
Aug	0.03	0.00	0.45	0.15	18.3
Sep	0.03	0.00	0.48	0.18	20.6
Oct	0.03	0.00	0.38	0.21	22.4
Nov	0.05	0.00	0.66	0.15	23.2
Dec	0.03	0.00	0.41	0.17	23.0

*Table 5- 60 Characteristics of the trends from the current time series of minimum temperature by month in **Machinga ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.60	0.18	21.4
Feb	0.03	0.00	0.65	0.15	21.2
Mar	0.03	0.00	0.68	0.14	21.0
Apr	0.03	0.00	0.47	0.16	19.8
May	0.03	0.00	0.48	0.18	17.6
Jun	0.02	0.01	0.22	0.20	16.1
Jul	0.03	0.01	0.24	0.22	16.3
Aug	0.03	0.00	0.57	0.16	17.1
Sep	0.03	0.00	0.48	0.21	19.1
Oct	0.04	0.00	0.49	0.19	21.1
Nov	0.05	0.00	0.68	0.15	21.9
Dec	0.03	0.00	0.65	0.17	21.7

*Table 5- 61 Characteristics of the trends from the current time series of minimum temperature by month in **Blantyre ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0.00	0.69	0.14	18.0
Feb	0.03	0.00	0.69	0.15	17.6
Mar	0.03	0.00	0.61	0.15	17.3
Apr	0.02	0.00	0.37	0.19	16.1
May	0.03	0.00	0.45	0.18	14.3
Jun	0.02	0.01	0.22	0.20	13.2
Jul	0.02	0.00	0.39	0.20	13.0
Aug	0.03	0.00	0.49	0.15	13.9
Sep	0.03	0.00	0.42	0.20	15.7
Oct	0.03	0.00	0.43	0.20	17.2
Nov	0.05	0.00	0.71	0.14	18.0
Dec	0.03	0.00	0.58	0.16	18.1

5.3.1.3 **Annual Mean Minimum Temperature**

The annual minimum temperature is also portraying the increasing trend in all the 8 ADDs. The trend characteristics are shared in Tab. 5-62. All the ADD have the uniform significant positive trend of annual minimum temperature of +0.03 degrees Celsius per year from 1991-2020.

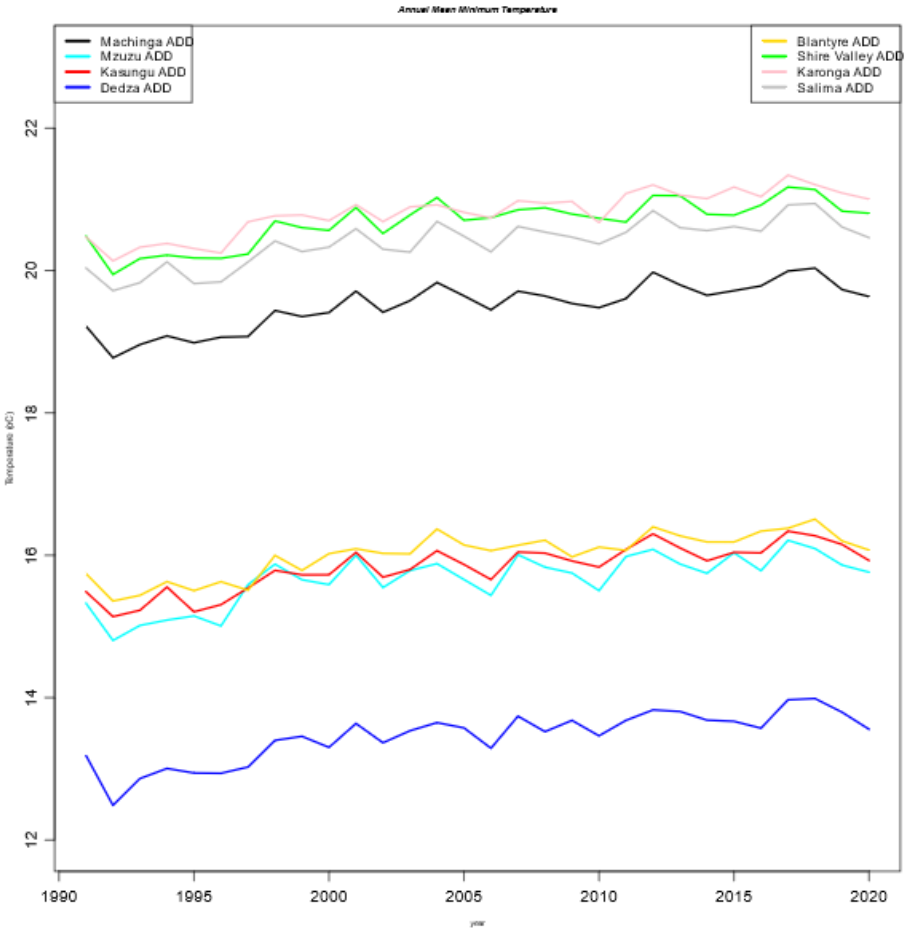


Figure 5- 39 Current (1991-2020) annual mean minimum temperature in eight ADDs

*Table 5- 62 Characteristics of the trends from the current time series of **annual minimum temperature** by month in eight target ADDs (linear models), significant changes are presented in bold.*

ADD	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Machinga	0.03	0.00	0.70	0.14	19.5
Mzuzu	0.03	0.00	0.55	0.17	15.7
Karonga	0.03	0.00	0.75	0.13	20.8
Kasungu	0.03	0.00	0.70	0.15	15.8
Salima	0.03	0.00	0.67	0.15	20.4
Lilongwe	0.03	0.00	0.69	0.13	13.5
Blantyre	0.03	0.00	0.68	0.15	16.0
Shire Valley	0.03	0.00	0.64	0.15	20.7

5.3.2 Minimum Temperature Projections

5.3.2.1 Monthly Minimum Temperature

5.3.2.1.1 Karonga ADD

The minimum temperature projection for Karonga ADD is presented in Fig. 5-42 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-63. The monthly increasing trends are significant and are around +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.05 degrees Celsius per year.

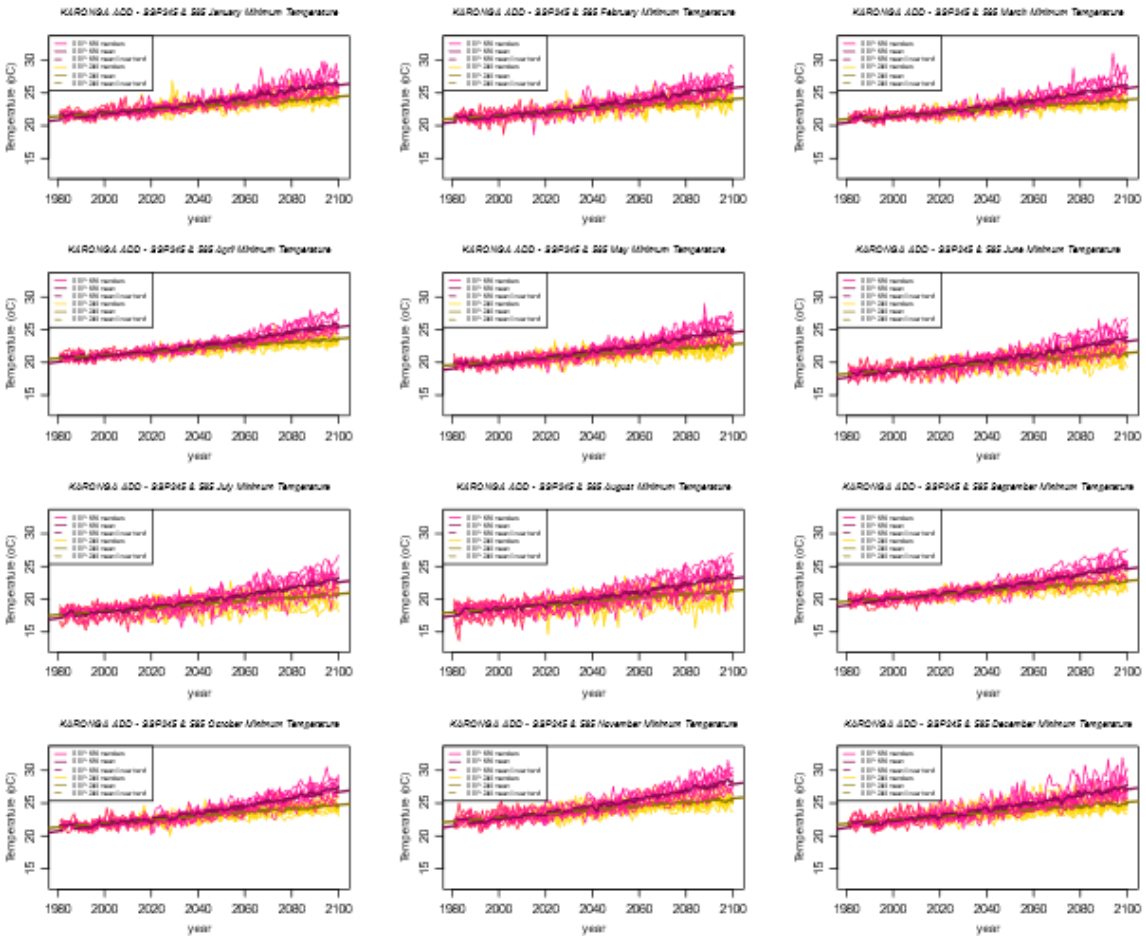


Figure 5- 40 Monthly minimum temperature projections in Karonga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 63 Characteristics of the trends from the projected minimum temperature time series by month in Karonga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Karonga ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.025**	**0.000**	**0.934**	**0.069**	22.6 (22.1 - 23.5)	23.1 (22.7 - 23.9)	23.6 (23 - 24.8)

Feb	**0.025**	**0.000**	**0.930**	**0.075**	22.2 (21.8 - 22.6)	22.8 (22.2 - 23.4)	23.4 (22.5 - 24.2)
Mar	**0.025**	**0.000**	**0.944**	**0.063**	22.1 (21.7 - 22.5)	22.7 (22.2 - 23.3)	23.2 (22.7 - 24.2)
Apr	**0.025**	**0.000**	**0.960**	**0.052**	21.7 (21.4 - 21.9)	22.3 (22.1 - 22.8)	22.8 (22.2 - 23.5)
May	**0.026**	**0.000**	**0.940**	**0.065**	20.8 (20.4 - 21.1)	21.4 (20.9 - 21.9)	21.9 (21.1 - 22.9)
Jun	**0.027**	**0.000**	**0.926**	**0.073**	19.4 (18.7 - 20)	20.1 (19.2 - 21)	20.6 (19.4 - 21.9)
Jul	**0.027**	**0.000**	**0.933**	**0.070**	18.8 (17.7 - 19.5)	19.4 (17.9 - 20.4)	20 (18.5 - 21.4)
Aug	**0.028**	**0.000**	**0.916**	**0.076**	19.2 (18.2 - 20.1)	19.9 (18.5 - 21.2)	20.5 (18.7 - 22.1)
Sep	**0.026**	**0.000**	**0.957**	**0.060**	20.9 (20.3 - 21.4)	21.4 (20.8 - 22.5)	22 (21.1 - 23.3)
Oct	**0.029**	**0.000**	**0.943**	**0.066**	22.6 (22 - 22.9)	23.2 (22.6 - 23.7)	23.8 (22.8 - 24.6)
Nov	**0.030**	**0.000**	**0.945**	**0.066**	23.6 (22.6 - 24.6)	24.2 (23.5 - 25)	24.9 (23.9 - 26.1)
Dec	**0.028**	**0.000**	**0.929**	**0.070**	23.2 (22.2 - 24.2)	23.7 (22.9 - 24.9)	24.3 (23.5 - 26)
Karonga ADD SSP5.85							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	**0.044**	**0.000**	**0.947**	**0.067**	22.6 (22.3 - 23.3)	23.4 (22.9 - 24.2)	24.5 (23.8 - 25.7)
Feb	**0.044**	**0.000**	**0.944**	**0.066**	22.3 (21.8 - 22.9)	23.2 (22.4 - 24)	24.2 (23.3 - 25.1)

Mar	**0.044**	**0.000**	**0.949**	**0.066**	22.2 (21.8 - 22.7)	23 (22.4 - 23.8)	24.1 (23.3 - 25)
Apr	**0.044**	**0.000**	**0.952**	**0.061**	21.8 (21.4 - 22.1)	22.7 (22.1 - 23.3)	23.7 (23 - 24.7)
May	**0.046**	**0.000**	**0.952**	**0.065**	20.9 (20.6 - 21.2)	21.8 (21.4 - 22.2)	22.8 (21.9 - 23.7)
Jun	**0.046**	**0.000**	**0.943**	**0.068**	19.5 (18.6 - 20.2)	20.4 (19.5 - 21.2)	21.4 (20.1 - 23)
Jul	**0.046**	**0.000**	**0.954**	**0.060**	18.9 (17.8 - 19.7)	19.8 (18.4 - 20.8)	20.8 (19.5 - 22.4)
Aug	**0.047**	**0.000**	**0.951**	**0.061**	19.4 (18.3 - 20.3)	20.3 (19.2 - 21.6)	21.4 (20.2 - 23.4)
Sep	**0.046**	**0.000**	**0.951**	**0.064**	20.9 (20.4 - 21.4)	21.7 (21.2 - 22.6)	22.9 (21.8 - 24.3)
Oct	**0.050**	**0.000**	**0.952**	**0.061**	22.7 (22.1 - 23.1)	23.6 (22.9 - 24.1)	24.8 (23.6 - 25.7)
Nov	**0.053**	**0.000**	**0.955**	**0.061**	23.6 (23.1 - 24.4)	24.6 (23.7 - 25.6)	25.9 (24.7 - 27.1)
Dec	**0.049**	**0.000**	**0.955**	**0.059**	23.2 (22.5 - 24.2)	24.2 (23.3 - 25.4)	25.3 (24.6 - 27)

5.3.2.1.2 Mzuzu ADD

The minimum temperature projection for Mzuzu ADD is presented in Fig. 5-43 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-64. The monthly increasing trends are significant and are ranging

from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

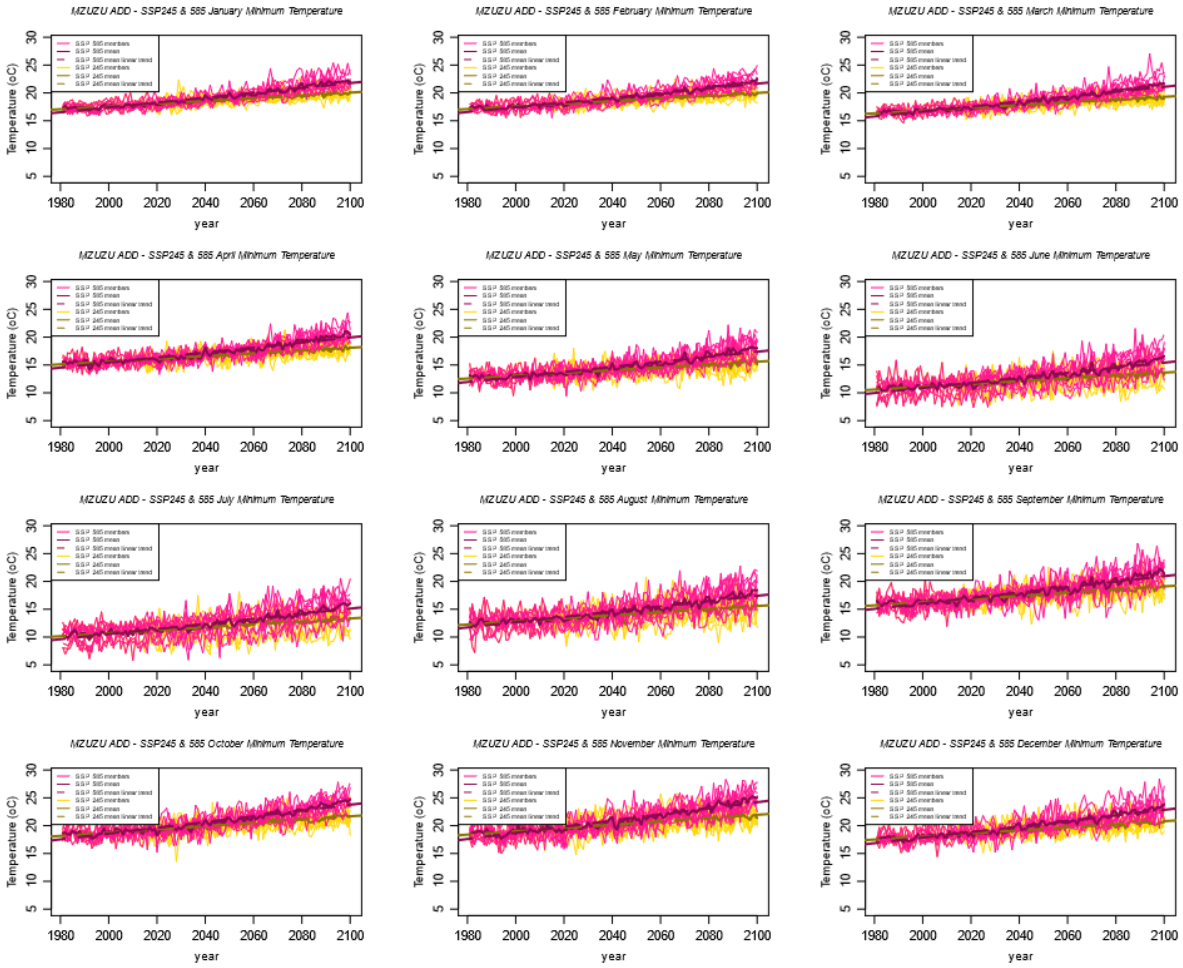


Figure 5- 41 Monthly minimum temperature projections in Mzuzu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 64 Characteristics of the trends from the projected minimum temperature time series by month in Mzuzu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Mzuzu ADD SSP2.45							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.02**	**0.00**	**0.93**	**0.07**	18.2 (17.6 - 19.4)	18.7 (18.2 - 19.9)	19.3 (18.5 - 20.7)
Feb	**0.02**	**0.00**	**0.92**	**0.08**	18.2 (17.5 - 19.2)	18.7 (17.8 - 19.9)	19.3 (18.2 - 20.7)
Mar	**0.02**	**0.00**	**0.92**	**0.07**	17.4 (17 - 18.1)	18 (17.4 - 18.9)	18.6 (17.9 - 19.8)

Apr	**0.02**	**0.00**	**0.88**	**0.08**	16.2 (15.8 - 16.4)	16.8 (16.4 - 17.4)	17.3 (16.6 - 18.3)
May	**0.03**	**0.00**	**0.85**	**0.09**	13.7 (13.1 - 14.3)	14.2 (13.3 - 15)	14.8 (13.5 - 16.1)
Jun	**0.03**	**0.00**	**0.84**	**0.10**	11.6 (10.2 - 12.7)	12.3 (10.8 - 13.6)	12.8 (10.9 - 14.5)
Jul	**0.03**	**0.00**	**0.86**	**0.09**	11.3 (9.5 - 12.6)	11.9 (9.6 - 13.2)	12.5 (10.3 - 14.3)
Aug	**0.03**	**0.00**	**0.82**	**0.11**	13.5 (11.9 - 14.6)	14.1 (12.3 - 15.4)	14.7 (12.8 - 16.2)
Sep	**0.03**	**0.00**	**0.82**	**0.11**	17 (16.5 - 17.4)	17.7 (17.1 - 18.6)	18.2 (17.3 - 19.2)
Oct	**0.03**	**0.00**	**0.85**	**0.10**	19.4 (18.2 - 20.2)	20.1 (19.2 - 20.9)	20.8 (19.5 - 21.9)
Nov	**0.03**	**0.00**	**0.83**	**0.10**	19.8 (18.1 - 21.5)	20.4 (19.1 - 21.9)	21.1 (19.8 - 22.5)
Dec	**0.03**	**0.00**	**0.88**	**0.09**	18.8 (17.8 - 20.1)	19.4 (18.6 - 20.8)	19.9 (18.9 - 21.9)
Mzuzu ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	**0.04**	**0.00**	**0.94**	**0.07**	**18.2 (17.7 - 19.2)**	**19.1 (18.4 - 20.1)**	**20.1 (19.3 - 21.6)**
Feb	**0.04**	**0.00**	**0.94**	**0.07**	**18.2 (17.5 - 19.4)**	**19.1 (18.1 - 20.5)**	**20.1 (18.9 - 21.5)**
Mar	**0.04**	**0.00**	**0.93**	**0.07**	**17.5 (17 - 18.3)**	**18.4 (17.7 - 19.4)**	**19.4 (18.5 - 20.7)**
Apr	**0.05**	**0.00**	**0.90**	**0.07**	**16.3 (16 - 16.6)**	**17.1 (16.7 - 17.8)**	**18.2 (17.6 - 19.3)**

May	**0.05**	**0.00**	**0.90**	**0.09**	**13.7 (13 - 14.4)**	**14.6 (13.8 - 15.3)**	**15.6 (14.1 - 16.7)**
Jun	**0.05**	**0.00**	**0.89**	**0.09**	**11.7 (10.1 - 12.9)**	**12.6 (11.1 - 13.9)**	**13.6 (11.6 - 15.5)**
Jul	**0.05**	**0.00**	**0.91**	**0.08**	**11.4 (9.6 - 12.6)**	**12.3 (10.1 - 13.7)**	**13.3 (11.3 - 15.1)**
Aug	**0.05**	**0.00**	**0.90**	**0.08**	**13.6 (12.3 - 14.7)**	**14.5 (13.1 - 15.9)**	**15.6 (14 - 17.4)**
Sep	**0.05**	**0.00**	**0.88**	**0.09**	**17 (16.6 - 17.4)**	**18 (17.3 - 19)**	**19.1 (17.8 - 20.2)**
Oct	**0.05**	**0.00**	**0.92**	**0.08**	**19.5 (18.7 - 20.5)**	**20.6 (19.7 - 21.3)**	**21.8 (20.3 - 22.8)**
Nov	**0.06**	**0.00**	**0.90**	**0.08**	**19.8 (18.7 - 21.3)**	**20.8 (19.6 - 22.1)**	**22.2 (20.8 - 23.5)**
Dec	**0.05**	**0.00**	**0.93**	**0.07**	**18.8 (18 - 20.1)**	**19.9 (18.8 - 21.4)**	**21 (20 - 23)**

5.3.2.1.3 Kasungu ADD

The minimum temperature projection for Kasungu ADD is presented in Fig. 5-44 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-65. The monthly increasing trends are significant and are around +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

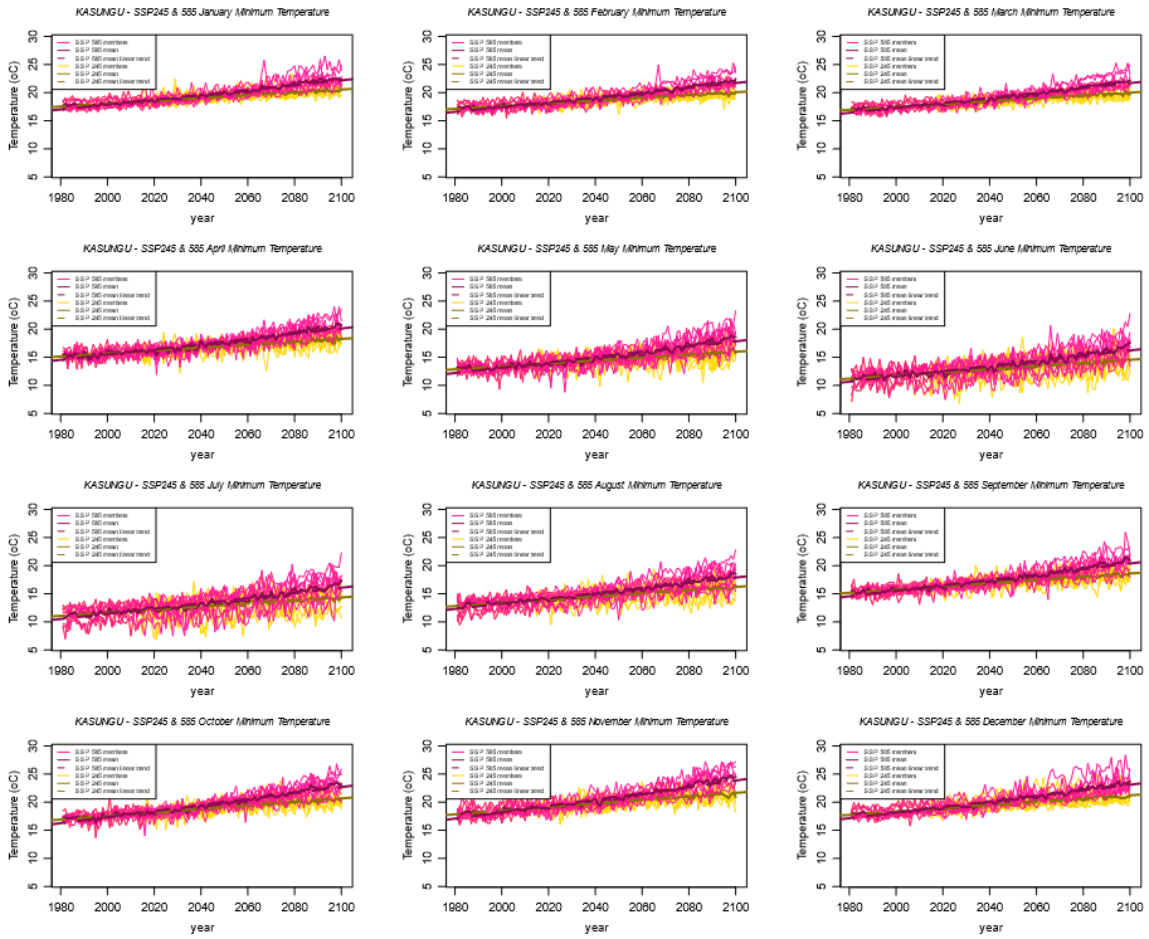


Figure 5- 42 Monthly minimum temperature projections in Kasungu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 65 Characteristics of the trends from the projected minimum temperature time series by month in Kasungu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Kasungu ADD SSP2.45							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.025**	**0**	**0.957**	**0.06**	18.7 (18.1 - 19.8)	19.2 (18.7 - 20.3)	19.8 (19.1 - 21.3)
Feb	**0.025**	**0**	**0.95**	**0.066**	18.2 (17.7 - 19.1)	18.8 (18.2 - 19.8)	19.4 (18.6 - 20.6)
Mar	**0.026**	**0**	**0.949**	**0.061**	18.1 (17.6 - 18.7)	18.6 (18.1 - 19.4)	19.2 (18.6 - 20.2)
Apr	**0.026**	**0**	**0.89**	**0.077**	16.3 (16 - 16.6)	16.9 (16.5 - 17.5)	17.4 (16.5 - 18.2)

May	**0.026**	**0**	**0.878**	**0.089**	14 (13.3 - 14.9)	14.6 (13.6 - 15.8)	15.1 (13.8 - 16.7)
Jun	**0.028**	**0**	**0.867**	**0.085**	12.4 (10.7 - 13.5)	13.1 (11.5 - 14.6)	13.6 (11.6 - 15.3)
Jul	**0.027**	**0**	**0.879**	**0.096**	12.3 (10.6 - 13.4)	12.9 (10.8 - 14.3)	13.5 (11.2 - 15.2)
Aug	**0.028**	**0**	**0.91**	**0.074**	14.1 (13 - 15)	14.8 (13.5 - 16)	15.3 (13.6 - 16.9)
Sep	**0.029**	**0**	**0.922**	**0.077**	16.5 (15.9 - 17.1)	17.2 (16.5 - 18.1)	17.7 (16.8 - 19.1)
Oct	**0.031**	**0**	**0.912**	**0.079**	18.3 (17.6 - 18.7)	19.1 (18.5 - 19.7)	19.7 (18.7 - 20.7)
Nov	**0.032**	**0**	**0.931**	**0.074**	19.3 (18.4 - 20.5)	20 (19.2 - 21.1)	20.7 (19.8 - 22.1)
Dec	**0.029**	**0**	**0.944**	**0.067**	19.1 (18 - 20.5)	19.7 (18.8 - 21.2)	20.3 (19.5 - 22.5)
Kasungu ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^oC)**	**Mean, Range 2060 (^oC)**	**Mean, Range 2080 (^oC)**
Jan	**0.043**	**0**	**0.951**	**0.066**	18.7 (18.2 - 19.8)	19.5 (18.9 - 20.6)	20.6 (19.7 - 22.2)
Feb	**0.043**	**0**	**0.95**	**0.065**	18.3 (17.7 - 19.3)	19.1 (18.5 - 20.3)	20.2 (19.2 - 21.5)
Mar	**0.044**	**0**	**0.953**	**0.064**	18.1 (17.6 - 18.9)	19 (18.4 - 19.9)	20.1 (19.3 - 21.2)
Apr	**0.046**	**0**	**0.92**	**0.074**	16.3 (16.1 - 16.7)	17.2 (16.8 - 18)	18.4 (17.5 - 19.6)
May	**0.047**	**0**	**0.915**	**0.081**	14 (13.1 - 15)	14.9 (13.8 - 16.1)	16 (14.2 - 17.8)

Jun	**0.046**	**0**	**0.901**	**0.079**	12.5 (10.7 - 13.7)	13.3 (11.7 - 14.7)	14.4 (12.3 - 16.5)
Jul	**0.046**	**0**	**0.924**	**0.07**	12.4 (10.3 - 13.5)	13.2 (11 - 14.7)	14.3 (12.2 - 16.2)
Aug	**0.047**	**0**	**0.951**	**0.058**	14.2 (12.9 - 15.1)	15.1 (13.8 - 16.2)	16.2 (14.8 - 18.1)
Sep	**0.049**	**0**	**0.942**	**0.064**	16.5 (15.8 - 17.1)	17.4 (16.8 - 18.3)	18.6 (17.4 - 20.2)
Oct	**0.054**	**0**	**0.949**	**0.061**	18.4 (17.8 - 18.9)	19.4 (18.9 - 20)	20.7 (19.4 - 21.7)
Nov	**0.056**	**0**	**0.946**	**0.066**	19.4 (18.7 - 20.5)	20.4 (19.3 - 21.6)	21.7 (20.2 - 23.2)
Dec	**0.05**	**0**	**0.958**	**0.058**	19.1 (18.2 - 20.5)	20.2 (19.1 - 21.7)	21.3 (20.3 - 23.5)

5.3.2.1.4 Lilongwe ADD

The minimum temperature projection for Lilongwe ADD is presented in Fig. 5-45 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-66 The monthly increasing trends are significant and are ranging from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

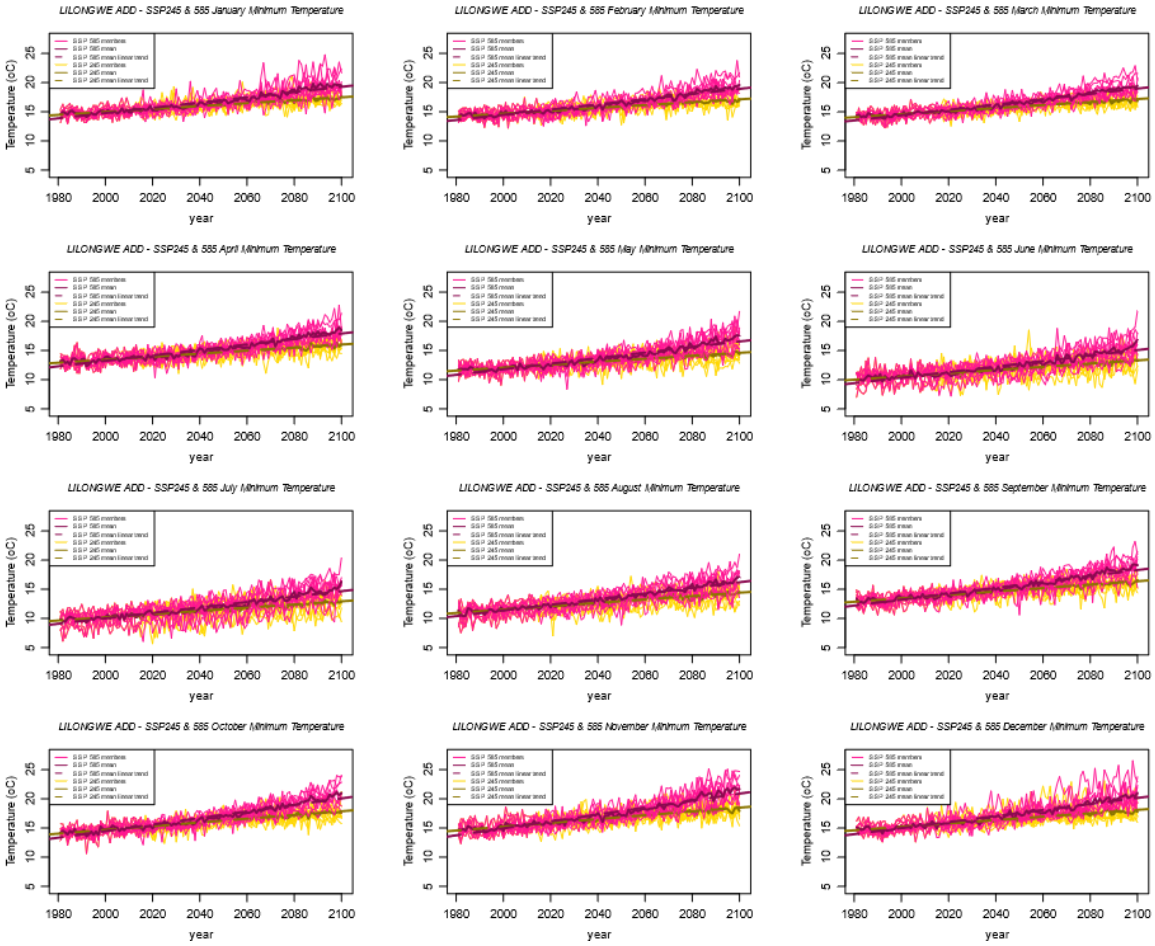


Figure 5- 43 Monthly minimum temperature projections in Lilongwe ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 66 Characteristics of the trends from the projected minimum temperature time series by month in Lilongwe ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Lilongwe ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.03**	**0.0**	**0.92**	**0.07**	15.6 (15.2 - 16.5)	16.5 (15.9 - 17.7)	17.6 (16.7 - 19.2)
Feb	**0.02**	**0.0**	**0.91**	**0.08**	15.3 (15 - 16.4)	16.2 (15.7 - 17.5)	17.3 (16.4 - 18.8)
Mar	**0.03**	**0.0**	**0.93**	**0.07**	15.3 (14.8 - 16)	16.2 (15.7 - 17.1)	17.3 (16.6 - 18.3)
Apr	**0.03**	**0.0**	**0.9**	**0.07**	14.1 (13.7 - 14.4)	15 (14.7 - 15.7)	16.1 (15.3 - 17.1)
May	**0.03**	**0.0**	**0.89**	**0.09**	12.7 (12.1 - 13.4)	13.6 (12.7 - 14.4)	14.7 (13.2 - 15.9)
Jun	**0.03**	**0.0**	**0.89**	**0.08**	11.3 (10 - 12)	12.1 (10.9 - 13.2)	13.3 (11.6 - 14.8)

Jul	**0.03**	**0.0**	**0.89**	**0.09**	11 (9.1 - 11.9)	11.7 (9.8 - 12.9)	12.9 (10.9 - 14.5)
Aug	**0.03**	**0.0**	**0.89**	**0.08**	12.4 (11.2 - 13.1)	13.3 (12.1 - 14.2)	14.5 (13.1 - 15.9)
Sep	**0.03**	**0.0**	**0.91**	**0.08**	14.2 (13.4 - 14.7)	15.2 (14.4 - 16)	16.4 (15.2 - 17.9)
Oct	**0.03**	**0.0**	**0.91**	**0.08**	15.5 (15.2 - 16)	16.6 (16.1 - 17.3)	18 (16.7 - 18.8)
Nov	**0.03**	**0.0**	**0.91**	**0.08**	16.2 (15.5 - 17.1)	17.2 (16.1 - 18.3)	18.6 (17 - 20)
Dec	**0.03**	**0.0**	**0.91**	**0.07**	16 (15.2 - 17.2)	17.1 (16.3 - 18.6)	18.2 (17.1 - 20.5)

Lilongwe ADD SSP2.45

Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.05**	**0.0**	**0.93**	**0.08**	15.6 (15 - 16.7)	16.1 (15.7 - 17.3)	16.7 (16.1 - 18.2)
Feb	**0.04**	**0.0**	**0.94**	**0.07**	15.3 (14.8 - 16.2)	15.9 (15.2 - 16.9)	16.4 (15.8 - 17.7)
Mar	**0.05**	**0.0**	**0.95**	**0.06**	15.2 (14.6 - 15.8)	15.8 (15.4 - 16.5)	16.4 (16 - 17.4)
Apr	**0.05**	**0.0**	**0.92**	**0.07**	14 (13.5 - 14.4)	14.7 (14.3 - 15.2)	15.2 (14.5 - 16)
May	**0.05**	**0.0**	**0.92**	**0.08**	12.7 (12.3 - 13.2)	13.3 (12.6 - 14.1)	13.8 (12.8 - 14.9)
Jun	**0.05**	**0.0**	**0.91**	**0.07**	11.2 (10 - 12)	11.9 (10.7 - 13.2)	12.4 (10.8 - 13.7)
Jul	**0.05**	**0.0**	**0.92**	**0.07**	10.9 (9.4 - 11.7)	11.5 (9.9 - 12.7)	12 (10 - 13.7)
Aug	**0.05**	**0.0**	**0.95**	**0.06**	12.2 (11.2 - 13)	12.9 (11.9 - 14)	13.5 (12 - 14.9)
Sep	**0.05**	**0.0**	**0.94**	**0.07**	14.2 (13.5 - 14.7)	14.9 (14.2 - 15.6)	15.4 (14.5 - 16.6)
Oct	**0.06**	**0.0**	**0.94**	**0.06**	15.4 (14.9 - 15.7)	16.3 (15.8 - 16.8)	16.9 (16 - 17.7)
Nov	**0.06**	**0.0**	**0.93**	**0.07**	16.1 (15 - 17)	16.7 (16 - 17.5)	17.5 (16.7 - 19)
Dec	**0.05**	**0.0**	**0.94**	**0.06**	15.9 (15 - 17.3)	16.6 (15.7 - 18)	17.2 (16.4 - 19.5)

5.3.2.1.5 Salima ADD

The minimum temperature projection for Salima ADD is presented in Fig. 5-46 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both

scenarios are presented in Tab. 5-67 The monthly increasing trends are significant and are ranging from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.05 degrees Celsius per year.

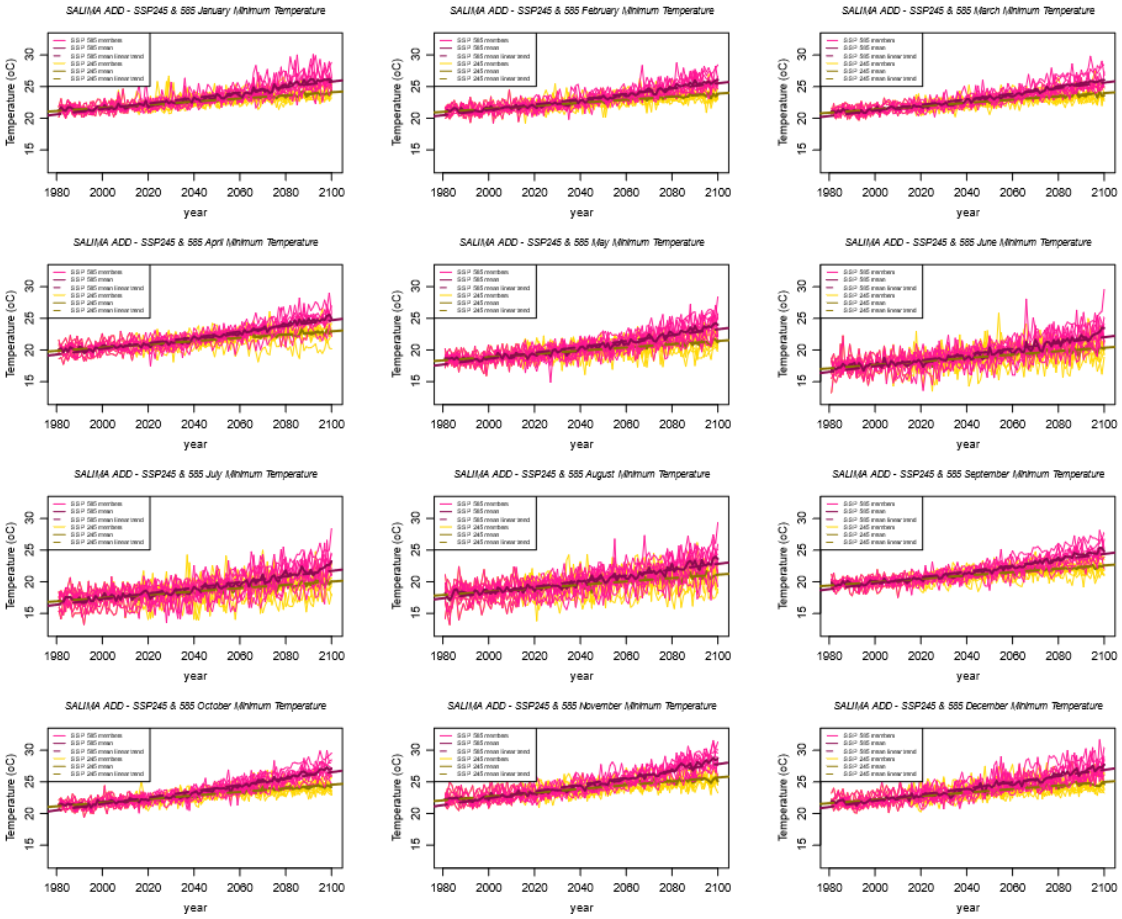


Figure 5- 44 Monthly minimum temperature projections in Salima ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 67 Characteristics of the trends from the projected minimum temperature time series by month in Salima ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Salima ADD SSP2.45							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	0.02	0.00	0.92	0.08	22.2 (21.8 - 23.3)	22.8 (22.4 - 23.7)	23.3 (22.7 - 24.6)
Feb	0.02	0.00	0.92	0.08	22.1 (21.5 - 22.7)	22.6 (22.1 - 23.4)	23.2 (22.6 - 24.3)
Mar	0.03	0.00	0.94	0.07	22 (21.5 - 22.6)	22.6 (22.2 - 23.4)	23.2 (22.8 - 24.4)

Apr	0.03	0.00	0.93	0.07	21 (19.8 - 21.8)	21.6 (20.4 - 22.3)	22.2 (20.4 - 23.1)
May	0.03	0.00	0.89	0.09	19.5 (19.1 - 20)	20.1 (19.4 - 20.9)	20.6 (19.6 - 21.8)
Jun	0.03	0.00	0.85	0.09	18.2 (17.2 - 19)	18.9 (17.8 - 20.3)	19.5 (18 - 20.8)
Jul	0.03	0.00	0.84	0.11	18 (16.3 - 18.9)	18.6 (16.7 - 20)	19.2 (16.7 - 21.1)
Aug	0.03	0.00	0.82	0.10	19.1 (17.3 - 20.2)	19.7 (17.9 - 21.1)	20.3 (17.9 - 22)
Sep	0.03	0.00	0.93	0.08	20.6 (20 - 21.2)	21.2 (20.7 - 22.1)	21.7 (21 - 23)
Oct	0.03	0.00	0.93	0.07	22.4 (21.8 - 22.7)	23.1 (22.6 - 23.8)	23.7 (23 - 24.6)
Nov	0.03	0.00	0.93	0.07	23.5 (22.5 - 24.4)	24.1 (23.3 - 24.8)	24.8 (24.1 - 25.7)
Dec	0.03	0.00	0.91	0.08	22.9 (21.8 - 24.1)	23.5 (22.6 - 24.7)	24.1 (23.4 - 25.7)
Salima ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	0.04	0.00	0.93	0.08	22.3 (22 - 23.2)	23.1 (22.7 - 24.1)	24.1 (23.4 - 25.5)
Feb	0.04	0.00	0.94	0.07	22.1 (21.6 - 23)	23 (22.4 - 24)	24 (23.2 - 25)
Mar	0.04	0.00	0.95	0.06	22.1 (21.6 - 22.8)	22.9 (22.4 - 23.9)	24 (23.5 - 25.2)
Apr	0.05	0.00	0.94	0.06	21.1 (20.1 - 21.7)	21.9 (20.8 - 22.5)	23 (21.3 - 24.3)

May	0.05	0.00	0.92	0.08	19.5 (18.9 - 20.2)	20.4 (19.7 - 21.2)	21.5 (20 - 22.8)
Jun	0.05	0.00	0.90	0.08	18.3 (17 - 19.1)	19.2 (18.1 - 20.2)	20.3 (18.9 - 21.9)
Jul	0.04	0.00	0.90	0.08	18.1 (16.4 - 19.3)	18.9 (17 - 20.2)	20 (17.9 - 21.8)
Aug	0.05	0.00	0.91	0.07	19.2 (17.5 - 20.2)	20.1 (18.5 - 21.3)	21.1 (19.4 - 23)
Sep	0.05	0.00	0.94	0.06	20.6 (20 - 21.2)	21.5 (20.7 - 22.5)	22.7 (21.7 - 24.3)
Oct	0.05	0.00	0.95	0.06	22.5 (22.1 - 22.7)	23.5 (23 - 24.2)	24.7 (23.6 - 25.7)
Nov	0.05	0.00	0.94	0.07	23.5 (23 - 24.3)	24.5 (23.5 - 25.5)	25.7 (24.4 - 26.6)
Dec	0.05	0.00	0.95	0.06	23 (22.1 - 24)	24 (22.9 - 25.2)	25.1 (24.1 - 26.7)

5.3.2.1.6 Shire Valley ADD

The minimum temperature projection for Shire Valley ADD is presented in Fig. 5-47 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-68 The monthly increasing trends are significant and are ranging from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

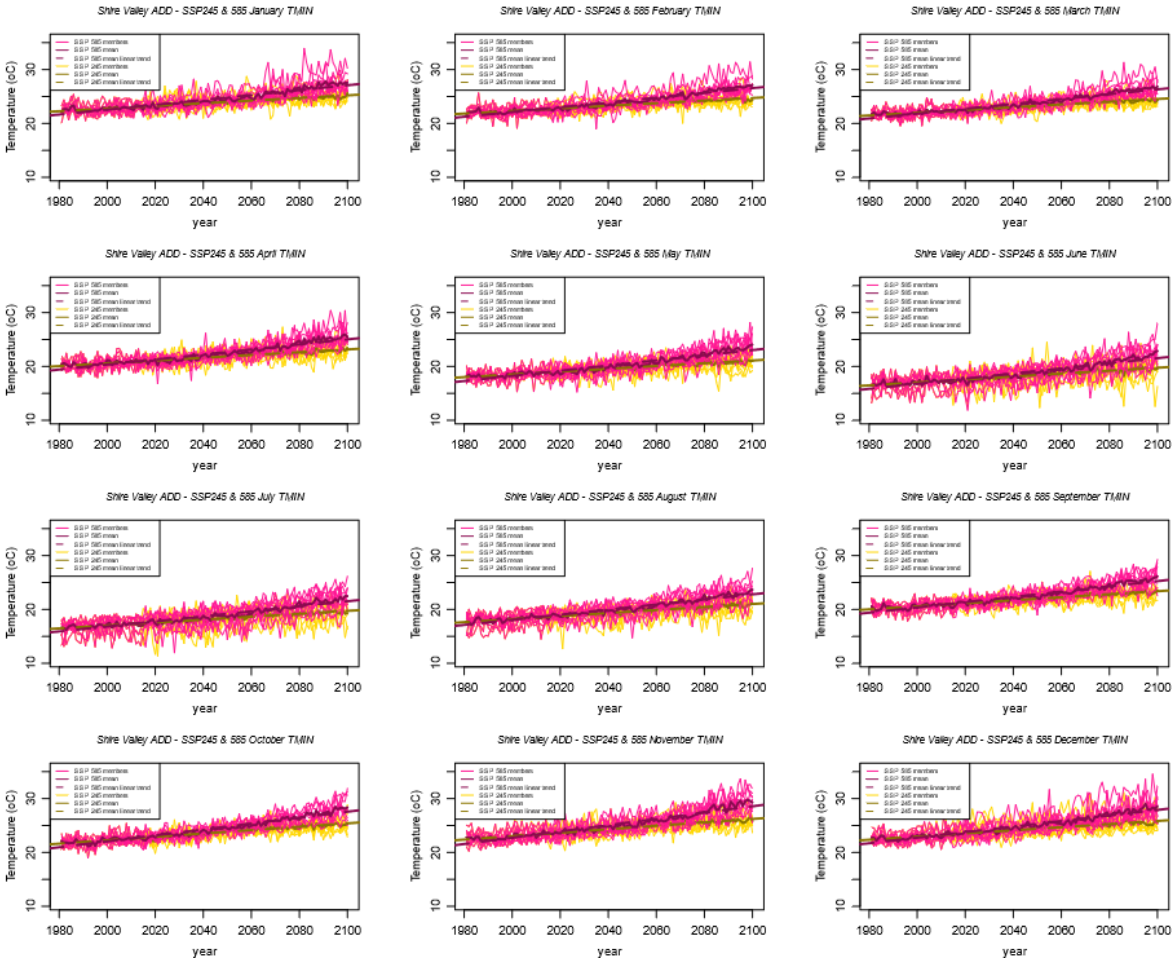


Figure 5- 45 Monthly minimum temperature projections in Shire Valley ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 68 Characteristics of the trends from the projected minimum temperature time series by month in Shire Valley ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Shire Valley ADD SSP2.45							
Month	**Slope (OC/ year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	0.025	0	0.894	0.085	23.3 (22.7 - 24.9)	23.9 (23.3 - 25.3)	24.5 (23.7 - 26.4)
Feb	0.024	0	0.906	0.085	22.9 (22.3 - 24.2)	23.5 (22.8 - 24.8)	24.1 (23.2 - 25.8)
Mar	0.025	0	0.91	0.079	22.5 (21.8 - 23.3)	23.2 (22.5 - 24.2)	23.8 (23.3 - 25.2)
Apr	0.026	0	0.893	0.082	21.1 (20.5 - 21.4)	21.8 (21.4 - 22.4)	22.4 (21.8 - 23.4)
May	0.026	0	0.877	0.095	19.2 (18.5 - 19.7)	19.7 (18.8 - 20.7)	20.3 (19.1 - 21.4)
Jun	0.027	0	0.845	0.104	17.6 (16.2 - 18.5)	18.3 (16.7 - 19.5)	18.9 (17 - 20.2)

Jul	0.027	0	0.877	0.096	17.6 (16.1 - 18.7)	18.2 (16.4 - 19.4)	18.9 (17 - 20.5)
Aug	0.028	0	0.872	0.087	18.9 (17.6 - 19.8)	19.5 (18 - 20.5)	20.1 (18.5 - 21.4)
Sep	0.028	0	0.898	0.084	21.2 (20.7 - 21.7)	21.9 (21.3 - 22.6)	22.5 (21.5 - 23.7)
Oct	0.032	0	0.918	0.077	23.0 (22.4 - 23.3)	23.8 (23.3 - 24.3)	24.5 (23.6 - 25.1)
Nov	0.032	0	0.917	0.076	23.9 (22.6 - 25)	24.5 (23.5 - 25.4)	25.3 (24.2 - 27)
Dec	0.029	0	0.896	0.082	23.7 (22.6 - 25.7)	24.3 (23.2 - 26.1)	25.0 (23.8 - 27.4)
Shire Valley ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	0.045	0	0.914	0.085	23.4 (22.9 - 24.6)	24.2 (23.4 - 26)	25.3 (24.3 - 27.4)
Feb	0.044	0	0.933	0.076	23.0 (22.4 - 24.3)	23.9 (23.1 - 25.6)	24.9 (23.9 - 26.8)
Mar	0.045	0	0.937	0.073	22.7 (22.2 - 23.6)	23.5 (22.9 - 24.7)	24.6 (23.9 - 26)
Apr	0.047	0	0.914	0.079	21.2 (20.9 - 21.5)	22.1 (21.7 - 22.7)	23.2 (22.6 - 24.2)
May	0.048	0	0.918	0.08	19.1 (18.2 - 19.8)	20.0 (18.9 - 20.9)	21.2 (19.7 - 22.4)
Jun	0.047	0	0.901	0.085	17.7 (16.1 - 18.5)	18.6 (17.1 - 19.7)	19.7 (17.8 - 21.2)
Jul	0.047	0	0.924	0.074	17.8 (16 - 18.7)	18.6 (16.6 - 19.7)	19.7 (17.7 - 21.2)
Aug	0.047	0	0.941	0.062	19.0 (17.6 - 19.9)	19.9 (18.7 - 20.8)	21.0 (19.6 - 22.5)
Sep	0.049	0	0.933	0.07	21.3 (20.8 - 21.8)	22.3 (21.7 - 23.1)	23.4 (22.5 - 24.9)
Oct	0.055	0	0.942	0.065	23.2 (22.9 - 23.6)	24.2 (23.6 - 24.9)	25.5 (24.3 - 26.4)
Nov	0.058	0	0.926	0.075	24.0 (23.2 - 25.2)	25.0 (23.8 - 26.4)	26.2 (24.8 - 27.5)
Dec	0.052	0	0.937	0.066	23.8 (22.8 - 25.5)	24.8 (23.7 - 26.7)	26.0 (24.8 - 28.7)

5.3.2.1.7 Machinga ADD

The minimum temperature projection for Machinga ADD is presented in Fig. 5-48 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in

temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-69 The monthly increasing trends are significant and are ranging from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

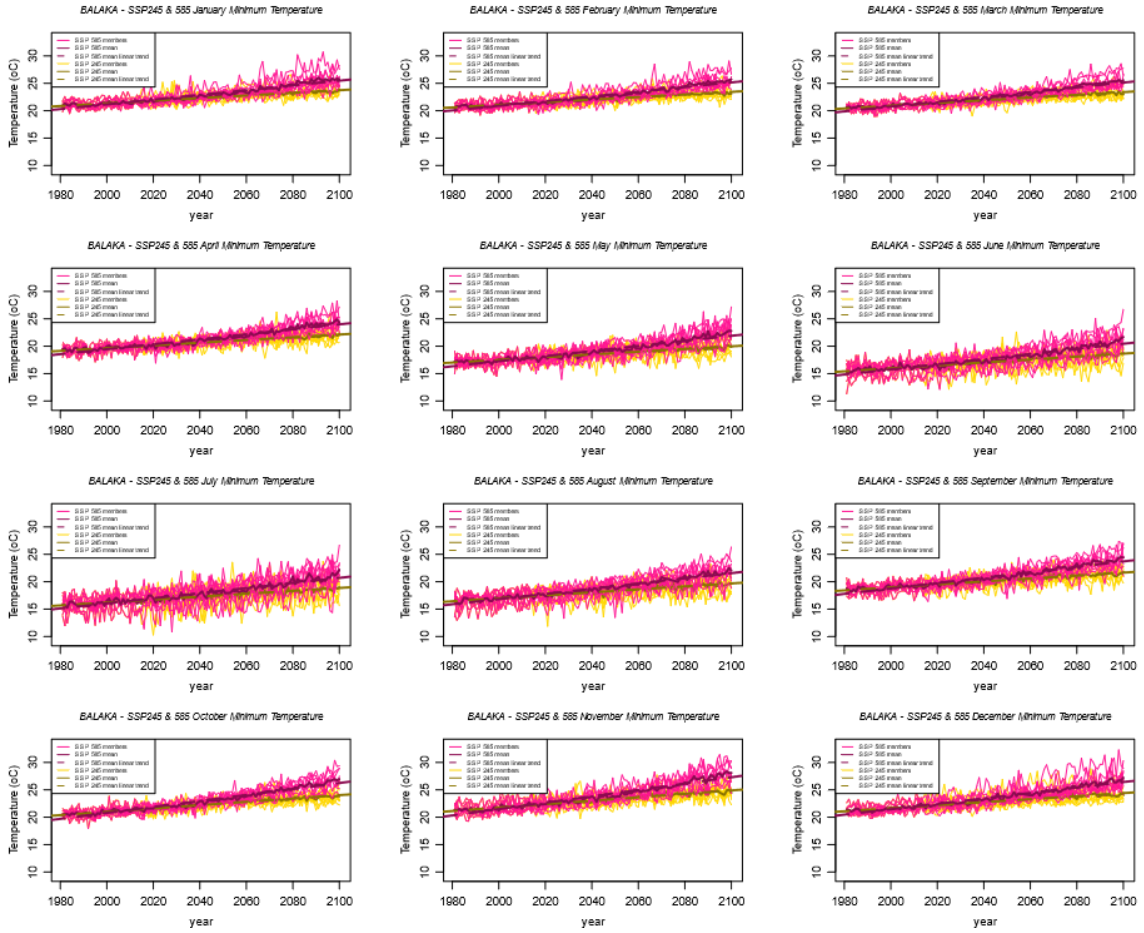


Figure 5- 46 Monthly minimum temperature projections in Machinga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 69 Characteristics of the trends from the projected minimum temperature time series by month in Machinga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Machinga ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (OC)**	**Mean, Range 2060 (OC)**	**Mean, Range 2080 (OC)**
Jan	**0.024**	**0**	**0.942**	**0.068**	**21.9 (19.4 - 24.4)**	**22.5 (20 - 24.9)**	**23 (20.4 - 25.7)**
Feb	**0.024**	**0**	**0.937**	**0.071**	**21.7 (19.1 - 24)**	**22.2 (19.6 - 24.6)**	**22.7 (20.2 - 25.3)**
Mar	**0.025**	**0**	**0.944**	**0.064**	**21.5 (19 - 23.8)**	**22 (19.5 - 24.4)**	**22.6 (20.1 - 25.1)**

Apr	**0.025**	**0**	**0.92**	**0.07**	**20.2 (17.1 - 22.9)**	**20.8 (17.7 - 23.6)**	**21.4 (18.2 - 24.3)**
May	**0.025**	**0**	**0.896**	**0.084**	**18.2 (14.6 - 21.2)**	**18.7 (15 - 21.9)**	**19.2 (15.4 - 22.5)**
Jun	**0.027**	**0**	**0.886**	**0.085**	**16.6 (12.2 - 20.2)**	**17.2 (12.8 - 20.9)**	**17.7 (13.4 - 21.5)**
Jul	**0.027**	**0**	**0.832**	**0.109**	**16.8 (11.8 - 21.4)**	**17.4 (12.3 - 22.2)**	**18 (13 - 22.7)**
Aug	**0.027**	**0**	**0.875**	**0.085**	**17.7 (13.6 - 21)**	**18.2 (14.1 - 21.6)**	**18.8 (14.7 - 22.4)**
Sep	**0.027**	**0**	**0.897**	**0.085**	**19.6 (16 - 22.6)**	**20.3 (16.7 - 23.4)**	**20.8 (17.1 - 24.1)**
Oct	**0.03**	**0**	**0.933**	**0.075**	**21.7 (18.4 - 24.5)**	**22.5 (19.2 - 25.3)**	**23.1 (19.7 - 26.1)**
Nov	**0.031**	**0**	**0.927**	**0.073**	**22.6 (19.4 - 25.8)**	**23.2 (19.8 - 26.7)**	**24 (20.6 - 27.5)**
Dec	**0.028**	**0**	**0.93**	**0.072**	**22.4 (19.8 - 25.2)**	**22.9 (20.3 - 26.2)**	**23.6 (20.8 - 27.2)**
Machinga ADD SSP5.85							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (OC)**	**Mean, Range 2060 (OC)**	**Mean, Range 2080 (OC)**
Jan	**0.043**	**0**	**0.942**	**0.072**	**22 (19.6 - 24.5)**	**22.8 (20.4 - 25.4)**	**23.8 (21.2 - 26.8)**
Feb	**0.043**	**0**	**0.95**	**0.063**	**21.7 (19.2 - 24.1)**	**22.6 (20.1 - 25.1)**	**23.6 (20.9 - 26.3)**
Mar	**0.044**	**0**	**0.954**	**0.063**	**21.6 (19.2 - 23.8)**	**22.5 (20 - 24.7)**	**23.5 (20.9 - 26)**
Apr	**0.045**	**0**	**0.932**	**0.07**	**20.3 (17.3 - 23)**	**21.2 (18.2 - 23.9)**	**22.3 (19 - 25.2)**
May	**0.046**	**0**	**0.923**	**0.076**	**18.1 (14.4 - 21.3)**	**19 (15.4 - 22.3)**	**20.1 (16.3 - 23.5)**
Jun	**0.047**	**0**	**0.922**	**0.073**	**16.7 (12.4 - 20.2)**	**17.6 (13.3 - 21.1)**	**18.7 (14.3 - 22.5)**

Jul	**0.047**	**0**	**0.909**	**0.074**	**17 (11.9 - 21.8)**	**17.8 (12.6 - 22.6)**	**18.9 (13.9 - 23.7)**
Aug	**0.047**	**0**	**0.954**	**0.055**	**17.8 (13.7 - 21.1)**	**18.7 (14.6 - 22.1)**	**19.9 (15.7 - 23.4)**
Sep	**0.049**	**0**	**0.943**	**0.067**	**19.7 (16.1 - 22.7)**	**20.7 (17.1 - 23.8)**	**21.9 (18.2 - 25.2)**
Oct	**0.055**	**0**	**0.957**	**0.059**	**21.9 (18.6 - 24.7)**	**22.9 (19.6 - 25.7)**	**24.2 (20.9 - 27.2)**
Nov	**0.058**	**0**	**0.942**	**0.067**	**22.7 (19.7 - 25.8)**	**23.7 (20.5 - 27.1)**	**25.1 (21.6 - 28.8)**
Dec	**0.05**	**0**	**0.954**	**0.059**	**22.5 (19.8 - 25.5)**	**23.5 (20.7 - 26.8)**	**24.6 (21.7 - 28.4)**

5.3.2.1.8 Blantyre ADD

The projections for monthly minimum temperature for Blantyre ADD are presented in Fig. 5-49 for both scenarios. Generally, the two scenarios suggests an increasing trend in minimum temperatures since the 1980's up to the end of the century in all the months. From the Tab. 5-70 , a significant increasing trend in the minimum temperatures is observed in all the months, ranging from +0.024 to +0.028

degrees Celsius per year under the SSP2.45 scenario. The rate of increase is quite significant under the SSP5.85 scenario, ranging from +0.045 to +0.059 degrees Celsius per year.

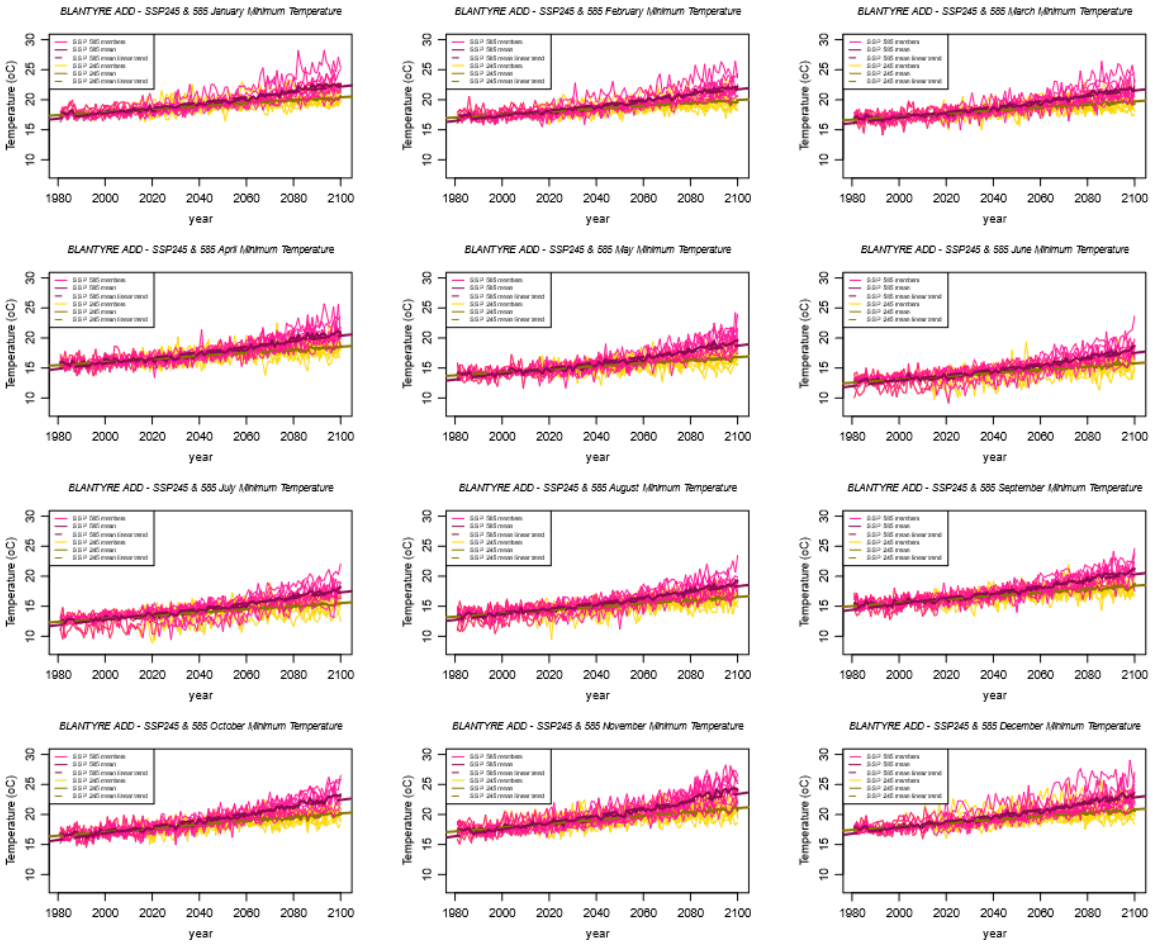


Figure 5- 47 Monthly minimum temperature projections Blantyre ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 70 Characteristics of the trends from the projected minimum temperature time series by month in Blantyre ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Blantyre ADD SSP2.45							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	0.025	0.000	0.948	0.064	18.5 (17.9 - 20.1)	19.1 (18.5 - 20.6)	19.7 (18.5 - 21.5)
Feb	0.024	0.000	0.932	0.075	18.2 (17.6 - 19.5)	18.8 (18.2 - 20.1)	19.4 (18.5 - 21)
Mar	0.025	0.000	0.921	0.074	17.7 (17.1 - 18.6)	18.3 (17.8 - 19.4)	18.9 (18.1 - 20.5)

Apr	0.025	0.000	0.919	0.077	16.5 (16 - 17)	17.2 (16.6 - 17.9)	17.8 (16.7 - 18.9)
May	0.025	0.000	0.910	0.083	14.9 (14.4 - 15.4)	15.5 (14.9 - 16.4)	16 (15 - 17.3)
Jun	0.027	0.000	0.911	0.078	13.6 (12.3 - 14.4)	14.4 (13.1 - 15.5)	14.9 (13.3 - 16.2)
Jul	0.026	0.000	0.924	0.073	13.5 (12 - 14.1)	14.1 (12.5 - 15.1)	14.7 (12.9 - 16.2)
Aug	0.027	0.000	0.898	0.081	14.5 (13.2 - 15.3)	15.1 (13.9 - 16.2)	15.7 (14.7 - 17.1)
Sep	0.028	0.000	0.913	0.075	16.2 (15.5 - 16.8)	16.9 (16.5 - 17.8)	17.5 (17 - 18.8)
Oct	0.031	0.000	0.919	0.076	17.8 (17.5 - 18.1)	18.6 (18.2 - 19.3)	19.2 (18.5 - 20.2)
Nov	0.032	0.000	0.926	0.073	18.7 (17.6 - 19.8)	19.3 (18.5 - 20.2)	20.1 (18.9 - 21.8)
Dec	0.028	0.000	0.933	0.067	18.7 (17.7 - 20.8)	19.3 (18.4 - 21.3)	20 (19 - 22.6)
Blantyre ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^oC)**	**Mean, Range 2060 (^oC)**	**Mean, Range 2080 (^oC)**
Jan	0.044	0.000	0.940	0.075	18.6 (18.2 - 19.8)	19.4 (18.8 - 21.2)	20.5 (19.4 - 22.6)
Feb	0.044	0.000	0.948	0.067	18.3 (17.8 - 19.6)	19.2 (18.5 - 20.8)	20.2 (19.3 - 22)
Mar	0.045	0.000	0.942	0.068	17.9 (17.4 - 18.9)	18.7 (18.2 - 20)	19.8 (18.9 - 21.3)
Apr	0.046	0.000	0.921	0.078	16.6 (16.3 - 17)	17.5 (17 - 18.3)	18.6 (17.4 - 19.7)

May	0.047	0.000	0.924	0.077	14.8 (14.1 - 15.6)	15.8 (14.7 - 16.7)	16.9 (15.9 - 18.3)
Jun	0.046	0.000	0.928	0.074	13.7 (12.3 - 14.5)	14.7 (13.2 - 15.7)	15.7 (14.5 - 17.2)
Jul	0.045	0.000	0.943	0.065	13.6 (11.9 - 14.4)	14.5 (12.6 - 15.5)	15.6 (14 - 17.1)
Aug	0.047	0.000	0.947	0.059	14.6 (13.2 - 15.4)	15.5 (14.3 - 16.4)	16.6 (15.5 - 18.2)
Sep	0.049	0.000	0.939	0.067	16.3 (15.6 - 16.9)	17.3 (16.5 - 18.1)	18.4 (17.5 - 20.1)
Oct	0.055	0.000	0.947	0.063	18 (17.6 - 18.2)	19 (18.5 - 19.8)	20.3 (19.2 - 21.4)
Nov	0.059	0.000	0.934	0.073	18.8 (18.3 - 20)	19.8 (18.8 - 21.1)	21 (19.7 - 22.3)
Dec	0.050	0.000	0.951	0.062	18.8 (18 - 20.7)	19.8 (19 - 21.9)	21 (19.7 - 23.9)

5.3.2.2 **Annual Minimum Temperature**

5.3.2.2.1 Karonga ADD

The annual minimum temperature trends are shown in Fig. 5-50 for Karonga ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-71. The annual minimum temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual minimum temperature increases by +1.2 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The

annual minimum temperature increase during the end-century (2080s) is by +1.8 degrees Celsius for SSP2.45 and +2.7 degrees Celsius for SSP5.85.

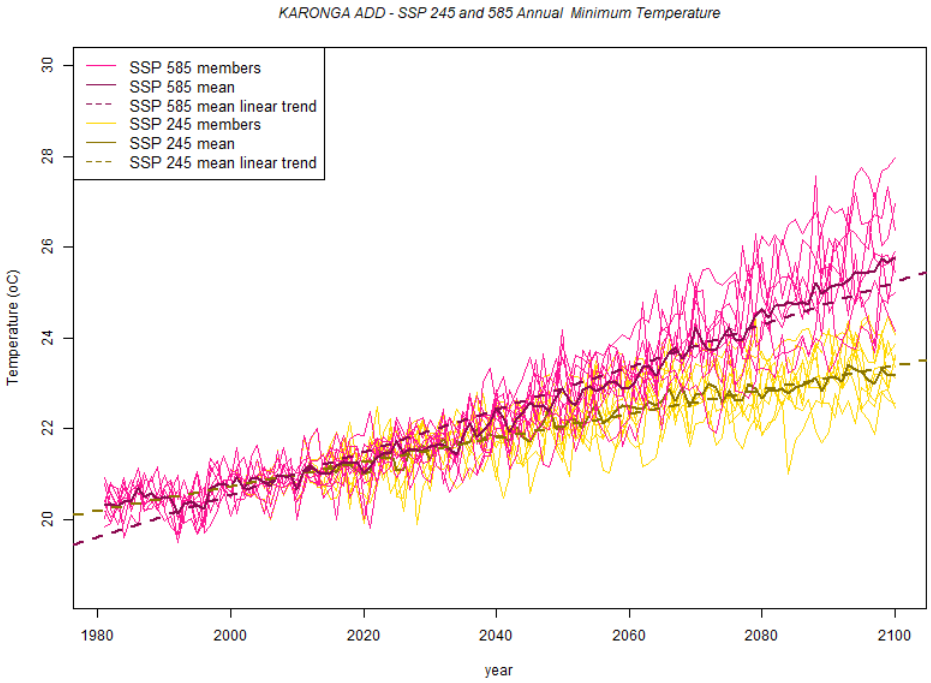


Figure 5- 48 Annual minimum temperature projections in Karonga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 71 Characteristics of the trends from the projected annual minimum temperature time series in Karonga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Karonga ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Karonga	**0.027**	**0.000**	**0.969**	**0.050**	21.5 (21.2 - 21.7)	22.1 (21.6 - 22.7)	22.7 (22 - 23.5)
Karonga ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**
Karonga	**0.047**	**0.000**	**0.961**	**0.058**	21.5 (21.2 - 21.9)	22.4 (21.9 - 23)	23.6 (22.6 - 24.6)

5.3.2.2.2 Mzuzu ADD

The annual minimum temperature trends are shown in Fig. 5-51 for Mzuzu ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-72. The annual minimum temperature increases by +0.5 degrees Celsius for SSP2.45 (ensemble mean) and +0.6 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual minimum temperature increases by +1.1 and +1.5 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual minimum temperature increase during the end-century (2080s) is by +1.7 degrees Celsius for SSP2.45 and +2.6 degrees Celsius for SSP5.85.

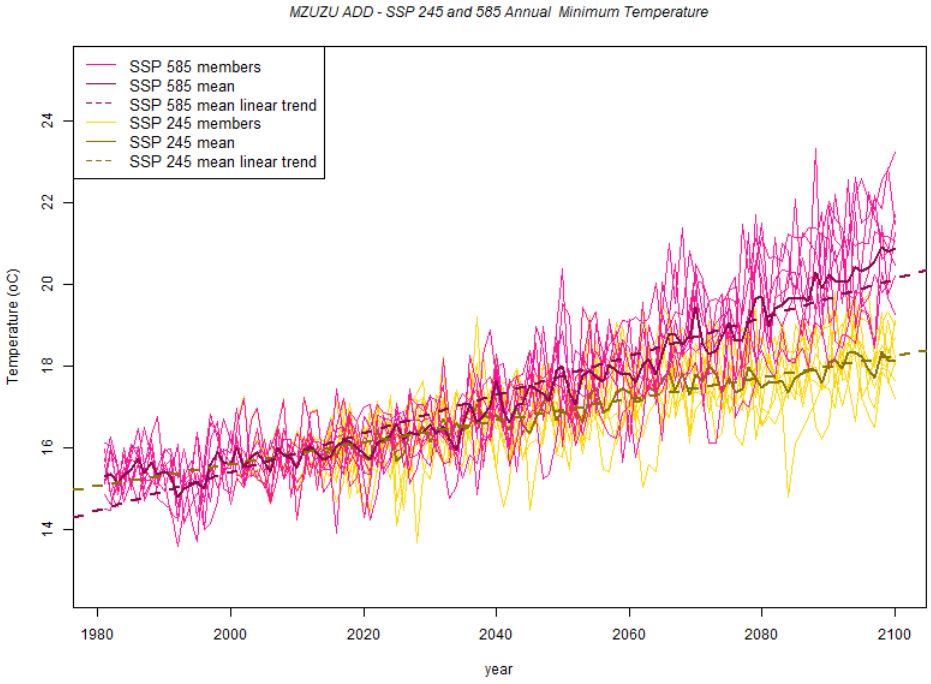


Figure 5- 49 Annual minimum temperature projections in Mzuzu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 72 Characteristics of the trends from the projected annual minimum temperature time series in Mzuzu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Mzuzu ADD SSP2.45							
	Slope (OC/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Mzuzu	**0.03**	**0.00**	**0.93**	**0.07**	16.3 (16.1 - 16.5)	16.9 (16.5 - 17.4)	17.5 (16.8 - 18.3)
Mzuzu ADD SSP5.85							
	Slope (OC/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**

Mzuzu	**0.05**	**0.00**	**0.93**	**0.07**	16.3 (16.1 - 16.7)	17.3 (16.7 - 17.8)	18.4 (17.5 - 19.3)

5.3.2.2.3 Kasungu ADD

The annual minimum temperature trends are shown in Fig. 5-52 for Kasungu ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-73. The annual minimum temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual minimum temperature increases by +1.3 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual minimum temperature increase during the end-century (2080s) is by +1.8 degrees Celsius for SSP2.45 and +2.7 degrees Celsius for SSP5.85.

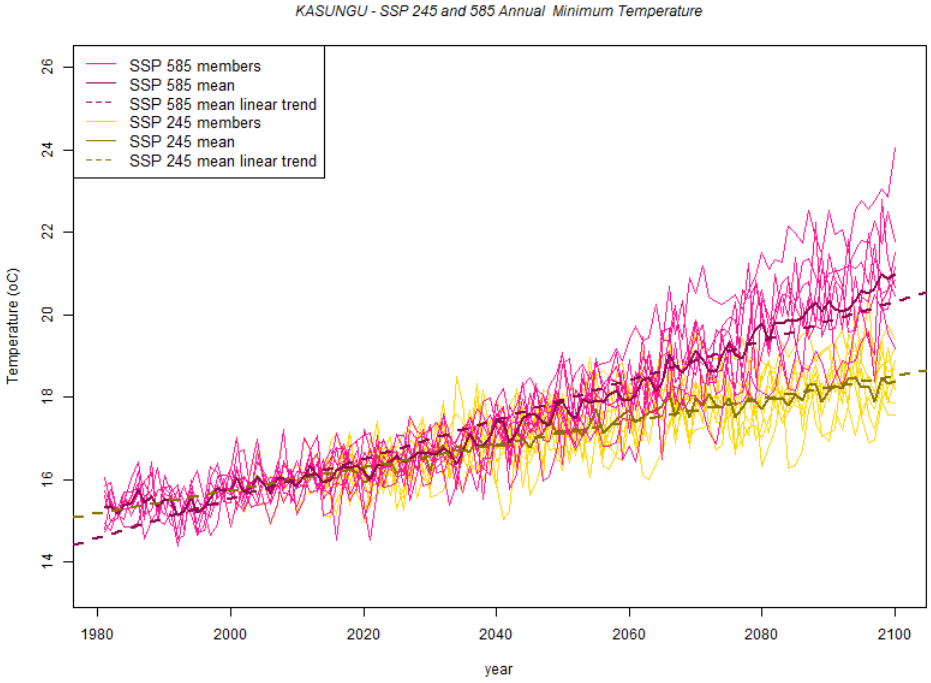


Figure 5- 50 Annual minimum temperature projections in Kasungu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 73 Characteristics of the trends from the projected annual minimum temperature time series in Kasungu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Kasungu ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Kasungu	**0.028**	**0**	**0.962**	**0.057**	**16.4 (13 - 19.3)**	**17.1 (13.6 - 20.1)**	**17.6 (14.1 - 20.8)**
Kasungu ADD SSP5.85							

	Slope (°C/year)	P-value	R^2	NRMSE	Mean, Range 2040 (°C)	Mean, Range 2040 (°C)	Mean, Range 2040 (°C)
Kasungu	**0.048**	**0**	**0.956**	**0.061**	**16.5 (13.1 - 19.4)**	**17.4 (13.9 - 20.4)**	**18.5 (14.9 - 21.9)**

5.3.2.2.4 Lilongwe ADD

The annual minimum temperature trends are shown in Fig. 5-53 for Lilongwe ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-74. The annual minimum temperature increases by +0.5 degrees Celsius for SSP2.45 (ensemble mean) and +0.6 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual minimum temperature increases by +1.2 and +1.5 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual minimum temperature increase during the end-century (2080s) is by +1.8 degrees Celsius for SSP2.45 and +2.7 degrees Celsius for SSP5.85.

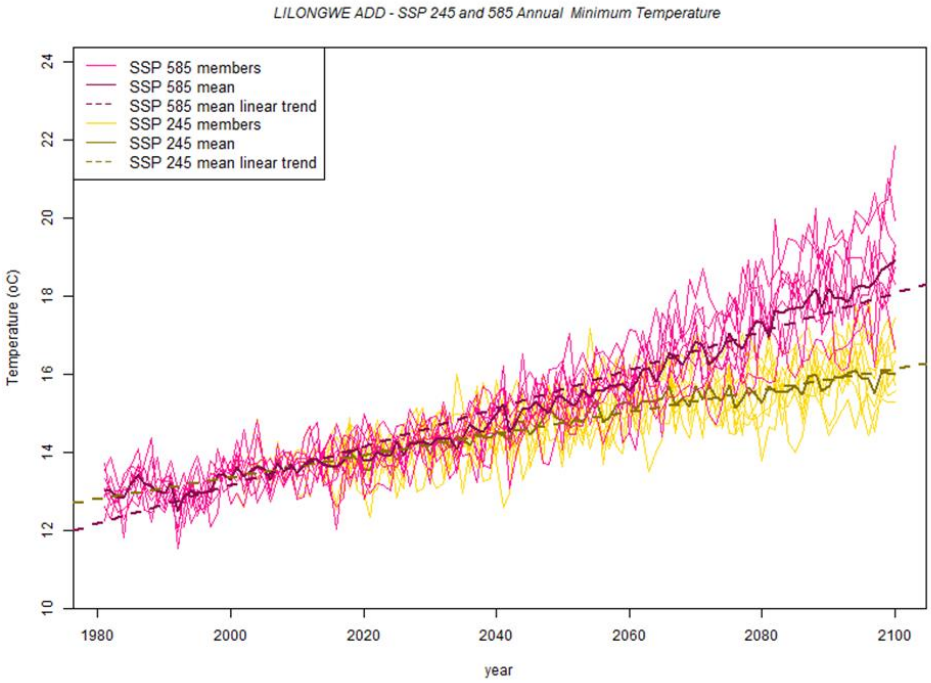


Figure 5- 51 Annual minimum temperature projections in Lilongwe ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 74 Characteristics of the trends from the projected annual minimum temperature time series in Lilongwe ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Lilongwe ADD SSP2.45							
	Slope (°C/year)	P-value	R^2	NRMSE	Mean, Range 2040 (°C)	Mean, Range 2060 (°C)	Mean, Range 2080 (°C)

Lilongwe	**0.03**	**0**	**0.96**	**0.06**	14.2 (13.8 - 14.5)	15.1 (14.6 - 15.6)	16.3 (15.4 - 17.2)
Lilongwe ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (mm)**	**Mean, Range 2060 (mm)**	**Mean, Range 2080 (mm)**
Lilongwe	**0.05**	**0**	**0.95**	**0.06**	14.1 (13.9 - 14.3)	14.7 (14.4 - 15.3)	15.3 (14.8 - 16.2)

5.3.2.2.5 Salima ADD

The annual minimum temperature trends are shown in Fig. 5-54 for Salima ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-75. The annual minimum temperature increases by +0.6 degrees Celsius for both SSP2.45 (ensemble mean) and SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual minimum temperature increases by +1.2 and +1.5 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual minimum temperature increase during the end-century (2080s) is by +1.7 degrees Celsius for SSP2.45 and +2.6 degrees Celsius for SSP5.85.

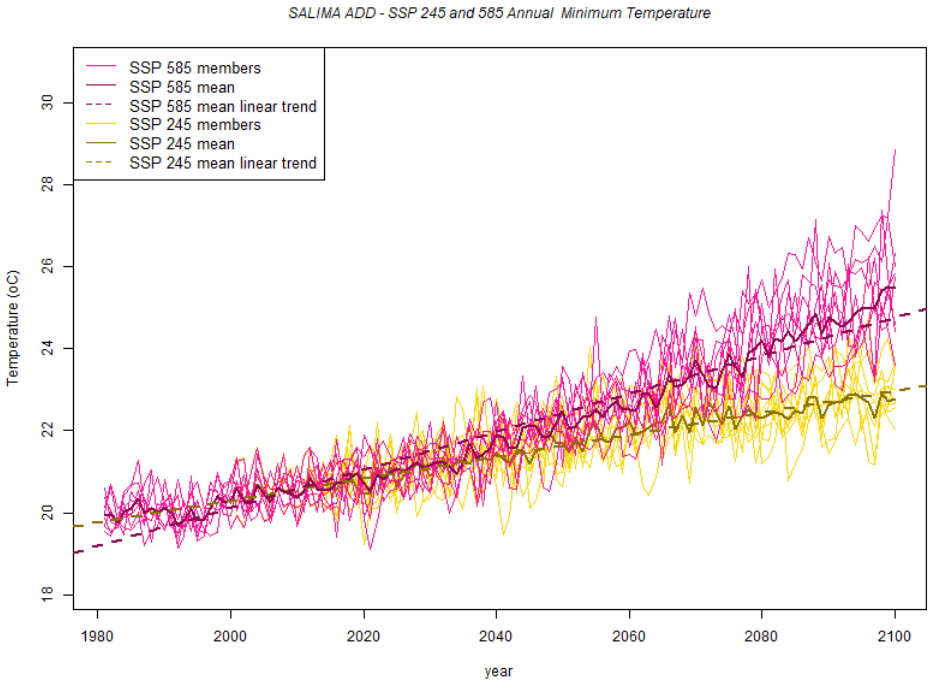


Figure 5- 52 Annual minimum temperature projections in Salima ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 75 Characteristics of the trends from the projected annual minimum temperature time series in Salima ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Salima ADD SSP2.45							
	Slope (OC/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Salima	0.03	0.00	0.95	0.06	21.3 (21.1 - 21.5)	22 (21.7 - 22.4)	22.6 (22 - 23.3)
Salima ADD SSP5.85							
	Slope (OC/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Salima	0.05	0	0.95	0.06	21.1 (20.9 - 21.3)	22 (21.7 - 22.5)	23.1 (22.4 - 24.1)

5.3.2.2.6 Shire Valley ADD

The annual minimum temperature trends are shown in Fig. 5-55 for Shire Valley ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-76. The annual minimum temperature increases by +0.5 degrees Celsius for SSP2.45 (ensemble mean) and +0.6 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual minimum temperature increases by +1.2 and +1.5 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual minimum temperature increase during the end-century (2080s) is by +1.8 degrees Celsius for SSP2.45 and +2.7 degrees Celsius for SSP5.85.

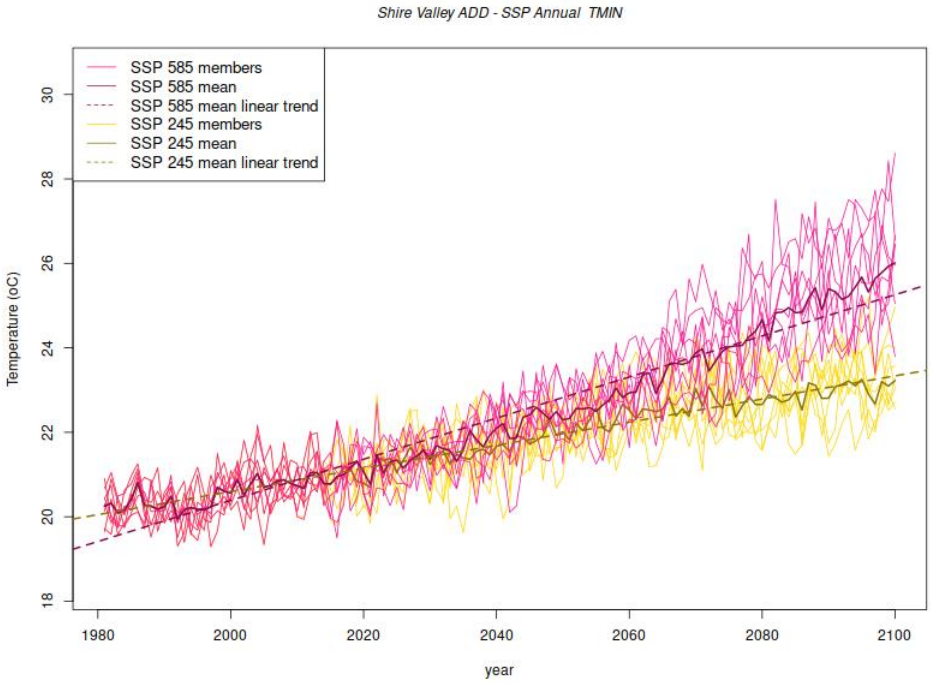


Figure 5- 53 Annual minimum temperature projections in Shire Valley ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 76 Characteristics of the trends from the projected annual minimum temperature time series in Shire Valley ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Shire Valley ADD SSP2.45							
	Slope (°C/ year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Shire Valley	0.0274	0	0.951	0.064	21.3 (21.1 - 21.5)	22.0 (21.7 - 22.4)	22.6 (22 - 23.3)
Shire Valley ADD SSP5.85							
	Slope (°C/ year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**
Shire Valley	0.048	0	0.948	0.064	21.4 (21 - 21.6)	22.3 (21.9 - 22.8)	23.5 (22.7 - 24.3)

5.3.2.2.7 Machinga ADD

The annual minimum temperature trends are shown in Fig. 5-56 for Machinga ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-77. The annual minimum temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s)

with reference from 1991-2020 period. While during the mid-century (2060s) the annual minimum temperature increases by +1.2 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual minimum temperature increase during the end-century (2080s) is by +1.7 degrees Celsius for SSP2.45 and +2.7 degrees Celsius for SSP5.85.

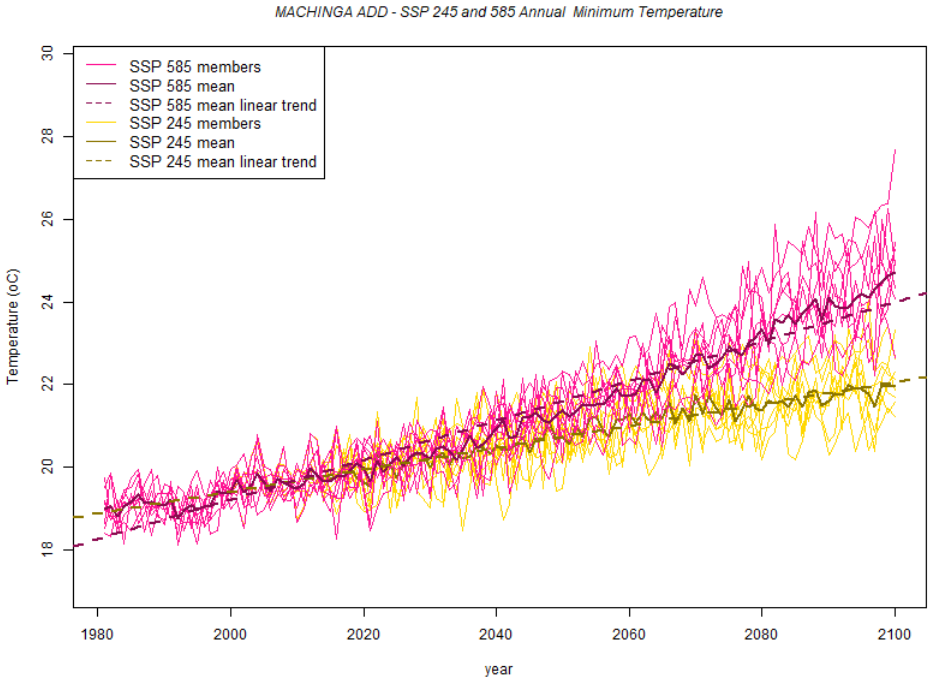


Figure 5- 54 Annual minimum temperature projections in Machinga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 77 Characteristics of the trends from the projected annual minimum temperature time series in Machinga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Machinga ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Machinga	**0.027**	**0**	**0.96**	**0.059**	**20.1 (16.7 - 23.1)**	**20.7 (17.2 - 23.8)**	**21.2 (17.8 - 24.5)**
Machinga ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**
Machinga	**0.048**	**0**	**0.959**	**0.058**	**20.2 (16.8 - 23.2)**	**21.1 (17.7 - 24.2)**	**22.2 (18.7 - 25.6)**

5.3.2.2.8 Blantyre ADD

The climate projections for annual minimum temperature indicates an increasing trend for both SSP2.45 and SSP5.85 scenarios as shown in Fig. 5-57. The rate of increase is about +0.030 degrees Celsius per year under the SSP2.45 while +0.048 degrees Celsius per year under the SSP5.85.

The annual minimum temperature increases by +0.72 degrees Celsius for SSP2.45 and +0.92 degrees Celsius for SSP5.85 during the near century (2040s) with reference from 1991-2020 period. During the mid-century (2060s) the annual minimum temperature increases by +1.42 and +1.82 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual minimum temperature increase during the end-century (2080s) is by +2.02 degrees Celsius for SSP2.45 and +3.12 degrees Celsius for SSP5.85.

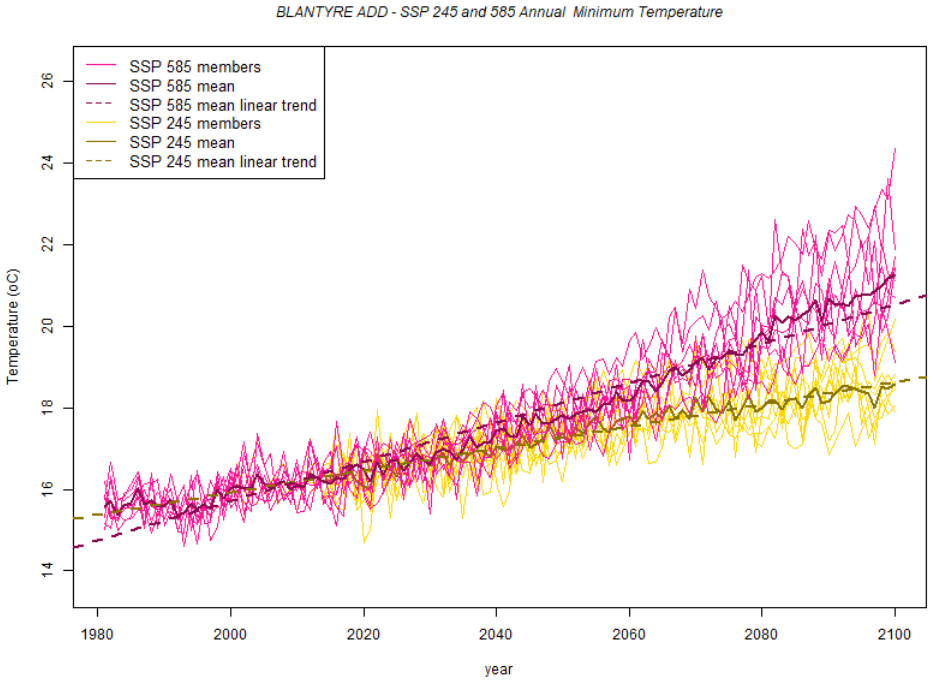


Figure 5- 55 Annual minimum temperature projections in Blantyre ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 78 Characteristics of the trends from the projected annual minimum temperature time series in Blantyre ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Blantyre ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Blantyre	0.030	0.000	0.960	0.060	16.6 (16.4 - 16.9)	17.3 (17 - 17.9)	17.9 (17.4 - 18.8)
Blantyre ADD SSP5.85							

	Slope (^{o} C/year)	P-value	R^2	NRMSE	Mean, Range 2040 (^{o}C)	Mean, Range 2060 (^{o}C)	Mean, Range 2080 (^{o}C)
Blantyre	0.048	0.000	0.953	0.063	16.7 (16.4 - 17)	17.6 (17.2 - 18.2)	18.8 (18 - 19.8)

5.3.2.3 Probability of occurrence of temperature less than 8 degrees Celsius

Table 5- 79 The probability of exceedance of minimum temperature less than 8 degrees Celsius at 8 ADDS for SSP2.45 and SSP5.85 (proxy to cold spells).

SSP2.45				
ADD	**2020**	**2040**	**2060**	**2080**
	Mean, Range	**Mean, Range**	**Mean, Range**	**Mean, Range**
Karonga				
Mzuzu				
Kasungu				
Salima				
Lilongwe				
Blantyre				
Shire Valley				
Machinga				
SSP5.85				
ADD	**2020**	**2040**	**2060**	**2080**
	Mean, Range	**Mean, Range**	**Mean, Range**	**Mean, Range**
Karonga				
Mzuzu				
Kasungu				
Salima				
Lilongwe				
Blantyre				
Shire Valley				
Machinga				

5.4 Mean Temperature

5.4.1 Current Mean Temperature

5.4.1.1 Seasonal Variations

The seasonal mean temperature according to the models from 1991-2020 is presented in Fig. 5-58. Like the maximum and minimum temperature, the coolest ADD is Lilongwe. Followed by Mzuzu ADD, Blantyre ADD and Kasungu ADD that have similar mean temperature seasonal cycle. At the same time, Karonga ADD, Salima ADD and Machinga ADD have also similar mean temperature pattern. But Shire Valley ADD is the hottest, and Karonga ADD is the hottest in winter (May, June and July).

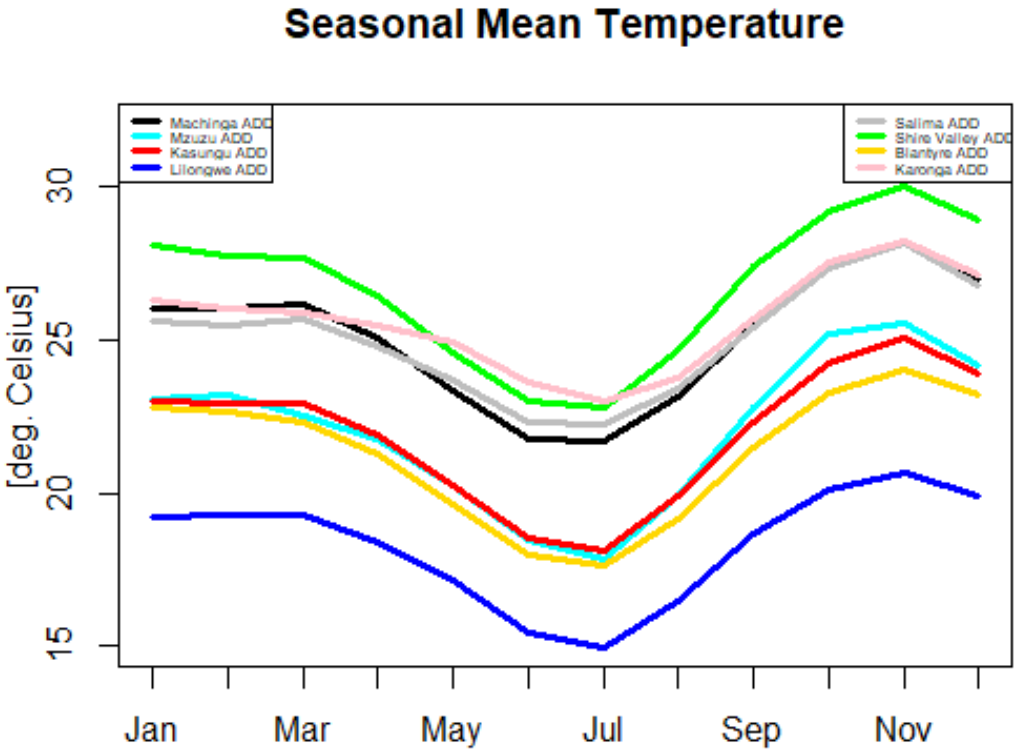


Figure 5- 56 Current (1991-2020) seasonal variations of the monthly mean temperature in eight ADDs

5.4.1.2 Monthly Mean Temperature

The comparison of mean temperature for the 8 ADDs per month during 1991-2020 are presented in Fig. 5-59. Like the seasonal variations, the warmest ADD is still the Shire Valley followed by Karonga ADD. Karonga ADD has similar mean temperature with Shire Valley ADD in May, June and July. Otherwise, the coolest is Lilongwe ADD. The monthly trend characteristics for all the ADDs are presented in Tab. 5-80 to Tab. 5-87. It is shown that the mean temperature is significantly increasing in all the ADDs at the rate between +0.02 and +0.05 degrees Celsius per year for all the months. The

hottest month of November has the highest increasing trend in all the ADDs. The lowest trend varies per ADD but the most common month is June in many of the ADDs.

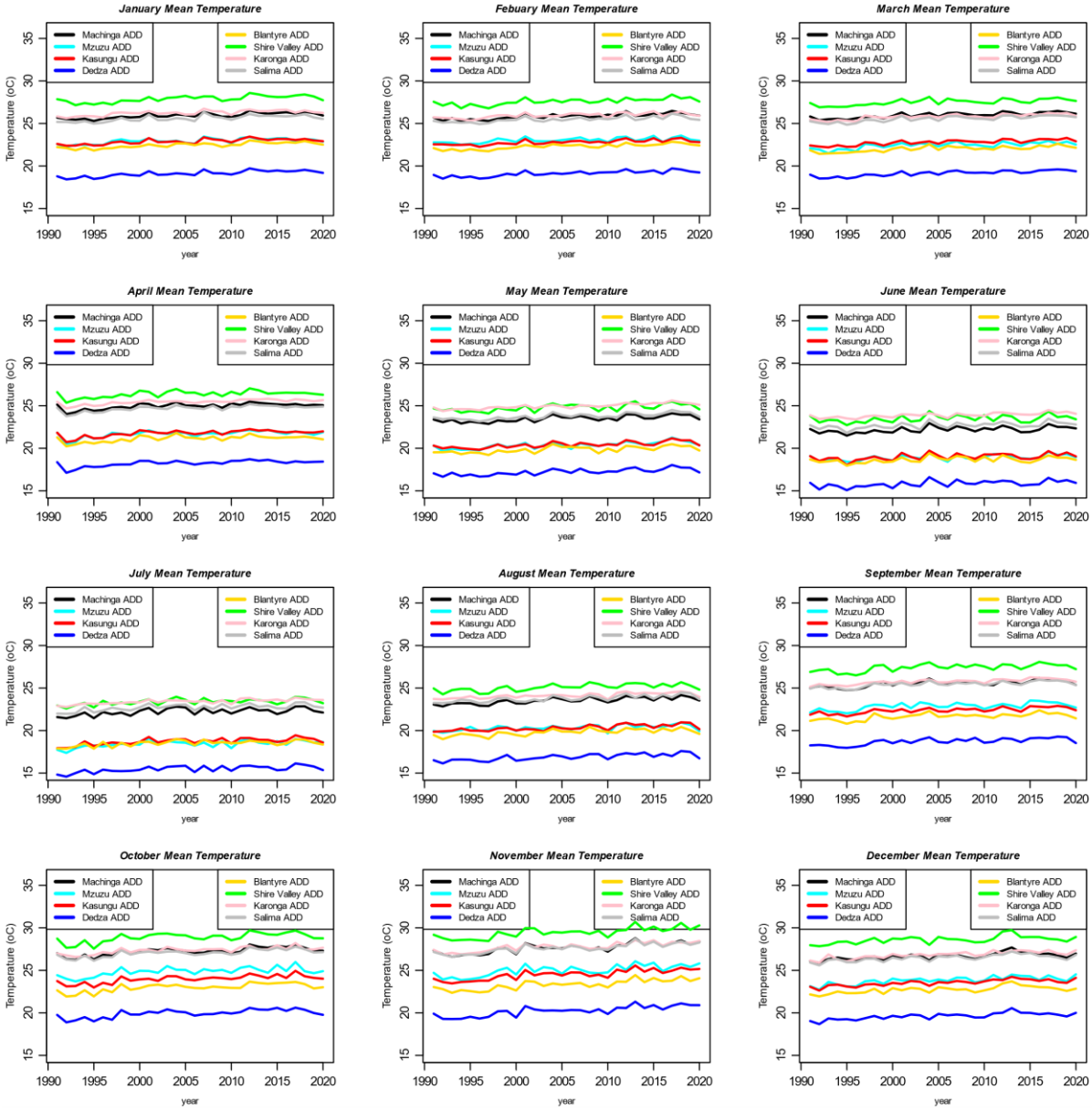


Figure 5- 57 Current (1991-2020) monthly mean temperature in the eight ADDs.

*Table 5- 80 Characteristics of the trends from the current time series of mean temperature by month in **Karonga ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.02	0	0.5	0.18	26.2
Feb	0.02	0	0.44	0.19	26
Mar	0.03	0	0.61	0.16	25.8
Apr	0.02	0	0.56	0.16	25.5
May	0.03	0	0.73	0.12	25
Jun	0.02	0	0.54	0.16	23.9
Jul	0.02	0	0.59	0.15	23.4
Aug	0.02	0	0.54	0.2	24.1
Sep	0.03	0	0.64	0.16	25.8
Oct	0.03	0	0.54	0.16	27.4
Nov	0.05	0	0.67	0.17	27.8
Dec	0.04	0	0.65	0.15	26.8

*Table 5- 81 Characteristics of the trends from the current time series of mean temperature by month in **Mzuzu ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.02	0	0.4	0.2	22.9
Feb	0.02	0	0.34	0.22	23
Mar	0.03	0	0.48	0.17	22.4
Apr	0.02	0	0.32	0.19	21.7
May	0.03	0	0.54	0.16	20.4
Jun	0.02	0	0.27	0.22	18.9
Jul	0.03	0	0.36	0.18	18.4
Aug	0.02	0	0.3	0.22	20.3
Sep	0.03	0	0.38	0.21	22.9
Oct	0.03	0	0.36	0.18	24.9
Nov	0.05	0	0.52	0.19	25
Dec	0.04	0	0.56	0.16	23.8

*Table 5- 82 Characteristics of the trends from the current time series of mean temperature by month in **Kasungu ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.02	0	0.52	0.19	22.9
Feb	0.02	0	0.53	0.17	22.8
Mar	0.03	0	0.66	0.16	22.8
Apr	0.03	0	0.41	0.18	21.8
May	0.03	0	0.5	0.18	20.4
Jun	0.02	0.01	0.22	0.19	19
Jul	0.03	0	0.46	0.18	18.7
Aug	0.03	0	0.54	0.2	20.3
Sep	0.03	0	0.56	0.18	22.4
Oct	0.04	0	0.52	0.15	24
Nov	0.05	0	0.68	0.15	24.5
Dec	0.03	0	0.64	0.13	23.5

*Table 5- 83 Characteristics of the trends from the current time series of mean temperature by month in **Lilongwe ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0	0.64	0.16	19.1
Feb	0.03	0	0.62	0.16	19.1
Mar	0.03	0	0.69	0.16	19.1
Apr	0.03	0	0.43	0.16	18.2
May	0.03	0	0.53	0.17	17.2
Jun	0.02	0	0.28	0.2	15.8
Jul	0.03	0	0.4	0.19	15.5
Aug	0.03	0	0.56	0.17	16.9
Sep	0.03	0	0.52	0.2	18.7
Oct	0.04	0	0.46	0.19	19.9
Nov	0.05	0	0.68	0.16	20.2
Dec	0.03	0	0.56	0.13	19.6

*Table 5- 84 Characteristics of the trends from the current time series of mean temperature by month in **Salima ADD**, significant changes are presented in bold.*

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0	0.5	0.18	25.6
Feb	0.02	0	0.48	0.18	25.5
Mar	0.03	0	0.63	0.18	25.5
Apr	0.03	0	0.46	0.17	24.7
May	0.03	0	0.53	0.17	23.8
Jun	0.02	0.01	0.25	0.18	22.7
Jul	0.03	0	0.38	0.22	22.7
Aug	0.03	0	0.53	0.2	23.8
Sep	0.03	0	0.52	0.19	25.4
Oct	0.04	0	0.53	0.17	27
Nov	0.05	0	0.67	0.14	27.6
Dec	0.03	0	0.49	0.16	26.5

Table 5- 85 Characteristics of the trends from the current time series of mean temperature by month in Shire Valley ADD, significant changes are presented in bold.

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0	0.48	0.19	27.9
Feb	0.03	0	0.48	0.17	27.6
Mar	0.03	0	0.46	0.21	27.5
Apr	0.02	0.01	0.24	0.19	26.4
May	0.03	0	0.32	0.23	24.8
Jun	0.02	0.06	0.12	0.23	23.5
Jul	0.02	0	0.3	0.21	23.4
Aug	0.03	0	0.39	0.21	25.1
Sep	0.03	0	0.36	0.21	27.4
Oct	0.04	0	0.37	0.2	28.9
Nov	0.05	0	0.58	0.17	29.5
Dec	0.03	0	0.32	0.19	28.6

Table 5- 86 Characteristics of the trends from the current time series of mean temperature by month in Machinga ADD, significant changes are presented in bold.

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0	0.61	0.15	25.9
Feb	0.03	0	0.58	0.17	25.8
Mar	0.03	0	0.62	0.18	26
Apr	0.02	0	0.38	0.18	25
May	0.03	0	0.47	0.2	23.5
Jun	0.02	0	0.25	0.2	22.2
Jul	0.03	0	0.3	0.24	22.2
Aug	0.03	0	0.58	0.18	23.5
Sep	0.03	0	0.44	0.19	25.5
Oct	0.04	0	0.52	0.18	27.3
Nov	0.05	0	0.63	0.16	27.6
Dec	0.03	0	0.44	0.16	26.7

Table 5- 87 Characteristics of the trends from the current time series of mean temperature by month in Blantyre ADD, significant changes are presented in bold.

Month	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Jan	0.03	0	0.66	0.15	22.4
Feb	0.03	0	0.65	0.16	22.3
Mar	0.03	0	0.55	0.18	22
Apr	0.02	0	0.3	0.19	21.1
May	0.03	0	0.41	0.21	19.9
Jun	0.02	0.03	0.17	0.2	18.7
Jul	0.02	0	0.29	0.24	18.5
Aug	0.03	0	0.47	0.19	19.8
Sep	0.03	0	0.39	0.18	21.6
Oct	0.04	0	0.47	0.19	23
Nov	0.05	0	0.66	0.16	23.3
Dec	0.03	0	0.44	0.17	22.7

5.4.1.3 **Annual Mean Temperature**

Like the minimum and maximum temperature, the annual mean temperature is also significantly increasing in all the 8 ADDs, Fig 5-60. The trend characteristics are shared in Tab. 5-88 and all the ADD have the uniform significant positive trend of annual mean temperature of +0.03 degrees Celsius per year from 1991-2020.

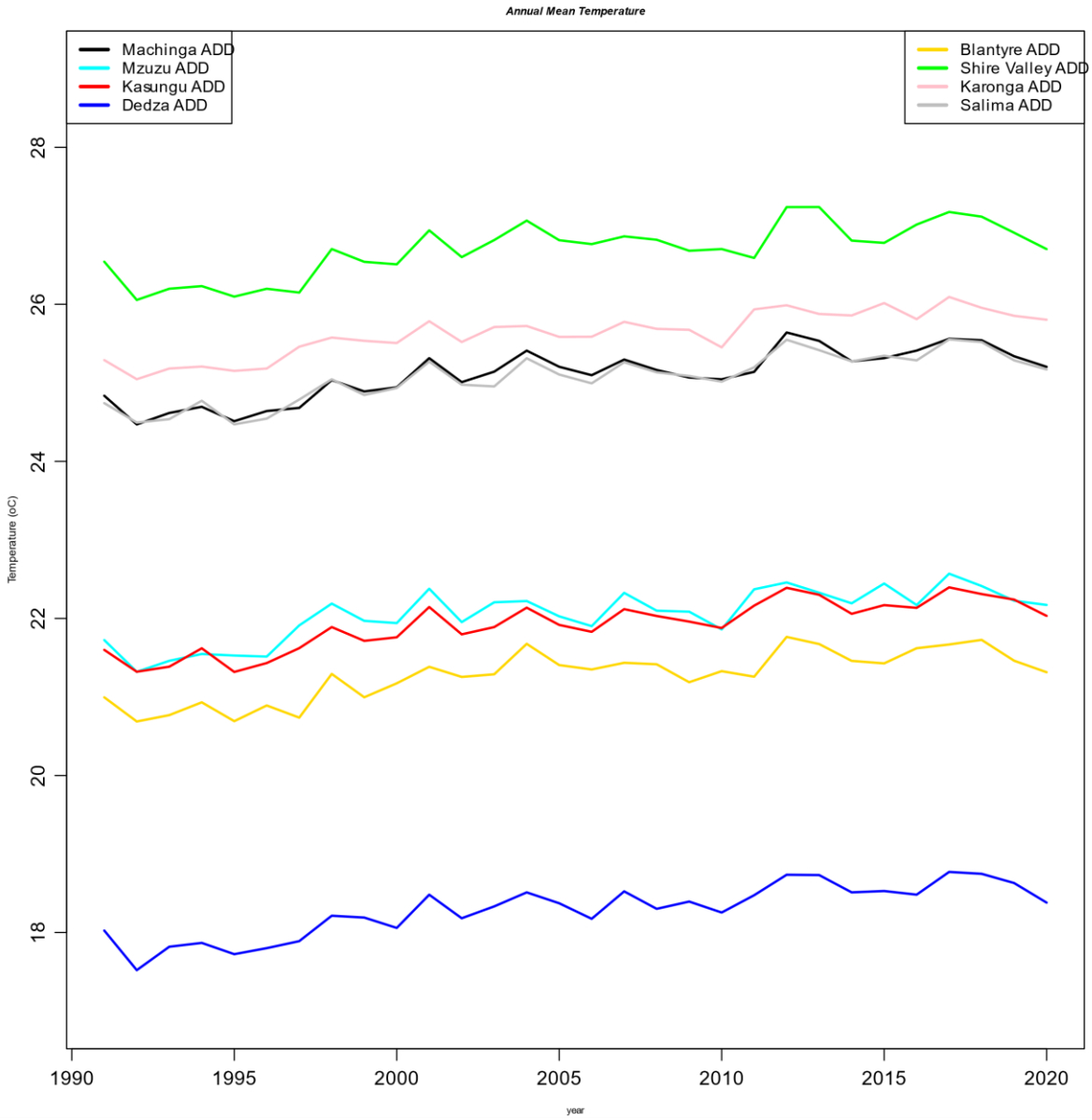


Figure 5- 58 Current (1991-2020) annual mean temperature in eight ADDs

Table 5- 88 Characteristics of the trends from the current time series of annual mean temperature by month in eight target ADDs (linear models), significant changes are presented in bold.

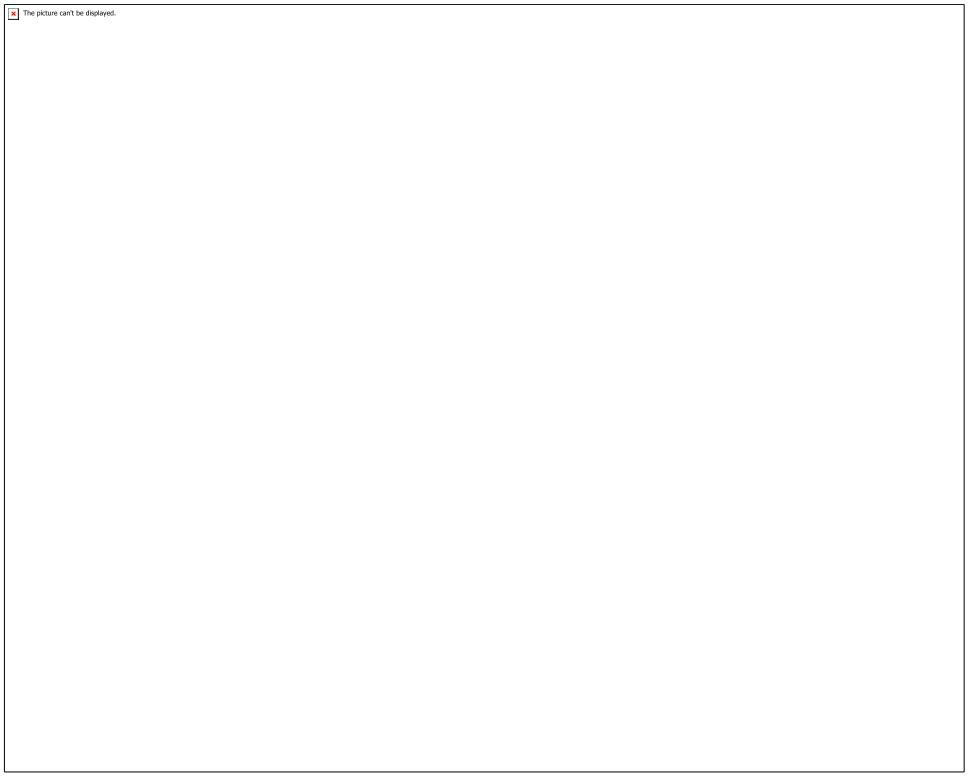
ADD	Slope (oC)	P-Value	R^2	NRME	Mean 1991-2020 (oC)
Machinga	0.03	0	0.68	0.15	25.1
Mzuzu	0.03	0	0.6	0.17	22.1
Karonga	0.03	0	0.75	0.13	25.6
Kasungu	0.03	0	0.73	0.15	21.9
Salima	0.03	0	0.71	0.15	25.1
Lilongwe	0.03	0	0.72	0.14	18.3
Blantyre	0.03	0	0.64	0.17	21.3
Shire Valley	0.03	0	0.56	0.19	26.7

5.4.2 Mean Temperature Projections

5.4.2.1 Monthly Mean Temperature

5.4.2.1.1 Karonga ADD

The mean temperature projection for Karonga ADD is presented in Fig. 5-61 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-89. The monthly increasing trends are significant and are ranging from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.



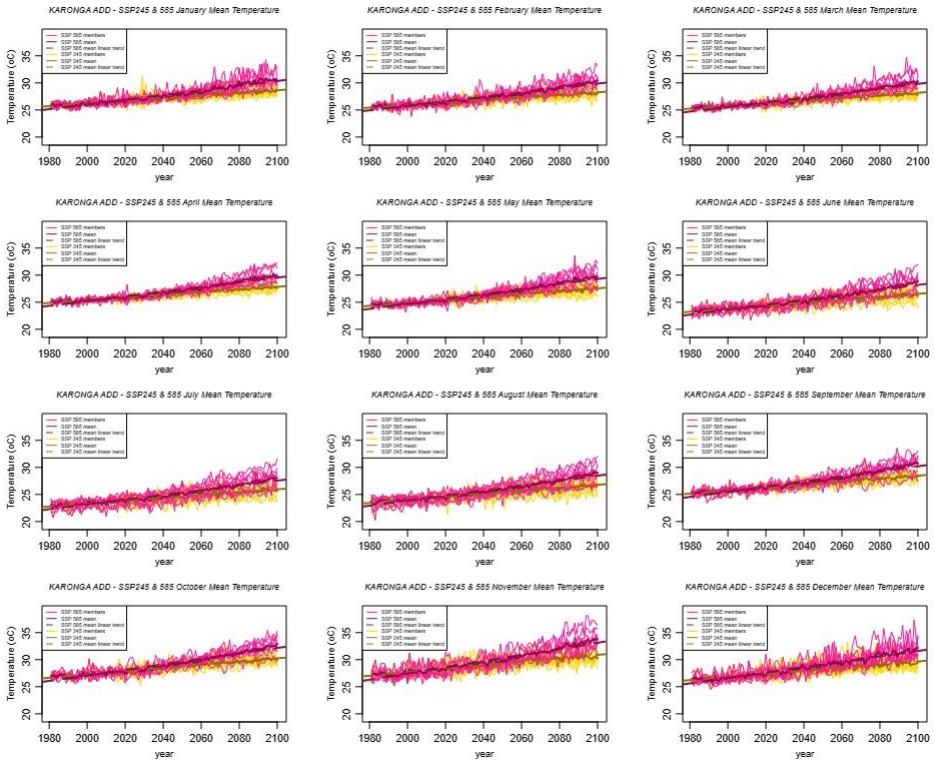


Figure 5- 59 Monthly mean temperature projections in Karonga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 89 Characteristics of the trends from the projected mean temperature time series by month in Karonga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Karonga ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.024**	**0.000**	**0.937**	**0.072**	26.8 (26.5 - 27.6)	27.3 (26.8 - 28.1)	27.9 (27.1 - 29)
Feb	**0.024**	**0.000**	**0.935**	**0.073**	26.5 (26.1 - 26.8)	27 (26.5 - 27.7)	27.6 (26.9 - 28.5)
Mar	**0.024**	**0.000**	**0.954**	**0.058**	26.3 (25.9 - 26.7)	26.9 (26.5 - 27.5)	27.4 (26.9 - 28.4)
Apr	**0.025**	**0.000**	**0.963**	**0.053**	25.9 (25.8 - 26.2)	26.6 (26.3 - 27.2)	27.1 (26.3 - 27.9)
May	**0.027**	**0.000**	**0.954**	**0.061**	25.6 (25.2 - 25.8)	26.1 (25.6 - 26.8)	26.7 (25.8 - 27.7)
Jun	**0.028**	**0.000**	**0.945**	**0.064**	24.4 (23.8 - 25)	25.1 (24.4 - 26.1)	25.7 (24.5 - 27)
Jul	**0.026**	**0.000**	**0.950**	**0.061**	23.9 (23 - 24.5)	24.5 (23.4 - 25.7)	25.1 (23.9 - 26.6)
Aug	**0.028**	**0.000**	**0.951**	**0.060**	24.7 (23.9 - 25.3)	25.3 (24.4 - 26.5)	25.9 (24.4 - 27.2)
Sep	**0.028**	**0.000**	**0.958**	**0.059**	26.4 (26 - 26.7)	27 (26.4 - 27.9)	27.6 (26.7 - 28.7)
Oct	**0.030**	**0.000**	**0.948**	**0.066**	28 (27.2 - 28.6)	28.7 (27.9 - 29.3)	29.3 (28.1 - 30.2)
Nov	**0.032**	**0.000**	**0.929**	**0.076**	28.5 (27.5 - 29.9)	29.2 (28.3 - 30.2)	30 (28.9 - 31.3)
Dec	**0.029**	**0.000**	**0.922**	**0.075**	27.5 (26.5 - 28.9)	28.2 (27.3 - 29.4)	28.8 (27.8 - 30.6)
Karonga ADD SSP5.85							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range**	**Mean, Range**	**Mean, Range**

					2040 (°C)	2060 (°C)	2080 (°C)
Jan	**0.043**	**0.000**	**0.942**	**0.072**	26.9 (26.5 - 27.5)	27.6 (27.1 - 28.4)	28.7 (28 - 29.9)
Feb	**0.041**	**0.000**	**0.949**	**0.064**	26.6 (26.1 - 27.1)	27.4 (26.6 - 28.3)	28.3 (27.3 - 29.5)
Mar	**0.042**	**0.000**	**0.952**	**0.064**	26.3 (26 - 26.7)	27.2 (26.6 - 28)	28.3 (27.4 - 29.4)
Apr	**0.043**	**0.000**	**0.948**	**0.064**	26 (25.8 - 26.5)	26.8 (26.3 - 27.5)	27.9 (27.2 - 29)
May	**0.046**	**0.000**	**0.953**	**0.066**	25.6 (25.3 - 26.1)	26.5 (26 - 27)	27.6 (26.5 - 28.6)
Jun	**0.046**	**0.000**	**0.950**	**0.063**	24.5 (23.8 - 25.3)	25.4 (24.5 - 26.2)	26.5 (25.1 - 27.9)
Jul	**0.044**	**0.000**	**0.953**	**0.062**	24 (23.1 - 24.8)	24.8 (23.8 - 25.9)	25.9 (24.6 - 27.4)
Aug	**0.046**	**0.000**	**0.956**	**0.057**	24.8 (24 - 25.6)	25.7 (24.8 - 26.7)	26.8 (25.3 - 28.4)
Sep	**0.047**	**0.000**	**0.947**	**0.066**	26.4 (25.9 - 26.9)	27.3 (26.4 - 27.9)	28.4 (26.9 - 29.6)
Oct	**0.051**	**0.000**	**0.953**	**0.060**	28 (27.4 - 28.8)	29 (28.2 - 29.7)	30.3 (28.8 - 31.3)
Nov	**0.057**	**0.000**	**0.953**	**0.063**	28.7 (28 - 29.7)	29.6 (28.5 - 31)	31 (29.5 - 32.8)
Dec	**0.050**	**0.000**	**0.952**	**0.061**	27.7 (26.9 - 28.7)	28.7 (27.6 - 29.9)	29.8 (28.9 - 31.5)

5.4.2.1.2 Mzuzu ADD

The mean temperature projection for Mzuzu ADD is presented in Fig. 5-62 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-90. The monthly increasing trends are significant and are ranging

from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

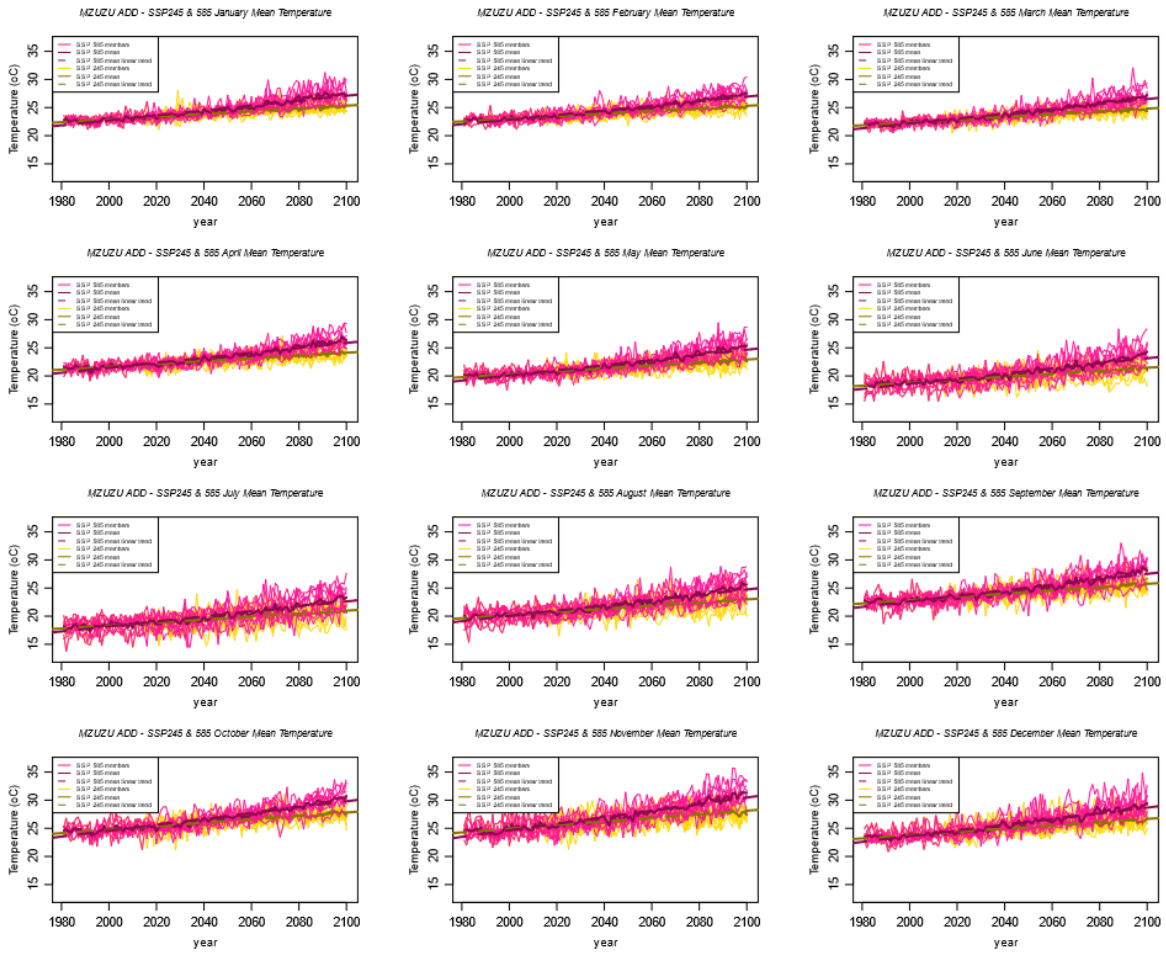


Figure 5- 60 Monthly mean temperature projections in Mzuzu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 90 Characteristics of the trends from the projected mean temperature time series by month in Mzuzu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Mzuzu ADD SSP2.45							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.02**	**0.00**	**0.92**	**0.08**	23.5 (23.2 - 24.5)	24.1 (23.5 - 24.9)	24.6 (23.7 - 25.8)
Feb	**0.02**	**0.00**	**0.92**	**0.08**	23.5 (22.9 - 24.2)	24.1 (23.4 - 25)	24.6 (23.8 - 25.7)

Mar	**0.02**	**0.00**	**0.93**	**0.07**	22.9 (22.6 - 23.5)	23.5 (23.1 - 24.2)	24.1 (23.6 - 25.2)
Apr	**0.02**	**0.00**	**0.91**	**0.07**	22.2 (21.9 - 22.5)	22.8 (22.4 - 23.5)	23.4 (22.6 - 24.1)
May	**0.03**	**0.00**	**0.90**	**0.08**	21 (20.6 - 21.4)	21.5 (20.8 - 22.4)	22.1 (20.9 - 23.3)
Jun	**0.03**	**0.00**	**0.88**	**0.09**	19.4 (18.4 - 20.2)	20.1 (19 - 21.4)	20.6 (19 - 22.1)
Jul	**0.03**	**0.00**	**0.87**	**0.09**	19 (17.6 - 19.9)	19.6 (17.9 - 21)	20.2 (18.5 - 21.9)
Aug	**0.03**	**0.00**	**0.89**	**0.09**	20.9 (19.9 - 21.7)	21.5 (20.3 - 22.7)	22.1 (20.4 - 23.4)
Sep	**0.03**	**0.00**	**0.88**	**0.09**	23.6 (23.2 - 23.8)	24.2 (23.5 - 25)	24.8 (23.8 - 25.8)
Oct	**0.03**	**0.00**	**0.89**	**0.09**	25.4 (24.4 - 26.3)	26.2 (25.4 - 27)	26.8 (25.5 - 28)
Nov	**0.03**	**0.00**	**0.88**	**0.10**	25.8 (24.3 - 27.1)	26.4 (25.4 - 27.4)	27.2 (26 - 28.6)
Dec	**0.03**	**0.00**	**0.89**	**0.08**	24.5 (23.5 - 26)	25.2 (24.3 - 26.6)	25.8 (24.6 - 27.7)

Mzuzu ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.04**	**0.00**	**0.93**	**0.08**	23.6 (23.1 - 24.3)	24.4 (23.7 - 25.2)	25.5 (24.6 - 26.7)
Feb	**0.04**	**0.00**	**0.94**	**0.07**	23.7 (23 - 24.5)	24.4 (23.5 - 25.7)	25.4 (24.1 - 26.6)
Mar	**0.04**	**0.00**	**0.94**	**0.07**	23 (22.5 - 23.5)	23.8 (23.2 - 24.8)	24.9 (24 - 26.2)
Apr	**0.04**	**0.00**	**0.92**	**0.07**	22.3 (22 - 22.7)	23.1 (22.6 - 23.8)	24.2 (23.4 - 25.2)

May	**0.05**	**0.00**	**0.92**	**0.08**	20.9 (20.4 - 21.6)	21.8 (21.2 - 22.6)	22.9 (21.6 - 24.1)
Jun	**0.05**	**0.00**	**0.91**	**0.08**	19.4 (18.4 - 20.4)	20.3 (19.2 - 21.5)	21.4 (19.7 - 23.1)
Jul	**0.04**	**0.00**	**0.91**	**0.08**	19 (17.6 - 19.9)	19.9 (18.3 - 21.1)	20.9 (19.3 - 22.5)
Aug	**0.05**	**0.00**	**0.92**	**0.07**	21 (20 - 21.8)	21.9 (20.9 - 23)	23 (21.5 - 24.5)
Sep	**0.05**	**0.00**	**0.91**	**0.08**	23.6 (23 - 23.9)	24.5 (23.5 - 25.5)	25.7 (23.9 - 26.7)
Oct	**0.05**	**0.00**	**0.93**	**0.07**	25.5 (24.8 - 26.6)	26.6 (25.7 - 27.4)	27.9 (26.2 - 29)
Nov	**0.06**	**0.00**	**0.93**	**0.08**	25.9 (24.8 - 27.2)	26.9 (25.6 - 28.1)	28.3 (26.7 - 29.8)
Dec	**0.05**	**0.00**	**0.94**	**0.07**	24.6 (23.8 - 25.8)	25.7 (24.6 - 27.1)	26.9 (25.8 - 28.8)

5.4.2.1.3 Kasungu ADD

The mean temperature projection for Kasungu ADD is presented in Fig. 5-63 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-91. The monthly increasing trends are significant and are ranging from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

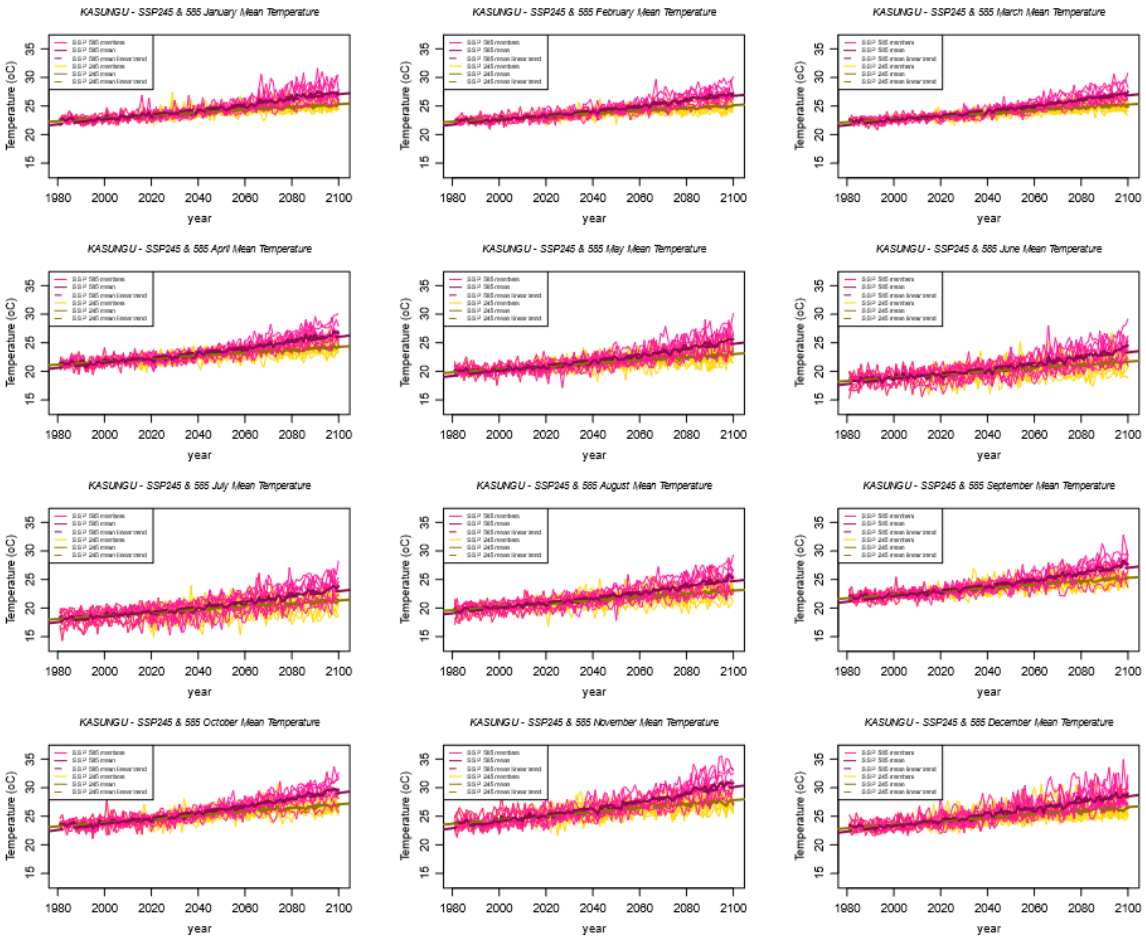


Figure 5- 61 Monthly mean temperature projections in Kasungu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 91 Characteristics of the trends from the projected mean temperature time series by month in Kasungu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Kasungu ADD SSP2.45							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.025**	**0**	**0.939**	**0.072**	**23.4 (21.1 - 25.8)**	**24 (21.6 - 26.4)**	**24.6 (22 - 27.2)**
Feb	**0.024**	**0**	**0.949**	**0.067**	**23.3 (21 - 25.5)**	**23.9 (21.4 - 26.2)**	**24.4 (21.9 - 26.8)**
Mar	**0.026**	**0**	**0.954**	**0.063**	**23.3 (21.1 - 25.3)**	**23.9 (21.6 - 26)**	**24.4 (22.1 - 26.7)**
Apr	**0.026**	**0**	**0.924**	**0.068**	**22.3 (19.6 - 24.6)**	**22.9 (20.1 - 25.4)**	**23.5 (20.5 - 26)**

May	**0.027**	**0**	**0.912**	**0.082**	**21 (18.1 - 23.7)**	**21.6 (18.6 - 24.5)**	**22.2 (19 - 25.2)**
Jun	**0.028**	**0**	**0.902**	**0.076**	**19.5 (16.1 - 22.5)**	**20.2 (16.8 - 23.4)**	**20.8 (17.4 - 24.2)**
Jul	**0.027**	**0**	**0.904**	**0.082**	**19.3 (15.7 - 22.3)**	**19.9 (16.2 - 23.2)**	**20.5 (16.7 - 24)**
Aug	**0.029**	**0**	**0.924**	**0.07**	**21 (18 - 23.7)**	**21.6 (18.4 - 24.5)**	**22.1 (18.8 - 25.2)**
Sep	**0.03**	**0**	**0.94**	**0.069**	**23.1 (20.4 - 25.6)**	**23.8 (21.1 - 26.4)**	**24.3 (21.5 - 27.1)**
Oct	**0.032**	**0**	**0.928**	**0.075**	**24.6 (21.5 - 27.3)**	**25.5 (22.5 - 28.2)**	**26.1 (23 - 29)**
Nov	**0.034**	**0**	**0.923**	**0.078**	**25.3 (21.8 - 28.5)**	**26 (22.4 - 29.4)**	**26.8 (23 - 30.3)**
Dec	**0.031**	**0**	**0.921**	**0.076**	**24.3 (21.4 - 27.5)**	**25 (22 - 28.7)**	**25.7 (22.5 - 29.8)**
Kasungu ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	**0.044**	**0**	**0.934**	**0.079**	**23.5 (21.1 - 25.9)**	**24.3 (21.8 - 26.7)**	**25.4 (22.6 - 28.6)**
Feb	**0.042**	**0**	**0.954**	**0.064**	**23.4 (21 - 25.7)**	**24.2 (21.7 - 26.6)**	**25.2 (22.5 - 27.9)**
Mar	**0.043**	**0**	**0.956**	**0.061**	**23.3 (21.1 - 25.3)**	**24.2 (21.9 - 26.3)**	**25.3 (22.7 - 27.7)**
Apr	**0.045**	**0**	**0.93**	**0.069**	**22.3 (19.7 - 24.8)**	**23.2 (20.5 - 25.6)**	**24.4 (21.3 - 27.1)**
May	**0.047**	**0**	**0.929**	**0.077**	**21 (18.1 - 23.6)**	**21.9 (18.9 - 24.7)**	**23 (19.8 - 26.3)**
Jun	**0.046**	**0**	**0.917**	**0.075**	**19.6 (16.2 - 22.7)**	**20.4 (17 - 23.6)**	**21.6 (18 - 25.2)**

Jul	**0.045**	**0**	**0.93**	**0.071**	**19.3 (15.7 - 22.4)**	**20.1 (16.4 - 23.2)**	**21.3 (17.3 - 24.9)**
Aug	**0.047**	**0**	**0.95**	**0.056**	**21 (17.9 - 23.7)**	**21.9 (18.7 - 24.8)**	**23 (19.5 - 26.3)**
Sep	**0.049**	**0**	**0.945**	**0.062**	**23.1 (20.4 - 25.6)**	**24 (21.3 - 26.7)**	**25.2 (22 - 28.2)**
Oct	**0.054**	**0**	**0.954**	**0.06**	**24.7 (21.6 - 27.3)**	**25.8 (22.7 - 28.5)**	**27.1 (23.9 - 30)**
Nov	**0.06**	**0**	**0.946**	**0.066**	**25.4 (22.1 - 28.5)**	**26.4 (22.8 - 29.7)**	**27.8 (23.8 - 31.5)**
Dec	**0.051**	**0**	**0.946**	**0.065**	**24.4 (21.5 - 27.8)**	**25.5 (22.3 - 29.3)**	**26.7 (23.2 - 31)**

5.4.2.1.4 Lilongwe ADD

The mean temperature projection for Lilongwe ADD is presented in Fig. 5-64 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-92. The monthly increasing trends are significant and are ranging

from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

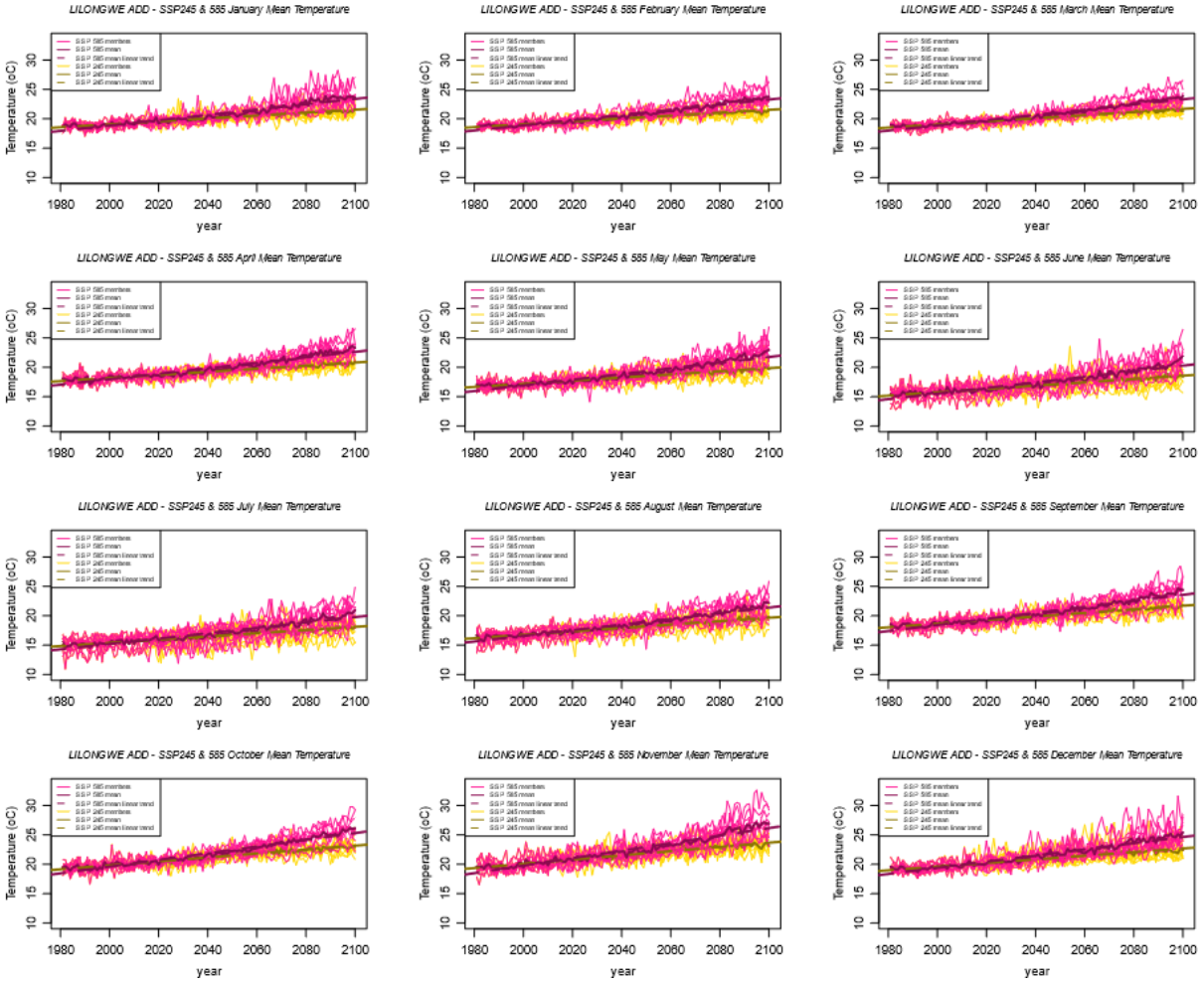


Figure 5- 62 Monthly mean temperature projections in Lilongwe ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 92 Characteristics of the trends from the projected mean temperature time series by month in Lilongwe ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Lilongwe ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.02**	**0.0**	**0.93**	**0.07**	18.8 (18.5 - 19.1)	20.2 (19.8 - 21)	20.8 (20.1 - 22)
Feb	**0.02**	**0.0**	**0.94**	**0.07**	17.9 (17.6 - 18.2)	20.2 (19.7 - 21.1)	20.8 (20.2 - 21.9)
Mar	**0.03**	**0.0**	**0.95**	**0.06**	16.4 (15.4 - 17.2)	20.2 (19.9 - 20.8)	20.8 (20.3 - 21.9)
Apr	**0.03**	**0.0**	**0.93**	**0.06**	16 (14.6 - 16.9)	19.5 (19 - 20.1)	20 (19.4 - 20.7)
May	**0.03**	**0.0**	**0.92**	**0.08**	17.5 (16.6 - 18.3)	18.5 (18 - 19.4)	19 (18.1 - 20.2)

Jun	**0.03**	**0.0**	**0.91**	**0.08**	19.4 (19 - 19.8)	17.1 (16.1 - 18.4)	17.6 (16.1 - 19)
Jul	**0.03**	**0.0**	**0.9**	**0.09**	20.6 (19.9 - 21.1)	16.7 (15.2 - 17.9)	17.3 (15.6 - 18.9)
Aug	**0.03**	**0.0**	**0.91**	**0.08**	21 (19.9 - 22.1)	18.1 (17.1 - 19.2)	18.7 (17.1 - 19.9)
Sep	**0.03**	**0.0**	**0.93**	**0.07**	20.4 (19.3 - 21.9)	20.2 (19.5 - 20.8)	20.7 (19.8 - 21.6)
Oct	**0.03**	**0.0**	**0.93**	**0.07**	**20.6 (17.3 - 23.3)**	21.5 (20.9 - 22.1)	22.1 (21 - 22.8)
Nov	**0.04**	**0.0**	**0.92**	**0.08**	**21 (17.6 - 24.3)**	21.7 (20.9 - 22.5)	22.6 (21.7 - 24.1)
Dec	**0.03**	**0.0**	**0.92**	**0.07**	**20.4 (17.5 - 23.4)**	21.1 (20.2 - 22.5)	21.8 (20.7 - 23.9)

Lilongwe ADD SSP5.85

Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.05**	**0.0**	**0.93**	**0.08**	19.7 (19.4 - 20.4)	20.5 (20 - 21.5)	21.6 (20.6 - 23.1)
Feb	**0.04**	**0.0**	**0.95**	**0.07**	19.7 (19.3 - 20.5)	20.6 (20 - 21.7)	21.6 (20.5 - 22.9)
Mar	**0.04**	**0.0**	**0.96**	**0.06**	19.7 (19.3 - 20.2)	20.6 (20.1 - 21.4)	21.7 (20.9 - 22.8)
Apr	**0.05**	**0.0**	**0.93**	**0.07**	18.8 (18.6 - 19.2)	19.7 (19.4 - 20.5)	20.9 (20 - 22)
May	**0.05**	**0.0**	**0.93**	**0.07**	17.8 (17.1 - 18.6)	18.7 (17.8 - 19.7)	19.9 (18.6 - 21.2)
Jun	**0.05**	**0.0**	**0.92**	**0.07**	16.4 (15.2 - 17.2)	17.3 (16 - 18.5)	18.5 (16.9 - 20.1)
Jul	**0.05**	**0.0**	**0.92**	**0.07**	16.1 (14.4 - 16.9)	16.9 (15.1 - 18.1)	18 (16.5 - 19.6)
Aug	**0.05**	**0.0**	**0.95**	**0.06**	17.5 (16.5 - 18.3)	18.4 (17.5 - 19.3)	19.6 (18.3 - 21)
Sep	**0.05**	**0.0**	**0.94**	**0.06**	19.4 (19.1 - 19.8)	20.4 (19.6 - 21.1)	21.6 (19.8 - 22.9)
Oct	**0.06**	**0.0**	**0.95**	**0.06**	20.7 (20.4 - 21.3)	21.8 (21 - 22.7)	23.2 (21.4 - 24.1)
Nov	**0.06**	**0.0**	**0.94**	**0.07**	21.1 (20.3 - 22.2)	22.2 (20.8 - 23.4)	23.6 (21.8 - 25)
Dec	**0.05**	**0.0**	**0.95**	**0.06**	20.5 (19.6 - 21.6)	21.5 (20.7 - 23)	22.7 (21.4 - 24.9)
					21.1 (20.3 - 22.2)		
					20.5 (19.6 - 21.6)		

5.4.2.1.5 Salima ADD

The mean temperature projection for Salima ADD is presented in Fig. 5-65 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-93. The monthly increasing trends are significant and are ranging from +0.02 to +0.03 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.04 to +0.06 degrees Celsius per year.

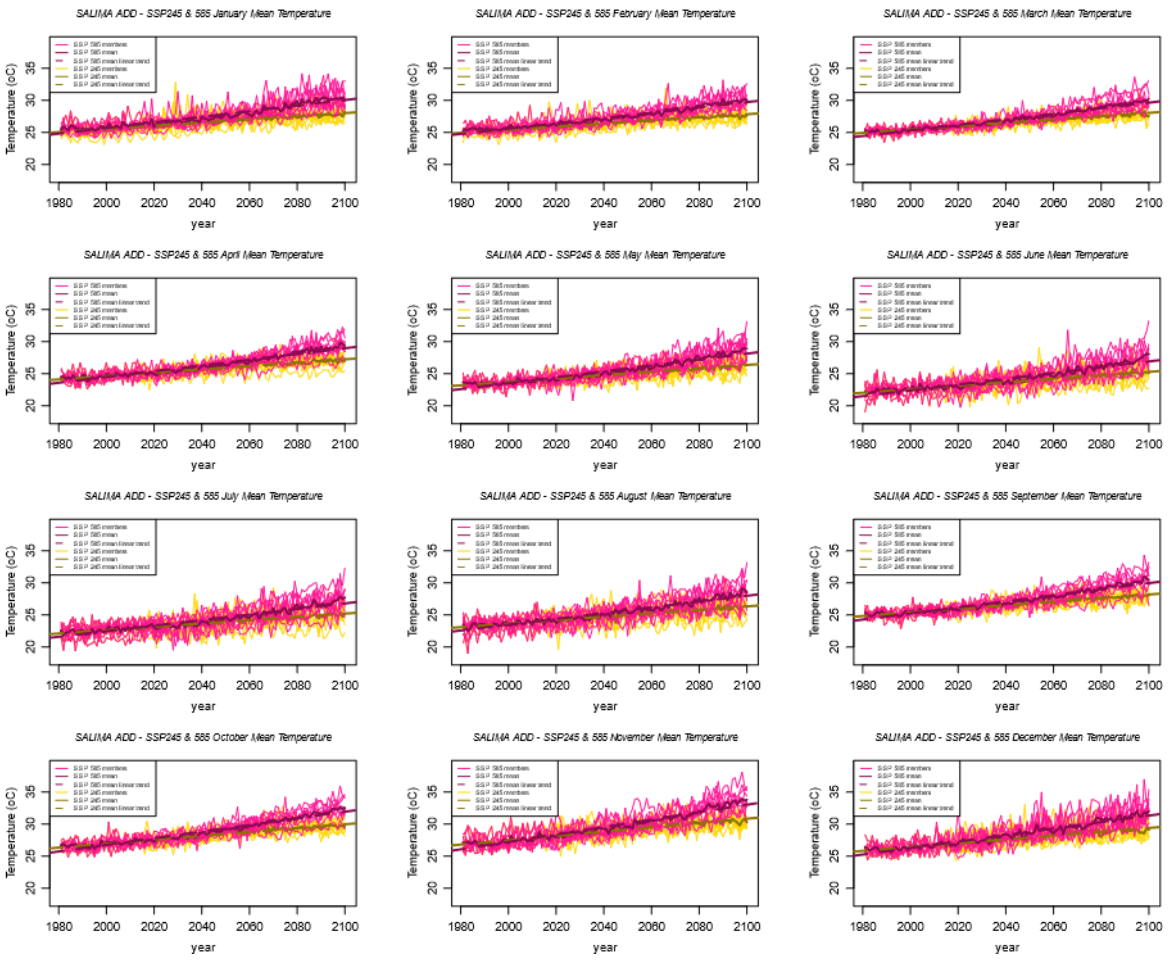


Figure 5- 63 Monthly mean temperature projections in Salima ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 93 Characteristics of the trends from the projected mean temperature time series by month in Salima ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Salima ADD SSP4.5							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**

Jan	0.02	0	0.9	0.09	26.2 (24.7 - 27.5)	26.7 (25.5 - 27.8)	27.3 (26.3 - 28.3)
Feb	0.02	0	0.93	0.08	26 (24.9 - 27.3)	26.6 (25.7 - 27.7)	27.1 (26.4 - 28.1)
Mar	0.03	0	0.94	0.07	26.1 (25.6 - 26.5)	26.7 (26.3 - 27.4)	27.2 (26.8 - 28.3)
Apr	0.03	0	0.94	0.07	25.2 (24.4 - 25.9)	25.9 (24.9 - 26.4)	26.4 (25 - 27.2)
May	0.03	0	0.92	0.08	24.4 (24.1 - 24.8)	25 (24.3 - 26)	25.5 (24.6 - 26.8)
Jun	0.03	0	0.9	0.08	23.2 (22.3 - 24)	23.8 (22.9 - 25.2)	24.4 (22.9 - 25.8)
Jul	0.03	0	0.88	0.09	23.2 (21.8 - 24)	23.8 (22.2 - 25.2)	24.5 (22.4 - 26.2)
Aug	0.03	0	0.89	0.08	24.4 (23.1 - 25.2)	24.9 (23.6 - 26.1)	25.5 (23.6 - 26.9)
Sep	0.03	0	0.94	0.07	26.1 (25.8 - 26.6)	26.8 (26.3 - 27.5)	27.3 (26.6 - 28.3)
Oct	0.03	0	0.93	0.07	27.7 (26.9 - 28.3)	28.4 (27.9 - 29)	29.1 (28.1 - 30.1)
Nov	0.03	0	0.93	0.08	28.4 (27.2 - 29.6)	29 (28 - 30)	29.9 (29 - 31.2)
Dec	0.03	0	0.9	0.09	27.2 (25.9 - 28.5)	27.9 (26.8 - 29)	28.5 (27.5 - 30)
Salima ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	0.04	0	0.92	0.08	26.5 (25.6 - 27.5)	27.3 (26.4 - 28.2)	28.4 (27.2 - 29.6)

Feb	0.04	0	0.95	0.07	26.4 (25.6 - 27.5)	27.2 (26.4 - 28)	28.2 (27 - 29.1)
Mar	0.04	0	0.96	0.06	26.1 (25.7 - 26.6)	27 (26.5 - 27.8)	28 (27.4 - 29.2)
Apr	0.04	0	0.94	0.06	25.3 (24.6 - 25.8)	26.2 (25.3 - 26.6)	27.3 (25.7 - 28.3)
May	0.05	0	0.94	0.07	24.4 (23.7 - 25.1)	25.3 (24.6 - 26.3)	26.4 (25 - 27.8)
Jun	0.05	0	0.92	0.07	23.3 (22.1 - 24.1)	24.1 (23.1 - 25.3)	25.2 (23.7 - 27)
Jul	0.04	0	0.92	0.07	23.3 (21.7 - 24.3)	24.1 (22.3 - 25.4)	25.2 (23.2 - 26.9)
Aug	0.05	0	0.93	0.06	24.4 (23.1 - 25.2)	25.3 (24 - 26.3)	26.3 (24.9 - 27.9)
Sep	0.05	0	0.95	0.06	26.1 (25.8 - 26.5)	27.1 (26.3 - 27.8)	28.2 (26.5 - 29.6)
Oct	0.05	0	0.96	0.06	27.8 (27.2 - 28.5)	28.8 (28 - 29.6)	30 (28.4 - 31)
Nov	0.06	0	0.94	0.07	28.5 (27.7 - 29.6)	29.5 (28.1 - 31.2)	30.8 (29.1 - 32.7)
Dec	0.05	0	0.94	0.07	27.3 (26.3 - 28.4)	28.4 (27.1 - 29.5)	29.5 (28.2 - 31)

5.4.2.1.6 Shire Valley ADD

The mean temperature projection for Shire Valley ADD is presented in Fig. 5-66 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-94. The monthly increasing trends are significant and are ranging from +0.03 to +0.04 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.05 to +0.06 degrees Celsius per year.

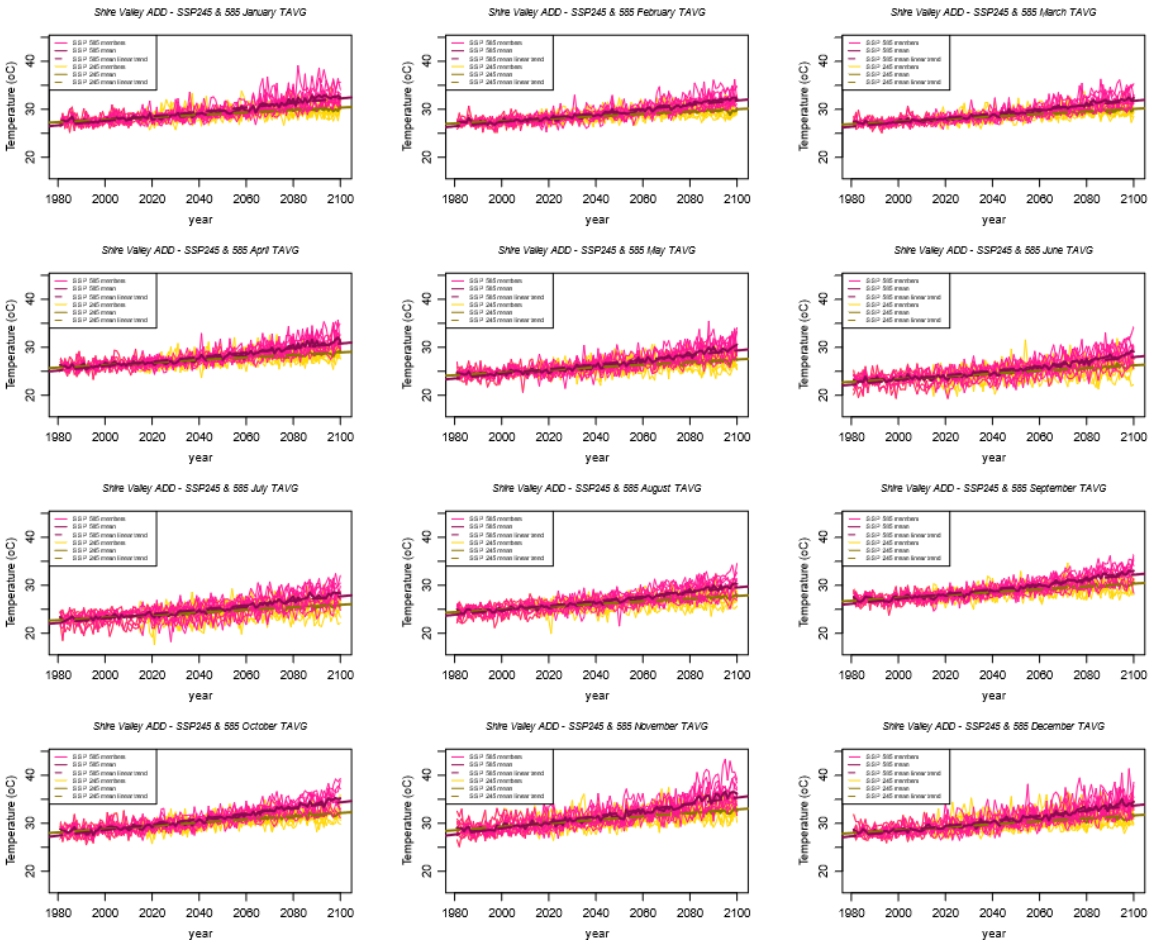


Figure 5- 64 Monthly mean temperature projections in Shire Valley ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 94 Characteristics of the trends from the projected mean temperature time series by month in Shire Valley ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Shire Valley ADD SSP2.45							
Month	**Slope (OC/ year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	0.025	0	0.884	0.09	28.5 (28 - 29.7)	29 (28.3 - 30)	29.6 (28.8 - 31)
Feb	0.025	0	0.883	0.091	28.1 (27.7 - 29.1)	28.7 (28.1 - 29.6)	29.3 (28.5 - 30.5)
Mar	0.026	0	0.896	0.089	28 (27.5 - 28.6)	28.7 (28.2 - 29.3)	29.3 (28.7 - 30.5)
Apr	0.026	0	0.884	0.084	26.9 (26.3 - 27.2)	27.6 (27.2 - 28.2)	28.1 (27.5 - 28.9)
May	0.027	0	0.868	0.098	25.4 (24.8 - 25.9)	26 (25.3 - 27.1)	26.6 (25.4 - 27.9)
Jun	0.029	0	0.866	0.097	24 (22.8 - 24.8)	24.7 (23.2 - 25.9)	25.4 (23.4 - 26.6)

Jul	0.027	0	0.872	0.1	23.8 (22.1 - 25)	24.5 (22.7 - 25.7)	25.1 (23.3 - 26.7)
Aug	0.028	0	0.879	0.089	25.7 (24.6 - 26.6)	26.3 (25 - 27.3)	26.9 (25 - 28)
Sep	0.03	0	0.894	0.088	28.1 (27.7 - 28.6)	28.8 (28.3 - 29.3)	29.4 (28.4 - 30.3)
Oct	0.034	0	0.901	0.082	29.5 (28.9 - 29.9)	30.4 (29.7 - 30.9)	31.1 (29.9 - 32.2)
Nov	0.036	0	0.893	0.083	30.3 (28.8 - 31.9)	30.9 (29.8 - 31.8)	31.8 (30.5 - 33.5)
Dec	0.031	0	0.876	0.097	29.3 (28.2 - 31.3)	30.1 (28.9 - 31.7)	30.7 (29.3 - 32.9)
Shire Valley ADD SSP5.85							
Month	**Slope (OC/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Jan	0.047	0	0.9	0.093	28.5 (28.1 - 29.4)	29.2 (28.5 - 30.6)	30.4 (29.3 - 32.1)
Feb	0.045	0	0.931	0.075	28.2 (27.7 - 29.2)	29.1 (28.4 - 30.3)	30.1 (29 - 31.3)
Mar	0.045	0	0.934	0.074	28.2 (27.8 - 28.7)	29 (28.3 - 29.7)	30.1 (29.2 - 31.1)
Apr	0.047	0	0.908	0.078	26.9 (26.7 - 27.3)	27.9 (27.5 - 28.7)	29 (28.1 - 30)
May	0.049	0	0.91	0.081	25.4 (24.3 - 26.1)	26.3 (25 - 27.4)	27.5 (26 - 28.9)
Jun	0.048	0	0.906	0.081	24 (22.6 - 24.8)	25 (23.3 - 26.2)	26.1 (24 - 27.8)
Jul	0.046	0	0.915	0.081	24 (22.2 - 25)	24.8 (22.9 - 26.1)	26 (24.1 - 27.5)
Aug	0.047	0	0.94	0.065	25.8 (24.5 - 26.7)	26.6 (25.5 - 27.7)	27.8 (26.2 - 29.2)
Sep	0.05	0	0.929	0.074	28.1 (27.8 - 28.5)	29.1 (28.3 - 29.8)	30.3 (28.8 - 31.6)
Oct	0.058	0	0.937	0.067	29.7 (29.3 - 30.2)	30.8 (29.9 - 31.7)	32.2 (30.6 - 33.3)
Nov	0.064	0	0.917	0.079	30.3 (29.4 - 31.8)	31.4 (29.8 - 33)	32.7 (30.9 - 34.6)
Dec	0.053	0	0.923	0.074	29.5 (28.6 - 31)	30.5 (29.5 - 32.2)	31.7 (30.3 - 34)

5.4.2.1.7 Machinga ADD

The mean temperature projection for Machinga ADD is presented in Fig. 5-67 for both SSP2.45 and SSP5.85. Both scenarios are showing the increasing trend and SSP5.85 has a faster increase in temperature than SSP2.45 more especially during end century. The trend characteristics for both scenarios are presented in Tab. 5-95. The monthly increasing trends are significant and are ranging from +0.02 to +0.04 degrees Celsius per year for SSP2.45. While SSP5.85 has the increase ranging from +0.05 to +0.06 degrees Celsius per year.

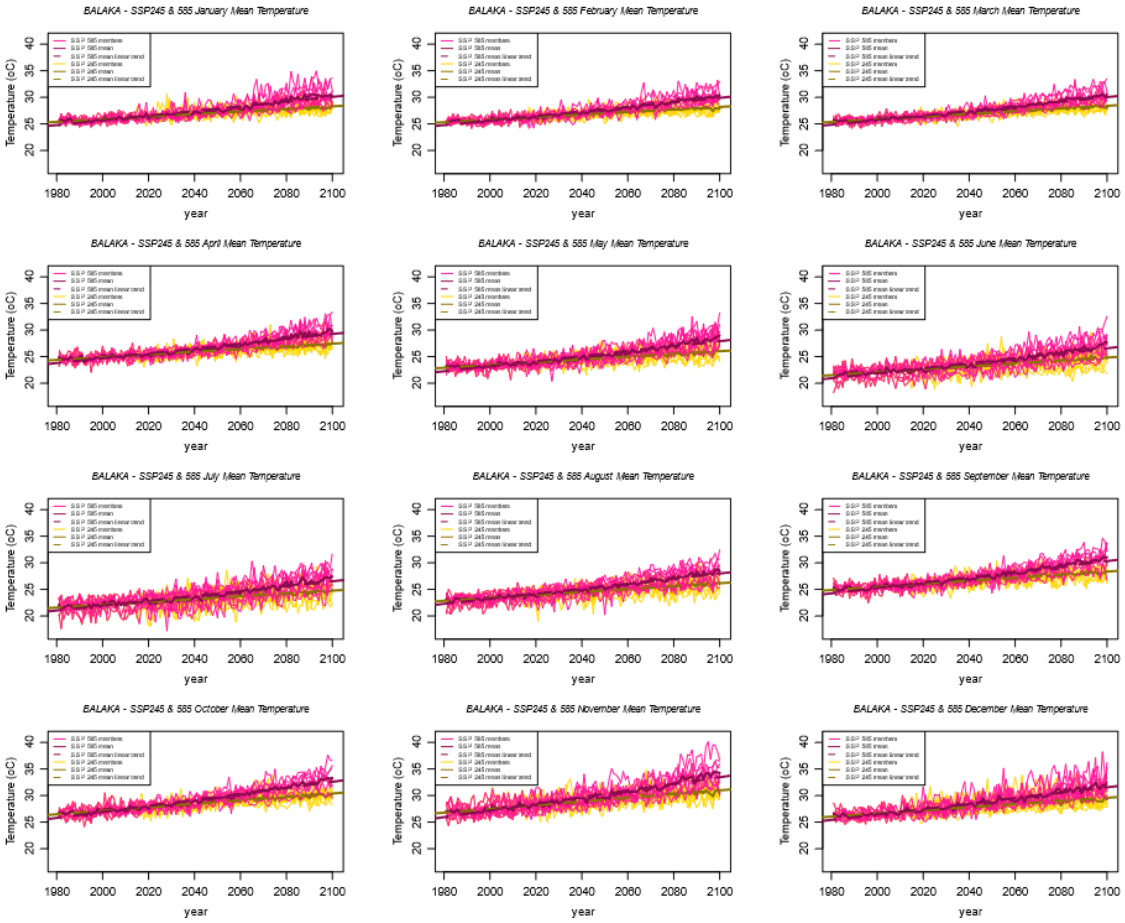


Figure 5- 65 Monthly mean temperature projections in Machinga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 95 Characteristics of the trends from the projected mean temperature time series by month in Machinga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Machinga ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	0.024	0	0.931	0.073	26.5 (23.9 - 29.1)	27 (24.4 - 29.7)	27.6 (24.8 - 30.5)

Feb	0.024	0	0.934	0.075	26.4 (23.8 - 28.8)	226.9 (24.2 - 29.5)	227.5 (24.8 - 30.2)
Mar	0.025	0	0.942	0.068	26.4 (24 - 28.7)	27 (24.5 - 29.4)	27.6 (25.1 - 30.2)
Apr	0.025	0	0.923	0.071	25.5 (22.7 - 28)	26.1 (23.2 - 28.9)	26.7 (23.6 - 29.6)
May	0.026	0	0.911	0.084	24.1 (21.1 - 26.9)	24.7 (21.5 - 27.7)	25.2 (22 - 28.3)
Jun	0.028	0	0.902	0.083	22.7 (19.2 - 25.8)	23.4 (19.8 - 26.7)	23.9 (20.5 - 27.4)
Jul	0.027	0	0.869	0.103	22.7 (18.8 - 26.3)	23.3 (19.3 - 27.2)	23.9 (20 - 27.9)
Aug	0.028	0	0.896	0.081	24.1 (20.8 - 27)	24.7 (21.2 - 27.7)	25.2 (21.7 - 28.5)
Sep	0.029	0	0.916	0.083	26.2 (22.8 - 29)	26.9 (23.5 - 29.7)	27.4 (24.1 - 30.5)
Oct	0.033	0	0.929	0.076	27.9 (24.3 - 30.9)	28.7 (25.2 - 31.7)	29.4 (25.8 - 32.5)
Nov	0.035	0	0.912	0.081	28.4 (24.6 - 32.2)	29 (25.1 - 33)	29.9 (25.8 - 33.9)
Dec	0.03	0	0.907	0.085	27.4 (24.3 - 30.8)	28.1 (24.8 - 32)	28.7 (25.4 - 33.1)
Machinga ADD SSP5.85							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^oC)**	**Mean, Range 2060 (^oC)**	**Mean, Range 2080 (^oC)**
Jan	0.044	0	0.929	0.081	26.5 (24 - 29.1)	27.3 (24.6 - 30.1)	28.4 (25.5 - 31.7)
Feb	0.043	0	0.951	0.066	26.5	27.3	28.3

					(23.9 - 29)	(24.6 - 29.9)	(25.4 - 31.2)
Mar	0.043	0	0.954	0.063	26.5 (24.2 - 28.8)	27.4 (24.9 - 29.7)	28.4 (25.8 - 31.1)
Apr	0.046	0	0.929	0.07	25.5 (22.8 - 28.1)	26.4 (23.6 - 29.1)	27.6 (24.5 - 30.5)
May	0.047	0	0.93	0.073	24.1 (21.1 - 26.9)	25 (21.9 - 28)	26.1 (22.8 - 29.4)
Jun	0.047	0	0.927	0.072	22.8 (19.4 - 26)	23.7 (20.2 - 27)	224.8 (21.2 - 28.5)
Jul	0.046	0	0.922	0.076	22.8 (18.8 - 26.5)	23.7 (19.5 - 27.5	24.8 (20.7 - 28.8)
Aug	0.047	0	0.953	0.058	24.2 (20.7 - 27.1)	25.1 (21.6 - 28.2)	26.2 (22.6 - 29.6)
Sep	0.051	0	0.944	0.066	26.2 (22.8 - 29)	27.3 (23.9 - 30.1)	28.4 (25 - 31.5)
Oct	0.057	0	0.957	0.058	28.1 (24.5 - 31)	29.1 (25.6 - 32.1)	30.5 (27 - 33.6)
Nov	0.063	0	0.937	0.071	28.5 (24.8 - 32.1)	29.6 (25.6 - 33.5)	31 (26.6 - 35.3)
Dec	0.051	0	0.941	0.067	27.5 (24.4 - 31.1)	28.5 (25.3 - 32.4)	29.7 (26.2 - 34.1)

5.4.2.1.8 Blantyre ADD

The projections for mean air temperature show an increasing trend for both scenarios for Blantyre ADD (Fig. 5-68) for all months of the year. The rate of increase is faster for SSP5.85 scenario than for SSP2.45 more especially during end of the century.

The monthly increasing trends are significant for both scenarios and all the months of the year. For the SSP2.45, the rate of increase is from +0.024 to +0.36 degrees Celsius per year while SSP5.85, the rate of increase is from +0.044 to +0.064 degrees Celsius per year.

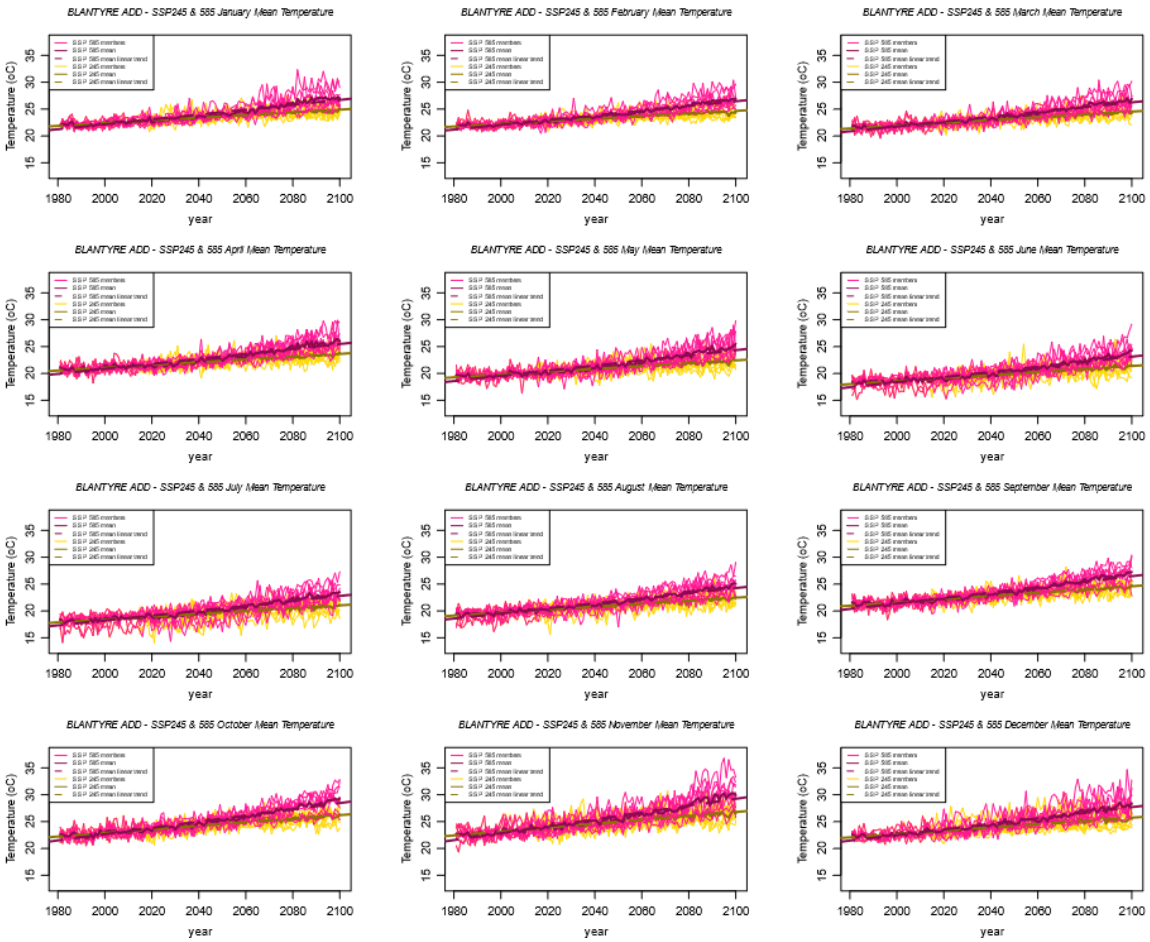


Figure 5- 66 Monthly mean temperature projections in Blantyre ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 96 Characteristics of the trends from the projected mean temperature time series by month in Blantyre ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Blantyre ADD SSP2.45							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Jan	**0.025**	**0.000**	**0.939**	**0.067**	23 (22.7 - 24.2)	23.6 (23 - 24.6)	24.2 (23.3 - 25.5)
Feb	**0.024**	**0.000**	**0.932**	**0.075**	22.8 (22.4 - 23.9)	23.4 (22.9 - 24.4)	24 (23.2 - 25.3)
Mar	**0.026**	**0.000**	**0.924**	**0.077**	22.5 (22 - 23.1)	23.1 (22.7 - 23.8)	23.7 (23 - 25)
Apr	**0.026**	**0.000**	**0.915**	**0.076**	21.6 (21.3 - 22.1)	22.3 (21.8 - 23.1)	22.9 (21.9 - 23.8)

May	**0.026**	**0.000**	**0.902**	**0.088**	20.4 (20 - 20.9)	21.1 (20.4 - 22.2)	21.7 (20.6 - 23)
Jun	**0.028**	**0.000**	**0.899**	**0.083**	19.2 (18 - 20)	19.9 (18.8 - 21.1)	20.5 (19.2 - 21.8)
Jul	**0.026**	**0.000**	**0.896**	**0.091**	19 (17.3 - 19.7)	19.6 (17.8 - 20.7)	20.2 (18.6 - 21.8)
Aug	**0.028**	**0.000**	**0.898**	**0.082**	20.4 (19.3 - 21.1)	21 (20.1 - 22.1)	21.6 (20.7 - 22.7)
Sep	**0.030**	**0.000**	**0.918**	**0.077**	22.2 (21.9 - 22.6)	23 (22.5 - 23.7)	23.7 (22.8 - 24.7)
Oct	**0.033**	**0.000**	**0.924**	**0.076**	23.7 (23.2 - 24.1)	24.5 (23.9 - 25.2)	25.2 (24.1 - 26.2)
Nov	**0.036**	**0.000**	**0.916**	**0.076**	24.2 (23 - 25.8)	24.8 (23.5 - 25.7)	25.7 (24.2 - 27.3)
Dec	**0.031**	**0.000**	**0.922**	**0.076**	23.4 (22.4 - 25.4)	24.1 (23.2 - 25.8)	24.8 (23.6 - 27)
Blantyre ADD SSP5.85							
Month	**Slope (°C/year)**	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^oC)**	**Mean, Range 2060 (^oC)**	**Mean, Range 2080 (^oC)**
Jan	**0.045**	**0.000**	**0.929**	**0.081**	23.1 (22.7 - 23.9)	23.8 (23.3 - 25.1)	24.9 (23.9 - 26.6)
Feb	**0.044**	**0.000**	**0.952**	**0.066**	22.9 (22.4 - 23.9)	23.8 (23.2 - 25)	24.8 (23.8 - 26.1)
Mar	**0.045**	**0.000**	**0.944**	**0.068**	22.6 (22.3 - 23.2)	23.5 (22.9 - 24.2)	24.6 (23.7 - 25.7)
Apr	**0.046**	**0.000**	**0.919**	**0.077**	21.7 (21.4 - 22.2)	22.5 (22.1 - 23.5)	23.8 (22.6 - 25)
May	**0.048**	**0.000**	**0.920**	**0.078**	20.4 (19.5 - 21.2)	21.3 (20.1 - 22.5)	22.5 (21.5 - 24)

Jun	**0.047**	**0.000**	**0.925**	**0.074**	19.2 (17.9 - 20)	20.2 (18.6 - 21.3)	21.4 (20.2 - 23)
Jul	**0.046**	**0.000**	**0.929**	**0.075**	19.1 (17.4 - 19.7)	19.9 (18 - 21)	21.1 (19.6 - 22.5)
Aug	**0.047**	**0.000**	**0.947**	**0.060**	20.5 (19.2 - 21.2)	21.3 (20.2 - 22.2)	22.5 (21.5 - 23.9)
Sep	**0.051**	**0.000**	**0.941**	**0.068**	22.3 (21.8 - 22.7)	23.4 (22.6 - 24.1)	24.6 (23 - 26)
Oct	**0.058**	**0.000**	**0.950**	**0.063**	23.8 (23.2 - 24.2)	24.9 (24 - 25.7)	26.3 (24.7 - 27.3)
Nov	**0.064**	**0.000**	**0.932**	**0.074**	24.2 (23.6 - 25.6)	25.3 (24 - 26.8)	26.6 (24.8 - 28.4)
Dec	**0.052**	**0.000**	**0.947**	**0.063**	23.6 (22.8 - 25.1)	24.6 (23.6 - 26.3)	25.8 (24.4 - 28.2)

5.4.2.2 **Annual Mean Temperature**

5.4.2.2.1 Karonga ADD

The annual mean temperature trends are shown in Fig. 5-69 for Karonga ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-97. The annual mean temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual mean temperature increases by +1.2 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual mean temperature increase during the end-century (2080s) is by +1.8 degrees Celsius for SSP2.45 and +2.7 degrees Celsius for SSP5.85.

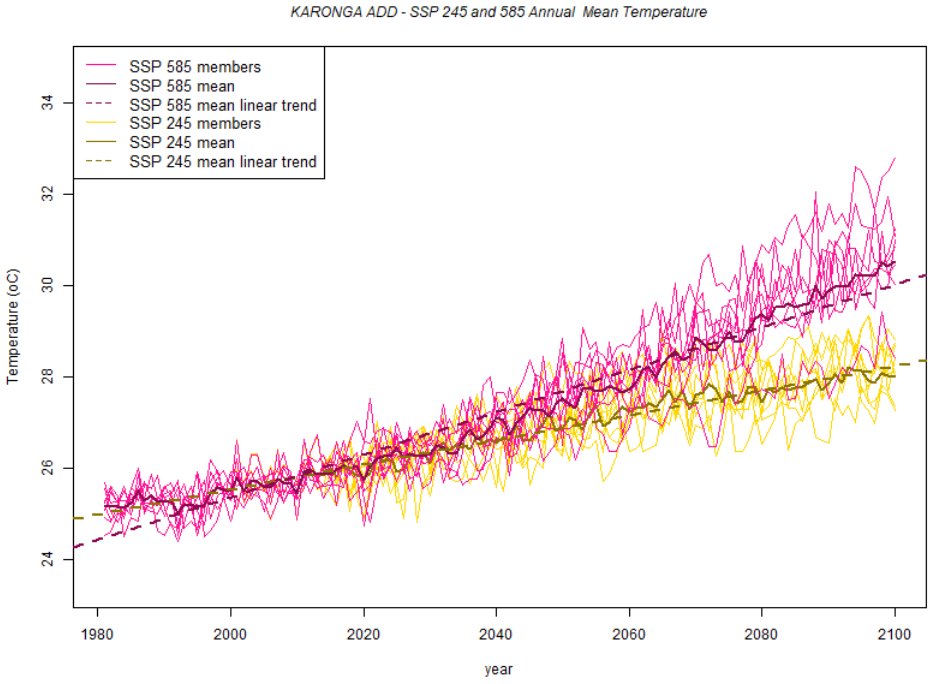


Figure 5- 672 Annual mean temperature projections in Karonga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 97 Characteristics of the trends from the projected annual mean temperature time series in Karonga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Karonga ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Karonga	**0.027**	**0.000**	**0.971**	**0.051**	26.2 (25.9 - 26.5)	26.8 (26.4 - 27.5)	27.4 (26.7 - 28.3)
Karonga ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**
Karonga	**0.046**	**0.000**	**0.961**	**0.059**	26.3 (26 - 26.7)	27.2 (26.5 - 27.8)	28.3 (27.2 - 29.3)

5.4.2.2.2 Mzuzu ADD

The annual mean temperature trends are shown in Fig. 5-70 for Mzuzu ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-98. The annual mean temperature increases by +0.5 degrees Celsius for SSP2.45 (ensemble mean) and +0.6

degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual mean temperature increases by +1.2 and +1.5 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual mean temperature increase during the end-century (2080s) is by +1.7 degrees Celsius for SSP2.45 and +2.6 degrees Celsius for SSP5.85.

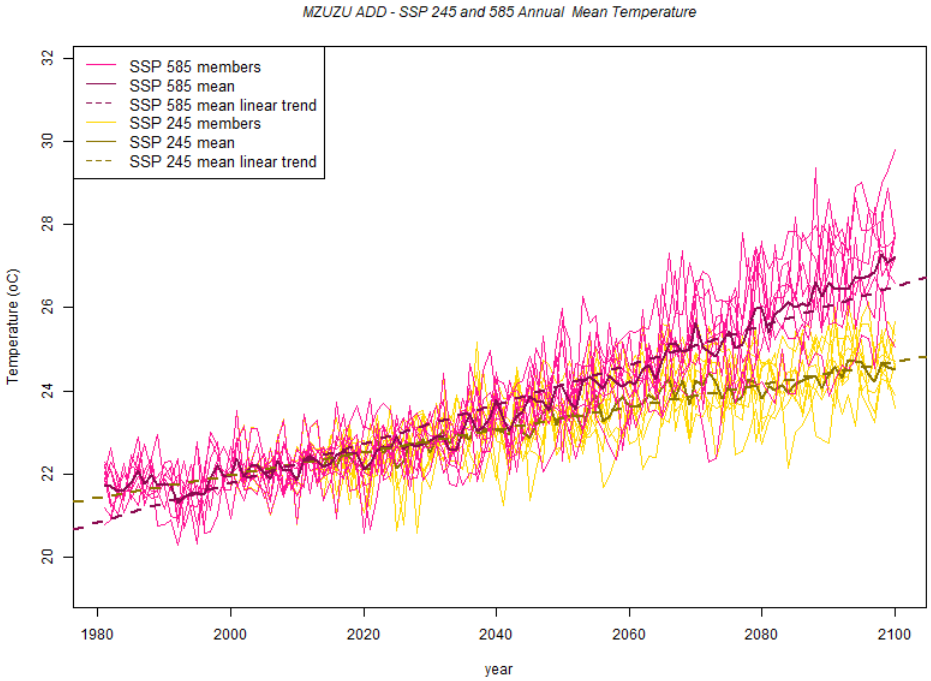


Figure 5- 68 Annual mean temperature projections in Mzuzu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 98 Characteristics of the trends from the projected annual mean temperature time series in Mzuzu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Mzuzu ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Mzuzu	**0.03**	**0.00**	**0.94**	**0.07**	22.6 (22.4 - 22.9)	23.3 (22.8 - 24)	23.9 (23.2 - 24.8)
Mzuzu ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Mzuzu	**0.05**	**0.00**	**0.94**	**0.07**	22.7 (22.4 - 23.1)	23.6 (22.9 - 24.2)	24.8 (23.6 - 25.7)

5.4.2.2.3 Kasungu ADD

The annual mean temperature trends are shown in Fig. 5-71 for Kasungu ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-99. The annual mean temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual mean temperature increases by +1.3 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual mean temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.7 degrees Celsius for SSP5.85.

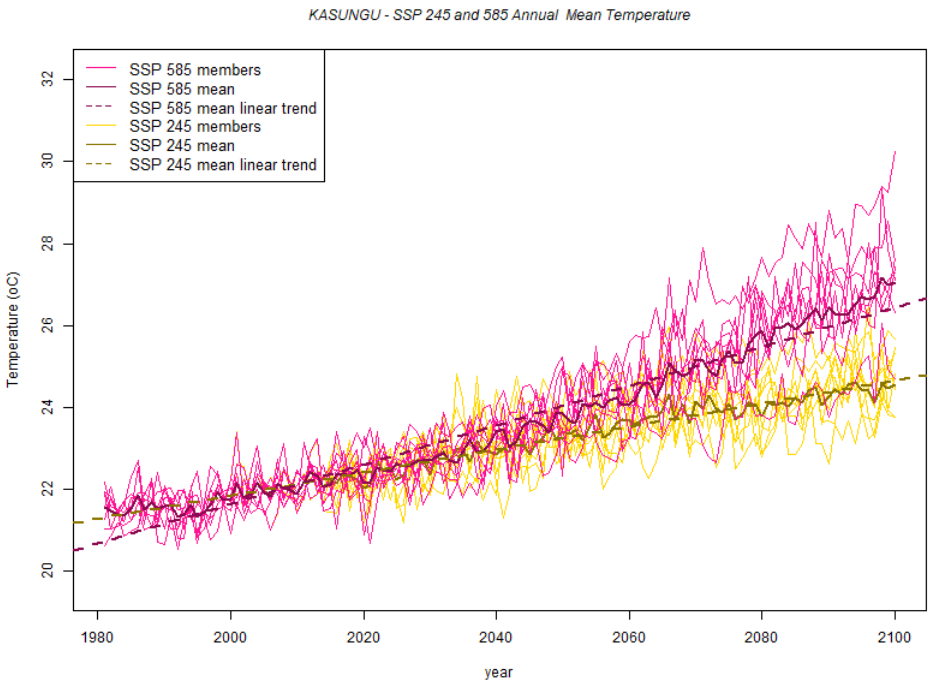


Figure 5- 693 Annual mean temperature projections in Kasungu ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 99 Characteristics of the trends from the projected annual mean temperature time series in Kasungu ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Kasungu ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^{O}C)**	**Mean, Range 2060 (^{O}C)**	**Mean, Range 2080 (^{O}C)**
Kasungu	**0.028**	**0**	**0.964**	**0.057**	22.5 (22.2 - 22.9)	23.2 (22.7 - 24.1)	23.8 (23 - 24.9)
Kasungu ADD SSP5.85							

	Slope (°C/year)	P-value	R^2	NRMSE	Mean, Range 2040 (°C)	Mean, Range 2040 (°C)	Mean, Range 2040 (°C)
Kasungu	**0.048**	**0**	**0.956**	**0.06**	22.6 (22.2 - 23.1)	23.5 (22.9 - 24.3)	24.6 (23.4 - 26)

5.4.2.2.4 Lilongwe ADD

The annual mean temperature trends are shown in Fig. 5-72 for Lilongwe ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-100. The annual mean temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual mean temperature increases by +1.3 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual mean temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.8 degrees Celsius for SSP5.85.

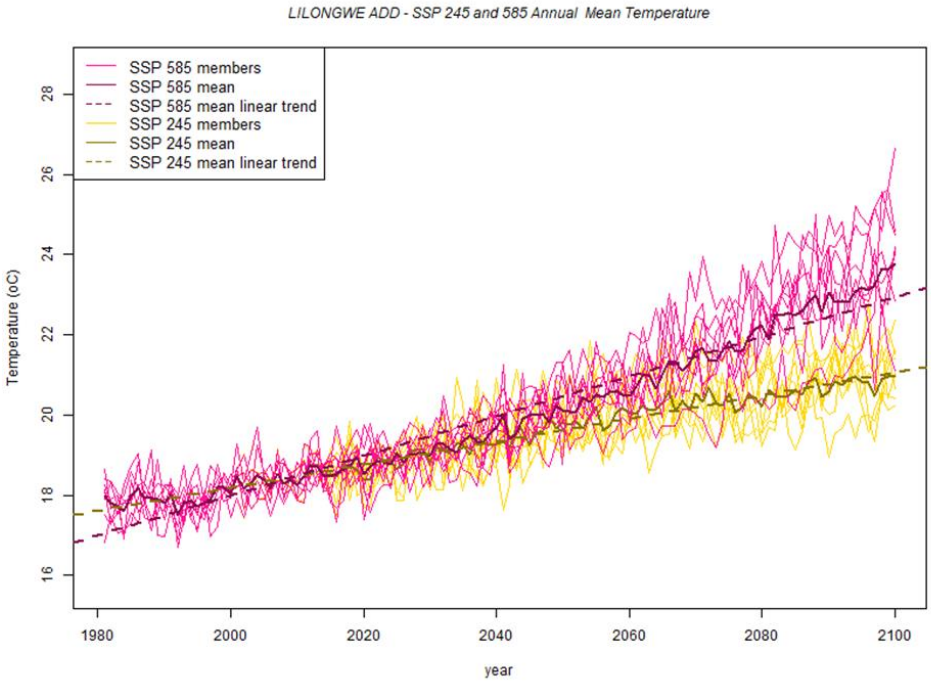


Figure 5- 704 Annual mean temperature projections in Lilongwe ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 100 Characteristics of the trends from the projected annual mean temperature time series Lilongwe ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Lilongwe ADD SSP2.45							
	Slope (°C/year)	P-value	R^2	NRMSE	Mean, Range 2040	Mean, Range	Mean, Range 2080 (°C)

					(°C)	**2060 (°C)**	
Lilongwe	**0.03**	**0**	**0.96**	**0.06**	18.9 (18.6 - 19.2)	19.6 (19.2 - 20.3)	20.2 (19.4 - 21.2)
Lilongwe ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Lilongwe	**0.05**	**0**	**0.95**	**0.06**	19 (18.7 - 19.3)	19.9 (19.4 - 20.6)	21.1 (19.9 - 22.2)

5.4.2.2.5 Salima ADD

The annual mean temperature trends are shown in Fig. 5-73 for Salima ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-101. The annual mean temperature increases by +0.5 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual mean temperature increases by +1.2 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual mean temperature increase during the end-century (2080s) is by +1.8 degrees Celsius for SSP2.45 and +2.7 degrees Celsius for SSP5.85.

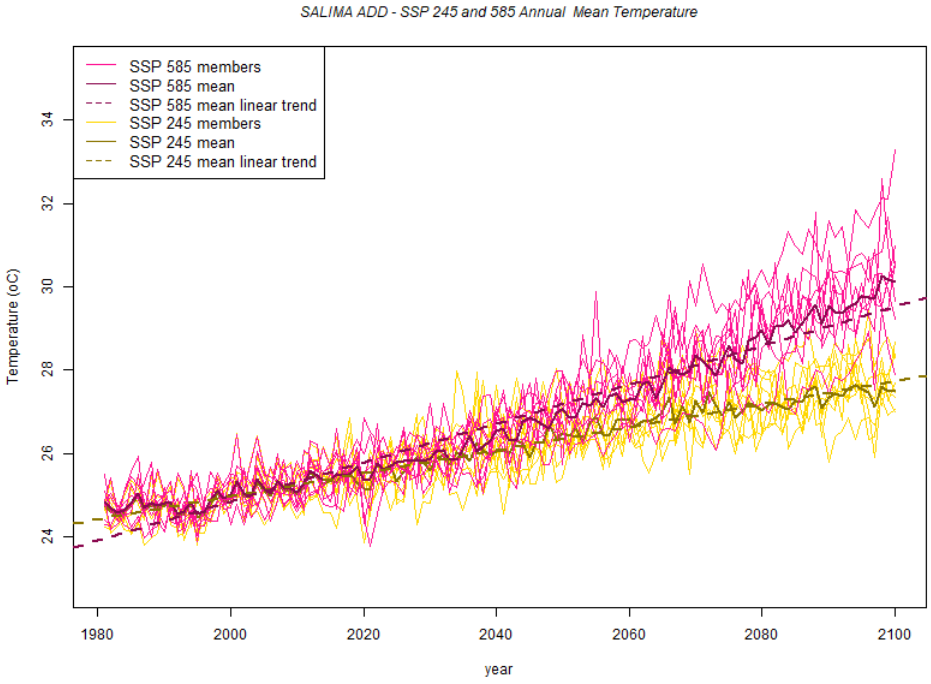


Figure 5- 71 Annual mean temperature projections in Salima ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 101 Characteristics of the trends from the projected annual mean temperature time series Salima ADD (linear models) for SSP2.45 and SSP5.85

Salima ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^oC)**	**Mean, Range 2060 (^oC)**	**Mean, Range 2080 (^oC)**
Salima	0.03	0	0.96	0.06	25.7 (25.1 - 26)	26.3 (25.8 - 27)	26.9 (26 - 27.8)
Salima ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (^oC)**	**Mean, Range 2060 (^oC)**	**Mean, Range 2080 (^oC)**
Salima	0.05	0	0.96	0.06	25.8 (25.4 - 26.1)	26.7 (26.2 - 27.3)	27.8 (26.7 - 28.9)

5.4.2.2.6 Shire Valley ADD

The annual mean temperature trends are shown in Fig. 5-74 for Shire Valley ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-102. The annual mean temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with

reference from 1991-2020 period. While during the mid-century (2060s) the annual mean temperature increases by +1.3 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual mean temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.8 degrees Celsius for SSP5.85.

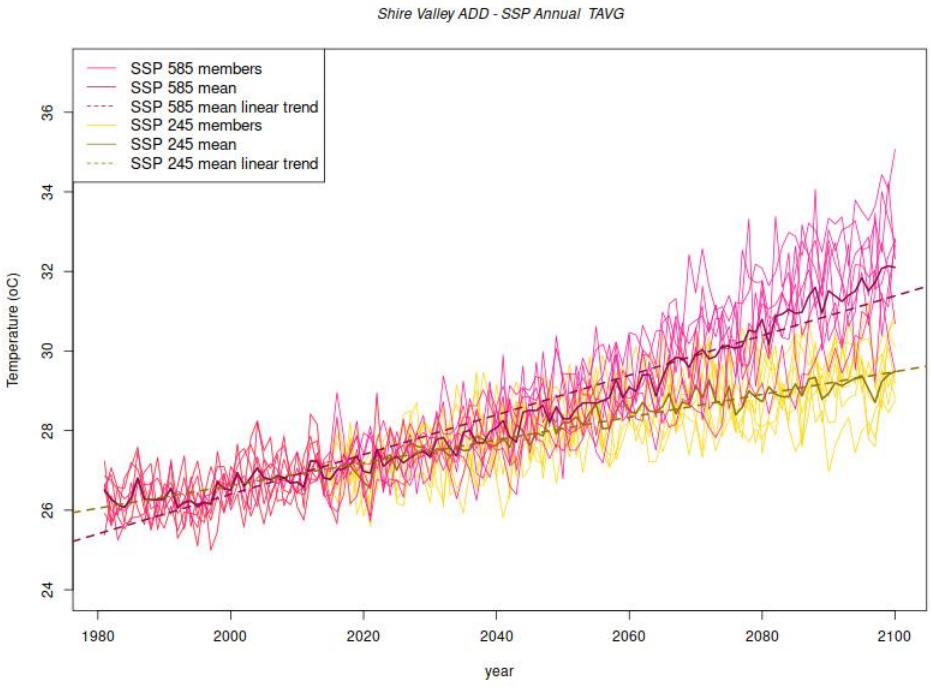


Figure 5- 72 Annual mean temperature projections in Shire Valley ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 102 Characteristics of the trends from the projected annual mean temperature time series Shire Valley ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Shire Valley ADD SSP2.45							
	Slope (°C/ year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Shire Valley	0.0286	0	0.9452	0.0696	27.3 (27 - 27.5)	28 (27.6 - 28.7)	28.6 (27.8 - 29.5)
Salima ADD SSP5.85							
	Slope (°C/ year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Shire Valley	0.0499	0	0.9452	0.0684	27.4 (27.1 - 27.6)	28.3 (27.8 - 28.9)	29.5 (28.4 - 30.6)

5.4.2.2.7 Machinga ADD

The annual mean temperature trends are shown in Fig. 5-75 for Machinga ADD. The temperature trend of +0.03 degrees Celsius per year during 1991-2020 shifts to +0.05 for SSP5.85 in the future, Tab 5-103. The annual mean temperature increases by +0.6 degrees Celsius for SSP2.45 (ensemble mean) and +0.7 degrees Celsius for SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual mean temperature increases by +1.2 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual mean temperature increase during the end-century (2080s) is by +1.8 degrees Celsius for SSP2.45 and +2.8 degrees Celsius for SSP5.85.

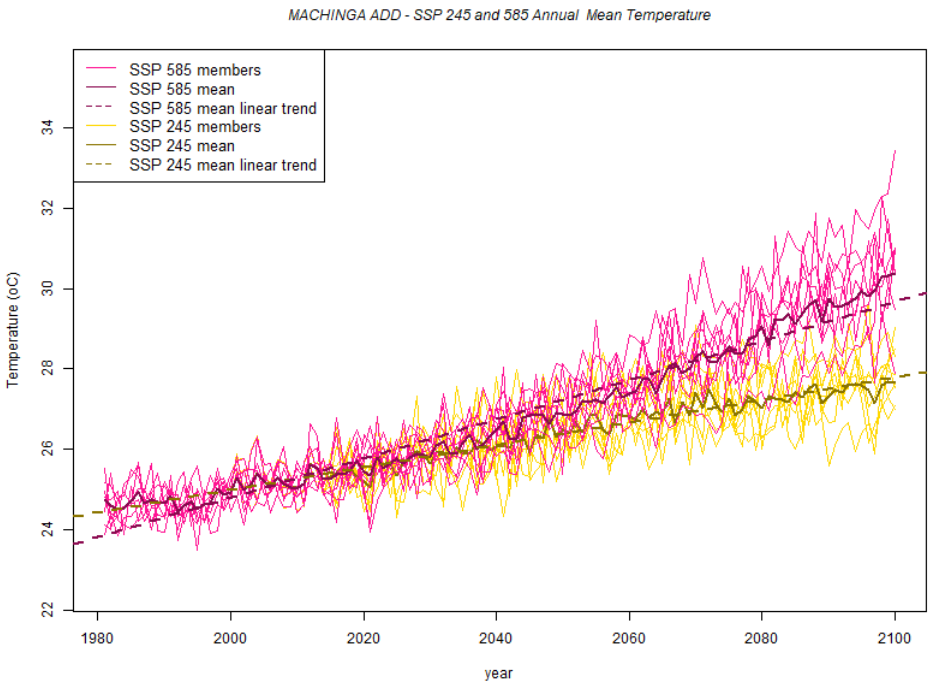


Figure 5- 73 Annual mean temperature projections in Machinga ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 103 Characteristics of the trends from the projected annual mean temperature time series Machinga ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Machinga ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Machinga	**0.028**	**0**	**0.96**	**0.061**	**25.7 (22.5 - 28.6)**	**26.3 (23.1 - 29.4)**	**26.9 (23.6 - 30.2)**
Machinga ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**	**Mean, Range 2040 (°C)**

Machinga	**0.049**	**0**	**0.957**	**0.061**	**25.8 (22.6 - 28.7)**	**26.7 (23.4 - 29.8)**	**27.9 (24.4 - 31.3)**

5.4.2.2.8 Blantyre ADD

The annual mean air temperature trends are shown in Fig. 5-76 for Blantyre ADD. The temperature trend of +0.028 degrees Celsius per year is observed for the SSP2.45 scenario while +0.049 for SSP5.85(Tab 5-104.) The annual mean air temperature increases by +0.6 degrees Celsius for both SSP2.45 (ensemble mean) and SSP5.85 (ensemble mean) scenarios during the near century (2040s) with reference from 1991-2020 period. While during the mid-century (2060s) the annual mean temperature increases by +1.2 and +1.6 degrees Celsius for SSP2.45 and SSP5.85 respectively. The annual mean temperature increase during the end-century (2080s) is by +1.9 degrees Celsius for SSP2.45 and +2.8 degrees Celsius for SSP5.85.

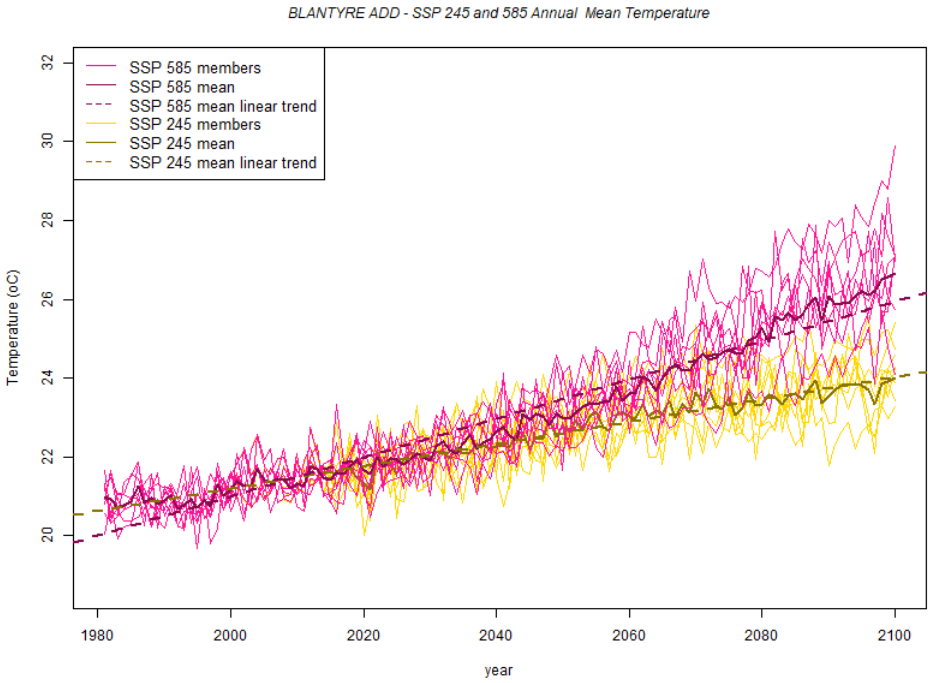


Figure 5- 74 Annual mean temperature projections in Blantyre ADD for both SSP2.45 (yellow) and SSP5.85 (pink). The dashed lines are the linear trends of the ensemble means for SSP members.

Table 5- 104 Characteristics of the trends from the projected annual mean temperature time series Blantyre ADD (linear models) for SSP2.45 and SSP5.85, significant changes are presented in bold.

Blantyre ADD SSP2.45							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**

Blantyre	**0.028**	**0.000**	**0.958**	**0.062**	21.9 (21.5 - 22.2)	22.5 (22.1 - 23.3)	23.1 (22.3 - 24.2)
Blantyre ADD SSP5.85							
	Slope (°C/year)	**P-value**	**R^2**	**NRMSE (%)**	**Mean, Range 2040 (°C)**	**Mean, Range 2060 (°C)**	**Mean, Range 2080 (°C)**
Blantyre	**0.049**	**0.000**	**0.952**	**0.064**	22 (21.7 - 22.3)	22.9 (22.4 - 23.6)	24.1 (23 - 25.3)

5.5 Meteorological wet and dry (droughts) projections

5.5.1 Meteorological wet and dry (drought) projections per ADD

5.5.1.1 Karonga ADD

Figure 5-77 Meteorological wet and dry projections in Karonga ADD for both SSP2.45 (orange) and SSP5.85 (green). The solid lines are the projections for ensemble means and associated trend lines.

5.5.1.2 Mzuzu ADD

Figure 5-78 Meteorological wet and dry projections in Mzuzu ADD for both SSP2.45 (orange) and SSP5.85 (green). The solid lines are the projections for ensemble means and associated trend lines.

5.5.1.3 Kasungu ADD

Figure 5-79 Meteorological wet and dry projections in Kasungu ADD for both SSP2.45 (orange) and SSP5.85 (green). The solid lines are the projections for ensemble means and associated trend lines.

5.5.1.4 Lilongwe ADD

Figure 5-80 Meteorological wet and dry projections in Lilongwe ADD for both SSP2.45 (orange) and SSP5.85 (green). The solid lines are the projections for ensemble means and associated trend lines.

5.5.1.5 Salima ADD

Figure 5-81 Meteorological wet and dry projections in Salima ADD for both SSP2.45 (orange) and SSP5.85 (green). The solid lines are the projections for ensemble means and associated trend lines.

5.5.1.6 Shire Valley ADD

Figure 5-82 Meteorological wet and dry projections in Shire Valley ADD for both SSP2.45 (orange) and SSP5.85 (green). The solid lines are the projections for ensemble means and associated trend lines.

5.5.1.7 Machinga ADD

Figure 5-83 Meteorological wet and dry projections in Machinga ADD for both SSP2.45 (orange) and SSP5.85 (green). The solid lines are the projections for ensemble means and associated trend lines.

5.5.1.8 Blantyre ADD

Figure 5-84 Meteorological wet and dry projections in Blantyre ADD for both SSP2.45 (orange) and SSP5.85 (green). The solid lines are the projections for ensemble means and associated trend lines.

5.5.2 Drought Characteristics per ADD

5.5.2.1 Drought duration

Table 5- 105 Drought duration as projected by the models under SS92.45 and SSP5.85 scenarios

ADD	2020	2040	2060	2080
	Mean, Range (Months)	Mean, Range (Months)	Mean, Range (Months)	Mean, Range (Months)
Karonga				
Mzuzu				
Kasungu				
Salima				
Lilongwe				
Blantyre				
Shire Valley				

Machinga				

5.5.1 Drought frequency

Table 5- 106

ADD	**2020**	**2040**	**2060**	**2080**
	Mean, Range	**Mean, Range**	**Mean, Range**	**Mean, Range**
Karonga				
Mzuzu				
Kasungu				
Salima				
Lilongwe				
Blantyre				
Shire Valley				
Machinga				

5.5.2 Drought Intensity

Table 5- 107

ADD	**2020**	**2040**	**2060**	**2080**
	Mean, Range	**Mean, Range**	**Mean, Range**	**Mean, Range**
Karonga				
Mzuzu				
Kasungu				
Salima				
Lilongwe				
Blantyre				
Shire Valley				
Machinga				

6. DISCUSSIONS AND CONCLUSIONS

6.1 HISTORICAL ANALYSIS

6.1.1 Rainfall

6.1.1.1 Monthly Rainfall

Mean monthly rainfall analysis shows increased variation in rainfall distribution. Most areas have mean rainfall in the range of 150 to 450mm during the month of Jan and Feb. However, Neno-Mwanza Basin shows more cases of rainfall exceeding 600mm in a month. Nkhata Bay 16G Basin shows a different distribution pattern compared to all the other basins. Nkhata Bay receives more rains from Mar to May and Apr is the wettest month over the Nkhataby catchment while Aug and Sep are the driest months.
Trend in rainfall distributions shows that the months of Oct, Nov and Decare receiving less rains than they used to receive for most stations except for Neno and Nkhata Bay. Uniform pattern of distribution variation is also observable during the months of Nov and Dec. Although the rainfall distributions show a decrease for some months in some basins, the trends are generally not significant.

6.1.1.2 Seasonal Rainfall

Seasonal rainfall analysis shows that most basins have similar distribution characteristics except for Nkhata Bay basin which shows a bimodal distribution of rainfall. Mar to May are the wettest months in Nkhata Bay basin as opposed to Decto Feb in the other basins. The catchment also receives more winter rains than the rest of the basins. The trends are also showing a significant decrease of winter rainfall in some basins.

6.1.1.3 Annual Rainfall

Annual rainfall distribution does not differ much in many basins except for Neno-Mwanza basin and Nkhata Bay where during some years high rainfall amounts are experienced. Historically in the 1980s and 1990s, Neno-Mwanza and Nkhata Bay respectively experience more rains than recent years. The worst dry years were observed more over Neno-Mwanza basin where every 10 years there is a noticed low rainfall.

6.1.2 Temperature

6.1.2.1 Monthly Temperature

Monthly temperatures show significant increase in all the month. Winter months are also showing more increase than summer.

6.1.2.2 Annual Temperature

Annual temperatures have increased significantly in the recent years. All the basins show significant increase in both maximum and minimum temperatures. However, more increase is observed in the minimum temperatures for all the stations.

6.2 FUTURE ANALYSIS

6.2.1 Karonga ADD

In Karonga ADD, the temperature is increasing significantly. All maximum, minimum and mean temperatures are increasing at +0.03 per year. Feb, Mar and Apr months are increasing at slower rate than the rest of the months. The increase is very likely to continue in the future and the annual increase for SSP5.85 is between 0.03 to 0.04 degrees Celsius more than SSP2.45. This is also resulting into the increase of evapotranspiration in the basin. Rainfall changes are not significant from both the current and future periods.

6.2.2 Mzuzu ADD

In Mzuzu ADD, both annual maximum and annual minimum temperatures are projected to be increasing across the centuries. This implies increasing mean temperature too for Nkhata Bay 16G basin. Much change is projected under SSP5.85 where minimum and maximum temperatures are shown to increase at the rate of +0.050°C and +0.053°C respectively. For SSP4.5, a projected changes at a rate of +0.022°C for maximum temperature and +0.020°C for minimum temperatures.

Temperature changes across the months, minimum temperatures are projected to increase at a rate of +0.02°C across all months under SSP4.5 and generally at a rate of +0.05°C across months under SSP5.85 with Nov and Dec having highest projected increase at +0.06°C. Maximum temperatures projections indicate more changes under SSP5.85 at a rate of generally +0.05°C with highest projection of +0.06°C for Oct, Nov, Dec and Jan.
The projected temperature changes are statistically significant for both SSP4.5 and SSP5.85 as well for all maximum, minimum and mean temperatures at annual or monthly scale. Projected rainfall changes are not significant under both SSP5.85 and SSP4.5.

6.2.3 Lilongwe ADD

The analysis for Lilongwe ADD indicates that both annual maximum and annual minimum temperatures are expected to increase over the centuries. This increase in temperature implies a rise in mean temperature as well for Dedza 4A basin. The rate of temperature change differs between the SSP scenarios.

Under SSP5.85, which represents a higher emission pathway, both minimum and maximum temperatures are projected to increase at a rate of 0.05°C per year. In comparison, under SSP4.5, representing a lower emission pathway, the change in both minimum and maximum temperatures is projected to be 0.02°C per year. This suggests that the temperature increase will be more pronounced under the SSP5.85 scenario.

When considering temperature changes across the months, it is observed that minimum temperatures are projected to increase more between August and November. The rate of increase is estimated to be 0.023°C per year under SSP4.5 and 0.056°C per year under SSP5.85. On the other hand, maximum temperatures are projected to show higher changes in the months of October (under SSP4.5) and November (under SSP5.85), with the highest increase rate reaching nearly 6°C per century under SSP5.85.

6.2.4 Kasungu ADD

Rainfall projections in Chitipa, Karonga and Rumphi 8A basin are indicating a decreasing trend with p-value of 0.46 for SSP2.45 and 0.41 SSP5.85. however, this decrease is not significant. On the other hand, the maximum, minimum and Mean temperatures analysis is indicating an increase which is scientifically significant with SSP2.45 having a slope of around 0.02°C and SSP5.85 having a slope of around 0.05°C per year. ETo projections in Chitipa, Karonga and Rumphi 8A basin for both SSP2.45 and SSP5.85. are indicating an increasing trend which is also significant. The slope is 0.2mm per year for SSP2.45 while 2.4 mm per year is being projected for SSP5.85. this means that the increase for Evapotranspiration under SSP5.85 is higher.

6.2.5 Salima ADD

In Neno and Mwanza 1M Basin, rainfall projections show a general decrease for both monthly and annual scales. However, the p-values for rainfall are high implying that the general decreasing trend is not significant. This applies for both SSP2.45 and SSP5.85. Jan, Feb and Mar show bigger decrease than the

rest of the months. For maximum temperatures, projections show a general increasing trend but the increase in higher during summer months for both scenarios. On an annual scale, the projections indicate that maximum temperatures under SSP5.85 will increase more than SSP2.45. When it comes to minimum temperature projections, for both monthly and annual SSP5.85 increases more than SSP2.45 temperature scenarios. P-values show statistically significant increases despite the slope of the trendlines being different under each scenario. For mean (Mean) temperatures, similar increasing trends have been observed in both monthly and annual mean temperatures. The increase is a higher under SSP5.85 compared to SSP2.45, slope of 0.02 and 0.06°C respectively. With respect to reference evapotranspiration, increasing trends have been observed for both monthly and annual. For SSP2.45 ETo is expected to increase by 0.9mm/year. Under SSP5.85, ETo is expected to increase by up to and 2.4mm/year, respectively. These results are statistically significant with p-values of zero.

6.2.6 Shire Valley ADD

In Nsanje 1G, analysis of rainfall shows decreasing trend of rainfall at the beginning of the rainfall seasons (Oct to Dec) but the decrease is not significant. However, increasing trend are observed Jan to Mar for SSP4.5 although the increase is also not significant. In annual rainfall, SSP4.5 shows an increase in rainfall at the beginning of the century while SSP5.85 shows decreasing trend. The month of Feb also shows increased departure from long term mean.

Temperatures were observed to increase significantly for all the month. The month of Oct, Nov and Mar shows more increase when compared to the other months. Temperatures for SSP4.5 are increasing in the range of 0.02 to 0.08˚C/year. More increase in temperature is observed in SSP5.85 where annual temperatures increase is reaching 0.1˚C. Winters are becoming warmer as shows by more increase in temperatures during the month of Jun and Jul.

6.2.7 Machinga ADD

For Machinga ADD, all temperatures (Maximum, Minimum and Mean) are projected to increase similarly. The annual increase which is significant is by +0.02˚C and +0.06˚C for SSP4.5 and SSP5.85 respectively. The months of Sep and Oct May increase at fastest rate than all months with +0.025˚C per year for SSP2.45 resulting in an increase in Evapotranspiration at rate of +0.093mm/year for SSP2.45 in Oct. While Nov May increase at fastest rate of +0.058˚C per year in SSP5.85 resulting in +0.023mm/year increase in ETo for SSP5.85 during this month. Rainfall is projected to have a decreasing trend in most months with the highest decrease of -0.126mm/year in Jan and notable increase in the month of Feb at rate of +0.22mm/year. But this decrease is not statistically significant.

6.2.8 Blantyre ADD

Annual rainfall under SSP4.5 scenario indicates an increasing trend while SSP5.85 indicates a decreasing trend. However, in both scenarios the trends are not statistically significant. For monthly rainfall, under SSP4.5, the months of Dec, Jan and Feb are expected to have increased rainfall while the rest of the months are expected to have decreased rainfall. The signal is also mixed under SSP5.85, except for Oct where the trend for decreasing rainfall is significant.

Annual maximum temperatures are projected to increase significantly under both scenarios. An Mean, Rangecrease of +0.02°C per year is projected under scenario SSP2.45 while and increase of +0.06°C per year is very likely under scenario SSP5.85. The projections are also showing significantly increasing trend of maximum temperatures for all months under both scenarios.

Considering minimum temperatures under both scenarios, the projections are showing a significant increasing trend for both annual and monthly temperatures. Annual minimum temperatures are

projected to increase significantly under both scenarios. An Mean, Rangecrease of +0.02°C per year is projected under scenario 4.5 while an increase of +0.05°C per year is very likely under scenario SSP5.85.

Annual mean air temperature is also projected to increasing significantly in future in both scenarios. An Mean, Rangecrease of +0.021°C per year is projected under scenario 4.5 while an increase of +0.053°C per year is very likely under scenario SSP5.85. Monthly mean air temperatures are likely to increase significantly across all the months in the future

Due to the expected temperature increases, ETo in the Thyolo 14D basin is also mostly likely to increase. Models are projecting significant increases in ETo in the basin. High rates of ETo are likely during all the months. Annual ETo is projected to increase at rate of +0.94mm per year in the SSP4.5 scenario in the future. It is likely to be as high as 2.4mm per year under SSP5.85 scenario.

Malawi is vulnerable to a number of climatic hazards, the critical ones being floods, droughts and dry spells, strong winds, hailstorms, pest infestations and disease epidemics. Their impacts coupled with degraded landscapes contributes towards poverty, food insecurity and high levels of vulnerability. Effective climate change adaptation planning will help Malawi to manage these impacts.

7. REFERENCES

https://www.carbonbrief.org/cmip6-the-next-generation-of-climate-models-explained/