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THE ANALYSIS OF PROJECTED CLIMATE CHANGE IN THE WINE REGIONS OF THE WESTERN CAPE OF SOUTH AFRICA

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Introduction

South Africa has a rich wine and viniculture history from time the Cape of Good Hope was discovered, the area was identified as optimal for wine growing, which later generated great wealth for wine farmers competing with top countries such as France (Pooley, 2009). However, it was not foreseen that this area would be prone to severe effects of climate change and other environmental issues it has come to face hundreds of years since the first wine grape was planted. The Western Cape of South Africa has suffered multi-year droughts over the years 2016–2021, and it has a history of vulnerability to droughts, however, the most recent drought brought severe problems including challenges for the viniculture industry (Archer et al., 2022), which significantly contributes to the country's GDP (approximately \$4 billion) thus employing over 300,000 people in the high unemployment country (D'Oliveira, 2019).

Reports from the WOSA[1] indicate that gape yield substantially decreased in the 2018 harvest due to challenges faced in the industry due to alterations in growing conditions (Martin, 2018). Warming increases the rate at which ripening occurs thus shortening the vegetation period in both regions [1 – WOSA]. Viniculture falls under agriculture therefore it is affected as other agricultural activities. The adverse effects of climate change on agriculture threaten food security in many parts of the world (Brown et al., 2009). Vineyard owners and vine grape famers are greatly affected by these challenges as it affects their livelihoods above everything. The change in climate made it harder to grow some vine grape variants, so wine producers could blend new variants/flavors hoping their customers will receive it well (Talanow et al., 2021).

As a summary of the progress made in the first two semesters of the PhD programme this paper aims to analyse the changes in the climate conditions within the wine growing region of the Western Cape, focusing on the first research question, namely, what are the effects of climate change on wineries in different scenarios within the 21st century? This is addressed by the analysis of temperature and precipitation using climate model simulations.

Furthermore, the long-term aim of this research project is to study the effects of climate change on vine grape production under various optimistic and pessimistic scenarios of the 21st century as per IPCC[2] using fine-scale regional climate model simulations, analyse and suggest possible adaptation and mitigation strategies beyond the results included in this report.

Study Area

The area of this study in the Western Cape province of South Africa is rich in vineyards (*Fig. 1*). The area is classified as a Mediterranean region and thus receives more rainfall than

[1] WOSA: Wines of South Africa
[2] IPCC: Intergovernmental Panel on Climate Change

the rest of the country with the precipitation gradient increasing from east to west. Weather patterns vary within short distances due to the complex topography of the area with an average temperature of 25 °C. This area receives more rain than the inland regions, which makes it optimal for grape production.

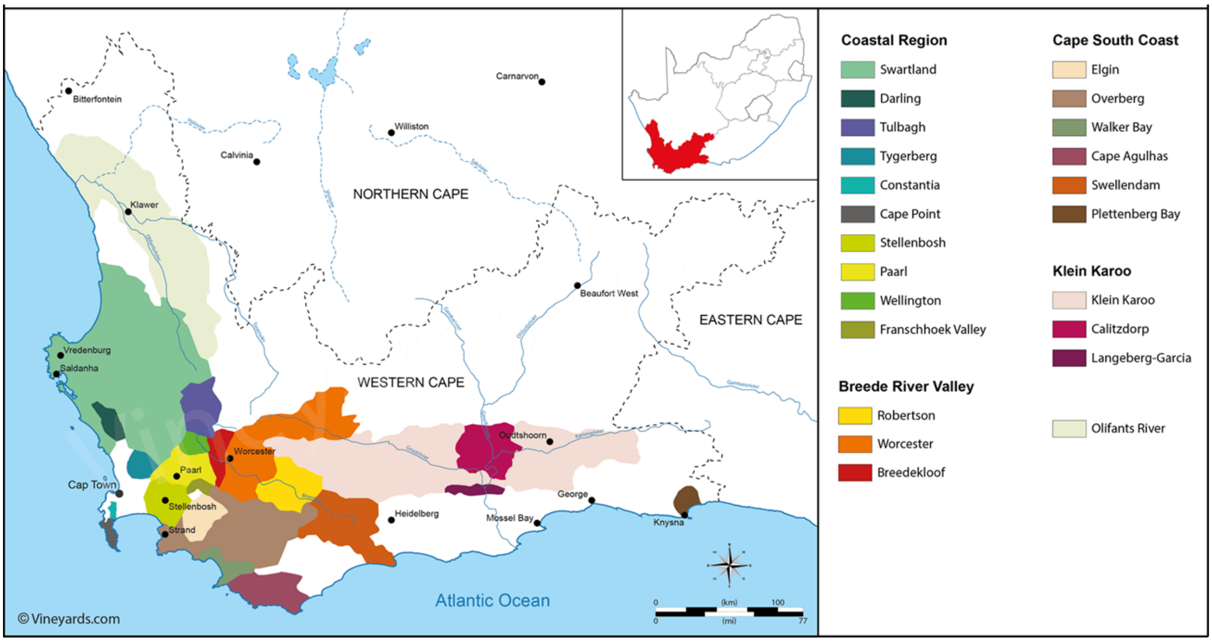

Figure 1: A map of the wine regions of South Africa.

The wine region covers approximately 92,005 ha, where five major wine regions were identified by the WOSA, from which, 17 subregions were selected for this study. Approximately 10,000 ha of grapevine area has been lost in the past decade and more area may be lost because of climate change [2 – DEA].

The most dominant wine regions include Stellenbosch, Paarl, and Robertson, which have experienced a decrease of greater than 100 ha in distribution [1 – WOSA]. White wines dominate the industry by 54%, and red wines contribute to 46% with Chenin blanc and Cabernet Sauvignon occupying most of the white and red wine distribution (16,827 ha and 9,811 ha), respectively.

Data and Methodology

The first phase of this PhD research (*Fig. 2*) used simulated data from the CORDEX[3] for the African domain from which data from 3 RCMs[4] (CCLM, REMO, RegCM) driven by 3 GCMs[5] (HADGEM2-ESM, MPI-ESM-MR, NorESM1-M) were availabe at the horizontal resolutions of 0.44° and 0.22°. To increase the highest accuracy possible, this study used the finest resolution available (0.22°) for both temperature and precipitation at a daily temporal resolution. The target periods for the study are the near future (2021–2040), mid-century (2041–2060), and the end of the century (2079–2098), which was shifted by two years in this study due to data constrains in the simulations. These three future periods were compared to the reference period 1981–2000 from the historical simulations as per previous IPCC reports.

[3]CORDEX: Coordinated Regional Climate Downscaling Experiment
[4]RCM: Regional Climate Model
[5]GCM: Global Climate Models

Two scenarios are analysed for the future, the business-as-usual and mitigation scenarios, i.e. RCP[6]8.5 and 2.6 (van Vuuren et al., 2011). RCP8.5 is based on the assumption that GHG[7] concentrations will increase by 2100 (Riahi et al., 2011). RCP2.6 includes global mitigation suggesting that if it starts now, the GHG concentrations will decrease by the end of the century, closer to the goals of the Paris Agreement. To accomplish the RCP2.6 scenario; drastic reductions is needed in the emission of GHGs such as carbon dioxide, methane, etc.

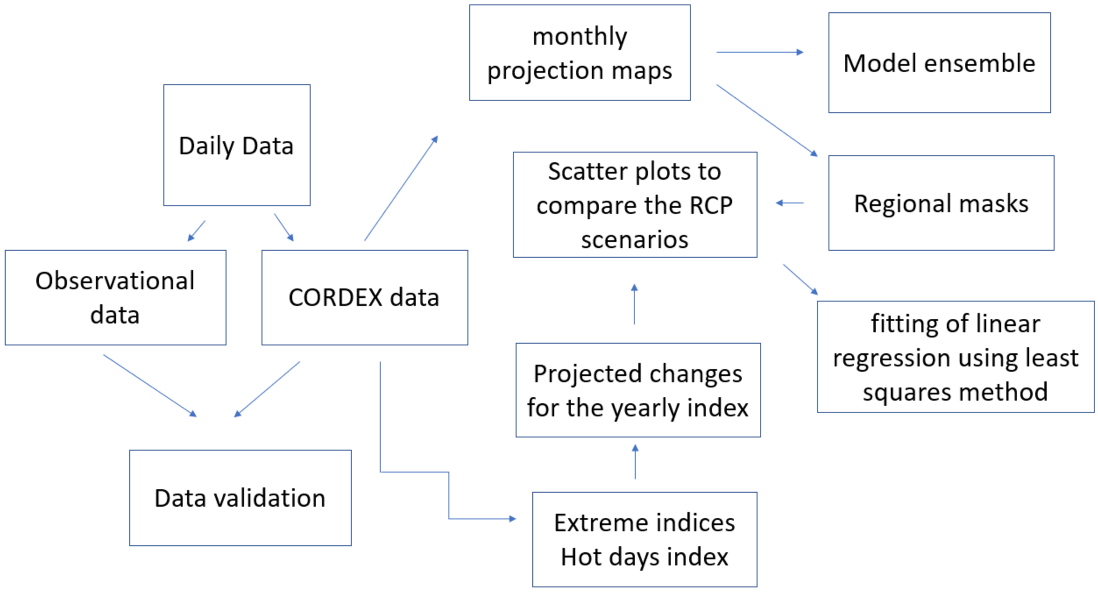

Figure 2: A flow diagram of the structure of the study.

Results and discussion

The temperature simulations indicate an overall increase over the wine region, although the interior of the country will warm up more that the coast. The projected warming of 0.2-1.5 °C and 2-5 °C warming in the winelands by 2079–2098 in the case of RCP2.6 and RCP8.5, respectively, will result in alterations of the optimum wine growing conditions.

There is a gradual projected increase in temperature in difference periods with the least change (< 0.5 °C) in the near future. Then, the warming is projected to continue by the mid-century, this trend is noted in all the subregions of the wine growing area where the greatest changes are likely to occur in the summer half-year. However, the HADGEM2/REMO projected the highest change in temperature in the winter months (JJA), with a maximum of 4.17 °C in Cape Agulhas.

The ensemble mean of the 9 available simulations indicates that there will be a temperature increase of 2 °C in the case of RCP2.6, and greater than 4 °C in the case of RCP8.5, during the harvest period (February) by the end of the century (*Fig. 3*). Because of the obvious relationship between the changes of temperature and radiative forcing, the mitigation scenario project less change than the business-as-usual scenario (Riahi et al., 2011). The projected temperature centennial changes in the case of RCP8.5 are more than double of the changes of RCP2.6 resulting in a regression coefficient between 1.9-2.9 for the individual subregions of the Western Cape. While the RCMs show a good ability to simulate temperature over the

[6]RCP: Representative Concentration Pathways
[7]GHG: greenhouse gas

wine region, precipitation simulated over the region indicates a great fluctuation over all the target periods.

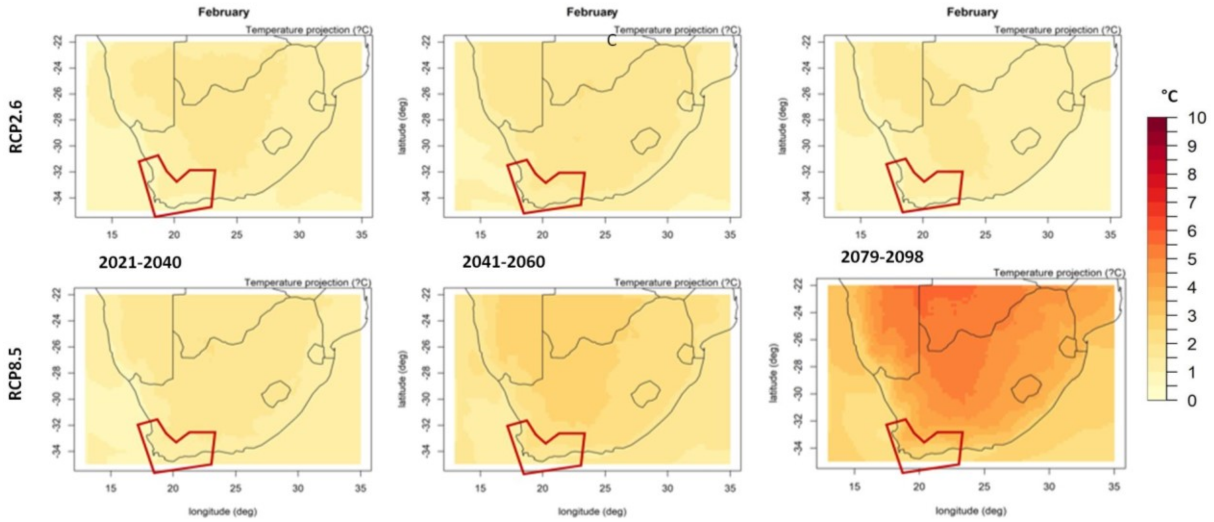

Figure 3: RCM ensemble maps of projected temperature change over South Africa with the Western Cape marked by red polygons over the maps, at the beginning of the harvest period (February – late summer in South Africa).

According to the projections there will be great declines in precipitation in all periods in both the mitigation and business-as-usual scenarios. Even though there is a fluctuation, more than 50% of the simulations fall below zero with the greatest decline occurring in JJA, i.e. the wet season. The results indicate that there will be approximately 40-60% less precipitation in the case of the business-as-usual scenario (*Fig. 4*).

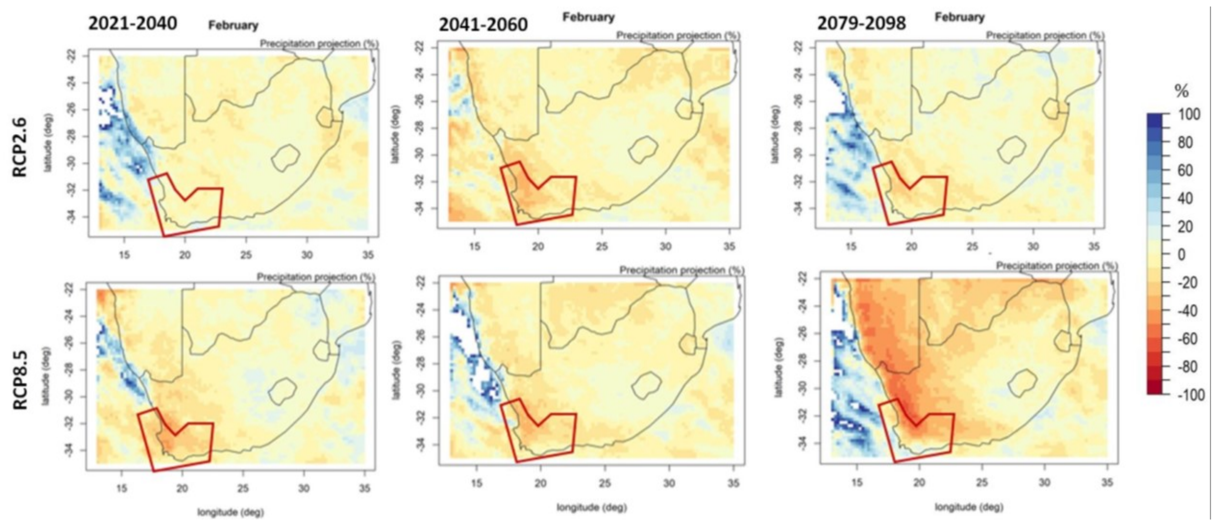

Figure 4: RCM ensemble maps of projected precipitation change over South Africa with the Western Cape marked by red polygons over the maps, at the beginning of the harvest period (February – late summer in South Africa).

The MPI-ESM-MR/REMO simulation shows an increase in the summer of all target periods. The simulated precipitation trends are seemingly not affected by their distance from the ocean, due to high variability of the topography and rainfall variability over short distances, those areas in the southern West Cape, along the border of the Indian and the

Atlantic oceans are projected to receive more rainfall than other regions at the end of the century.

Conclusions

The results from the ensemble of the projected RCM simulation means show that the wine regions in the Western Cape of South Africa, will experience an increase in temperature with time and the highest change in temperature will occur at the end of the century by 3 °C to 5 °C. Such great warming is accompanied by 40-60% less precipitation even during the wet season JJA.

The next phase of the study is to validate the RCMs against station data provided by the South African Agricultural Research Centre to identify biases and good models to use for the analysis of the effects of the climate change over the region.

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References

Archer, E., du Toit, J., Engelbrecht, C., Hoffman, M.T., Landman, W., Malherbe, J., Stern, M., 2022: The 2015-19 multi year drought in the Eastern Cape, South Africa: it's evolution and impacts on agriculture. *Journal of Arid Environments,* 196: 104630. https://doi.org/10.1016/j.jaridenv.2021.104630

Brown, M.E., Hintermann, B., Higgins, N., 2009: Markets, Climate Change, and Food Security in West Africa. *Environ. Sci. Technol.,* 43: 8016–8020. https://doi.org/10.1021/es901162d

Martin, *G.,* 2018: Winetech Annual Report. Paarl, South Africa. 30p. https://winetech.co.za/download/7/annual-reports/339/winetech-annual-report-2018.pdf

D'Oliveira, E.A., 2019: Towards a conceptual framework for stakeholder relationship management on South African wine farms. MCom Thesis (supervisors: Leonard, A., Grobler, A.F.), University of Pretoria, South Africa. 218p.

Pooley, S., 2009: Jan van Riebeeck as Pioneering Explorer and Conservator of Natural Resources at the Cape of Good Hope (1652-62). *Environment and History,* 15: 3–33. https://doi.org/10.3197/096734009X404644

Riahi, K., Rao, S., Krey, V., Cho, C., Chirkov, V., Fischer, G., Kindermann, G., Nakicenovic, N., Rafaj, P., 2011: RCP 8.5 – A scenario of comparatively high greenhouse gas emissions. *Climatic Change,* 109: 33–57. https://doi.org/10.1007/s10584-011-0149-y

Talanow, K., Topp, E.N., Loos, J., Martín-López, B., 2021: Farmers' perceptions of climate change and adaptation strategies in South Africa's Western Cape. *Journal of Rural Studies,* 81: 203–219. https://doi.org/10.1016/j.jrurstud.2020.10.026

van Vuuren, D.P., Stehfest, E., den Elzen, M.G.J., Kram, T., van Vliet, J., Deetman, S., Isaac, M., Klein Goldewijk, K., Hof, A., Mendoza Beltran, A., Oostenrijk, R., van Ruijven, B., 2011: RCP2.6: exploring the possibility to keep global mean temperature increase below 2 °C. *Climatic Change,* 109: 95–116. https://doi.org/10.1007/s10584-011-0152-3

Online references

[1 – WOSA] https://www.wosa.co.za/The-Industry/Overview/
[2 – DEA] https://www.dffe.gov.za/

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