CHAPTER 6 : CONCLUSIONS AND IMPLICATIONS OF THE STUDY

6.1 Findings of the study

Using a Ricardian Model this study explores the field crops sector performance to climate variation. We analyse data for 300 districts for the year 1993 and include seven crops that are wheat, sugar cane, maize, sorghum, sunflower, soybean and groundnut. The estimate best value function between district net revenues per hectare and the regressors that are climate factors (temperature and rainfall), soil indicators, labour, irrigation, population and geographic variables (altitude and latitude) is a non-linear semi-log function. The estimated parameters were all statistically significant and could explain 63% of the variation in net revenue. Also, the parameters have the expected signs except for the latitude variable (proxy for solar radiation). The results show that there is a quadratic relationship between climate variables and net revenue hectare as found in others Ricardian studies in South Africa (Poonyth *et al.*, 2002 and Deressa, 2003). Furthermore winter climate variables have a hill shaped relationship with net revenue whereas summer climate variables have a U shaped relationship.

For further insights of the interaction between field crops net revenue hectare and climate variables, firstly, the estimated regression was used for sensitivity analysis by elasticity estimates and climate optimum points identification. It was found that current rainfall levels are far from estimated critical damage points in contrary to current temperature levels. This therefore implies that the field crops will be very sensitive to marginal changes in temperature as the remaining range of tolerance to increased temperature is narrow compared to changes in precipitation. This finding is in line with Deressa (2003) study that was focussing only on sugar cane.

Hence, the changes in climate that will occur in the next 50 years are not marginal changes; elasticity measures could not give a full picture of the climate change impacts. Accordingly, to assess the likely impacts of climate change on the South African field crops sector, simulations analysis were carried by projecting net revenue per hectare using a range of climate outcomes that are predicted to occur over a period of 30 to 100 years under a conventional CO_2 doubling scenario (IPCC, 2001a). The scenarios used in this study forecasted rise in temperature and reduction in rainfall from the current levels. The impacts of climate change (changes in the dependent variable net revenue per ha) were simulated using the coefficients of the estimated model for each of the 300 districts for the 1993 year. Additionally, in the study we explored if moving from rain-fed to irrigated agriculture could be an effective adaptation option to reduce the harmful effects of climate change for the field crops.

The study suggests seasonal variation in the response of net revenue to climate change. The results show that in summer, the rise in temperature has a positive effect on net revenue hectare, whereas decrease in rainfall reduces the net revenue. For winter, both rise in temperature and reduction in rainfall causes damage for the field crops net revenue. The results also confirmed that adaptation in the form of irrigation is an effective option to reduce the harmful effects of climate change. It was found that when changes in climate variables create negative impacts, with irrigation as an adaptation option, the situation could be reversed. Thus, net gains could be achieved in net revenue (Table 6-1).

Table 6-1: Impacts of changing only temperature or rainfall on field crops' net revenue in percentage (%)

Climate Variable	Climate scenarios	Winter Season		Summer Season		Both seasons	
		No Adaptation	With Adaptation	No Adaptation	With Adaptation	No Adaptation	With Adaptation
Temperature	+ 2^0C	-11	26	26	63	12	47
Rainfall	-5%	-4	26	-1	34	-2	27

Furthermore we examined the total effect of simultaneously changing both temperature and precipitation in all seasons on the net revenue. Since the climate scenario are uncertain, we firstly analyse how sensitive the estimates impacts are to divers climate scenarios from a mild scenario of 2^0C increase in temperature and 5% decrease in rainfall to a severe scenario of 3^0C temperature and 20% decrease in rainfall. The results show that differences among climate scenarios are important and these can generate wide ranges of impacts. With minimal reduction in rainfall, benefits effects from rising temperature exceed the negative impacts from lowering rainfall. With further reduction in rainfall, the benefits effects from rising in temperatures are more than offset by the negative effects of rainfall reduction giving negative net effects (Table 6-2).

Table 6-2: Sensitivity of the impacts of climate change on net revenue to climate scenarios in percentage (%)

Climate change scenarios	Impacts on net revenue hectare (%)
+2^0 C and 5% reduction in rainfall	9
+2^0 C and 20% reduction in rainfall	-4.4
+3^0 C and 5% reduction in rainfall	17.3
+3^0 C and 20% reduction in rainfall	-11.3

Moreover, we also investigated the distributional effects of climate change in South Africa. Although the temperature rise and the rainfall reduction are uniform across the different districts, the spatial distribution of the impacts is not. Indeed, desert region, the interior steppe arid region and the subtropical winter regions will benefit from a 2^0 C and 5% reduction in rainfall, whereas the subtropical wet and the rest of the steppe arid region will suffer damages.

6.2 Limitations and Future studies

The findings of theses studies are based on aggregate district agricultural and climate data. Therefore results must be treated with some caution since important farm level decisions and phenomenon that influence net revenue may have been missed. This calls for further micro-level efforts in modelling agricultural climate change responses. Additionally, the study focused mainly on commercial agriculture hence future studies should take into consideration the subsistence agricultural sector as this sector is most at risk for various reasons and these farmers cannot avail themselves of risk pooling value of markets. With the adoption of the Ricardian approach in the present study, crop dependence on water availability is not fully captured, therefore future studies should also consider integrate water and agriculture since South Africa is a water scarce country. Moreover, although the adjustments to climate change (introduction or intensification of irrigation) are likely to entail economic costs, they are not fully reflected in the Ricardian approach adopted for this study. Thus, a region-specific analysis accounting for the relevant hydrology and institutional framework of water deliveries will be required to evaluate these costs in more detail (Cline, 1996; Quiggin and Horowitz, 1999 and 2003 and Schlenker *et al.*, 2003).

6.3 Conclusions and policy implications

The empirical results presented in this study provide sufficient evidence that climate change would affect the South African field crops' sector in many subtle ways. The current patterns of climate, and when, where and how climate change will unfold will determine the nature and extent of its impacts on net revenue.

This study found that production of field crops in South Africa will be very sensitive to marginal changes in temperature as the remaining range of tolerance to increased temperature is narrow compared to changes in precipitation. This result has important implications for appropriate adaptation measures and strategies. For instance, these results suggest that research on breeding for heat tolerance rather than draught tolerance should shape future agricultural research in the country.

On the other hand, irrigation has proved to be an effective adaptation measure to limit the harmful effects of climate change. However, the country is water stressed, which indicates the need for research in production technologies and methods that are more water efficient.
Given the sensitivity of the South African field crops to climate change, there is a need to identify effective risk-pooling mechanisms. Adaptation can be addressed in a variety of ways. First and foremost is the greatest challenge of educating farmers about the happenings of climate change and its impacts. For example, government bodies could provide farmers with good predictions of future climate change as well as information about appropriate adaptations. Hence more effective extension programs are needed to increase farmers' awareness of climate change. Certainly, prevention of losses can occur through more effective farm planning.

Crop insurance, diversified economic bases of regions dependent on farming, and improved monitoring/forecasts of weather will also increase resilience to cope with future changes. These strategies however, must take note of the fact that the study showed large seasonal variability in the response of field crops to climate change. Rising temperature is found beneficial in summer whereas it negatively affects net revenue in winter. Moreover, the study highlights the importance of location in dealing with climate change issues because climate impacts will differ within and between agro-ecological regions of the same country.

Finally, government need to commit itself to designing price and marketing policies that have a potential for reducing the risk and cost implications of the impact of climate change on agriculture in South Africa.

The study also indicates that knowledge about the economic impact of climate change on agriculture in South Africa is limited and requires much wider research and deeper analyses.