

South African Food Security and Climate Change: Agriculture Futures

Reviewer report

Overview

The paper seeks to examine the link between climate change, agricultural production and food security in South Africa. A general background is first provided on a range of socioeconomic and demographic trends in South Africa. The paper then summarizes the temperature and precipitation projections for South Africa from four climate models (GCMs) and a single emissions scenario (SRES). The results suggest that South Africa will become drier and hotter, although there is variation in climate outcomes across GCMs. Process-based crop models (DSSAT) are then used to estimate high-resolution changes in crop yields caused by the projected changes in climate by 2050. The paper then reports results from a global multi-market model (IMPACT). This model produces three agricultural supply and demand forecasts based on different projections of future economic and population growth and the yield deviations caused by climate change. Results suggest that South Africa's net food exporting position is likely to decline, with negative implications for national food security and child malnutrition. The paper concludes that climate change is a threat to poverty and food security in South Africa.

Is the contribution of the paper significant?

The paper is divided into three sections: (1) background; (2) crop yield analysis; and (3) global trade modeling. I discuss the original contribution of each of these in turn:

1. The background discussion on socioeconomic and demographic trends in South Africa is very general and does not always speak to the main objective of the paper, i.e., linking climate change to agriculture and food security in South Africa. These sections are overly long and their logic is unclear. For example, the link between life expectancy and food security in South Africa, while implied, is not adequately explained. From an academic perspective, there are too many statements and assertions that are not supported by references to the literature. The contribution of these background sections is therefore quite limited.

Perhaps most worrying is that the authors state in the Introduction and background sections that climate change will have an adverse effect on food security in South Africa. These statements come prior to presenting any original analysis by the authors (and in fact contradict the authors' analysis – see below). The authors do not substantiate these statements with references to either their own results or to other published studies. Unfortunately, this gives the impression that the paper's conclusions were predetermined or, worse, that the authors have a bias or stake in reaching this conclusion. It is possible that the individual sections of the paper were written by different people with their own interpretations of the results and there was no attempt to reconcile these. This undermines the scientific approach or contribution of the paper. Moreover, by categorically stating that climate change has negative implications, the authors downplay the element of uncertainty in climate outcomes that they themselves stress in their discussion of the climate projections and in the crop and trade modeling results.

2. The crop modeling analysis is interesting in that it produces high resolution estimates of how crop yields will deviate from historical trends due to climate change. This is perhaps the analysis that is most explicitly relevant to the objectives of the paper, i.e., linking climate change to food security. One concern about the contribution of the crop modeling work is that the source referenced in the figures is “IFPRI calculations” (Figures 18-25) rather than “authors calculations”. It is therefore unclear whether the authors conducted the crop modeling analysis themselves or are reporting results from earlier studies. The original contribution of the paper is therefore unclear. A more consistent approach to referencing throughout the paper might help clear up these kinds of concerns. If the authors did not conduct the crop modeling analysis and if they are published elsewhere, then the crop modeling in the paper is less of a significant contribution.
3. The global production and trade modeling is another interesting component of the paper. It suggests that food security in South Africa will deteriorate over coming decades, in terms of the country’s net trade position and the prevalence of child malnutrition. The analysis shows that the effect of climate change on food security is secondary to other factors, such as economic and population growth. To my knowledge, this is a fairly novel contribution to the literature on climate change impacts in South Africa, although the authors should review the literature in order to motivate their paper.

Overall, I feel that the contribution of the paper is unclear. The authors do not situate their paper within the literature or explain their methodological contribution relative to existing climate change impact studies, either for South Africa or elsewhere. The study’s conclusions appear to be predetermined and, as will be discussed below, do not necessarily follow from the results of the analysis. Finally, the structure and language of the paper is difficult to follow and some of the discussion, tables and figures do not add much value. Unfortunately, the paper feels as though it is a combination of sections drawn from other reports (or a longer report), rather than a well-crafted academic paper. This is unfortunate since I think there are few country-level studies on the implications of climate change for South African agriculture.

Is the analysis correct?

There are three parts to the analysis presented in the paper: (1) climate projections and crop modeling; (2) global production and trade modeling; and (3) greenhouse gas emissions. I discuss each in turn before considering the paper’s conclusions:

1. As mentioned, I think the crop modeling analysis is perhaps the more interesting and directly relevant component of the paper. However, one limitation of the crop analysis is the limited set of climate projections. The authors initially suggest that four GCMs and one SRES capture the full range of climate outcomes for South Africa, but this is contradicted in later sections. For example, Figures 1 and 2 are said to span the full distribution of climate outcomes – they reflect one SRES (A1b) modeled by four GCMs. Later in the paper the authors say they use two GCMs and two SRES (A1b and B1) and that these scenarios actually represent the range of climate outcomes (i.e., wet, dry, warm, cool – see Table 6). Finally, the global trade analysis appears to be based on the original four GCM and one SRES projections (see Figures 17-25). This is obviously very

confusing and undermines the credibility of analysis. The reader is left wondering whether the scenarios are truly representative of future climate change (or perhaps that these projections were chosen simply because down-scaled data was available or results had been published elsewhere).

Readers are referred to You et al. (2009) for an explanation of how land use is estimated using SPAM and to Jones et al. (2003) for an explanation of DSSAT. It would be useful for a general audience to explain how the models work, what they capture, etc. This is important because this is the main analysis of the paper and readers who are unfamiliar with these references may not understand the strengths and weaknesses of the methods used.

2. The global multi-market model is the second component of the paper's analysis. The model is well known and has been used in the past for a range of studies. I have little doubt that the authors have implemented the model correctly. Unfortunately, the discussion of the results does not pay much attention to the effects of climate change (in fact the words "climate change" do not appear once on pages 43-49, which is when the main results are presented). It is also unclear why the authors (i) report results for crops that are less relevant for food security in South Africa (e.g., groundnuts), and (ii) how the DSSAT results measuring climate change impacts inform the sugarcane production outcomes from IMPACT, since sugarcane was not one of the five crops included in the DSSAT analysis. I think the main finding from the IMPACT analysis is that factors other than climate change are more important for future food security (i.e., economic and population growth). This is generally consistent with the findings from climate change impact assessments for other countries.
3. The section on GHG emissions does not provide any additional insights and is not based on any original research. It should either be dropped or greatly expanded upon, possibly by linking IMPACT to a land use change and GHG emissions module.
4. Perhaps most worrying is that the paper seems to refute its own analysis when drawing conclusions. For example, the Conclusion states that "climate change poses a challenge to food security in South Africa" and that "...strategies need to be identified... to avert an increase in... poverty". Yet the results of the authors' analysis do not support this statement. The crop yield impacts from climate change are found to be very small (as the authors conclude in the section reporting the crop modeling results) and the yield effects are in fact positive for South Africa's main staple crop (as the authors mention later in the conclusion). Secondly, the analysis using the IMPACT model shows that future food security is mainly determined by GDP and population growth and not climate change (this is stated explicitly for the malnutrition results). So what then is the empirical evidence that the authors base their main conclusion on? The authors appear to have a different interpretation of the *cumulative* outcomes from the analysis than they reached at each *individual* stage of the analysis (i.e., in the crop modeling and global trade modeling sections).

Overall, there is no reason to suspect that the analysis in the paper is anything but accurate and well executed. It is based on well-established and documented methods and led by recognized researchers in this field. However, the writing of the paper is poorly executed and makes the work un-publishable in its

current form. A well-crafted scientific article should ideally provide a clear and concise (but sufficient) explanation of the research question, methods, data and results, and its conclusions should be based on the results from the analysis (with caveats if applicable). Unfortunately, this is not the approach followed in this paper and so the analysis cannot be interpreted with any confidence.

Detailed (unedited) comments

1. Title:

The title is a bit confusing. For example, many readers would think of “agriculture futures” as a financial instrument (like options, derivatives etc.) rather than future scenarios for agricultural production. Also I think you are discussing global climate change, as opposed to “South African” climate change (I’m not sure if the latter makes sense – see the authors’ own distinction between weather and climate in the paper). One option for a clearer title could be “Climate Change, Agriculture and Food Security in South Africa”.

2. Abstract:

- a. The abstract seems to focus on a general (“no climate change”) food supply/demand forecast for South Africa, rather than on the incremental effects of climate change. This is unexpected given the title of the paper.
- b. Line 1: “prices” not “priced”
- c. There are perhaps too many unnecessary acronyms in the abstract (or at least ones that need to be spelt out given the broad audience of this journal). These include GCM, IPCC, DSSAT, IMPACT, and GDP.
- d. The abstract could be shortened, and the specifics of the analysis (i.e., methods, data, etc.) might be better discussed within the main text of the manuscript.
- e. “...consistent warming over the subcontinent...particularly on the eastern side...” – are you referring to sub-Saharan Africa and East Africa? (South Africa is obviously not a sub-continent but it’s the only region that has been referred to at this point). Perhaps this discussion of Africa-wide climate changes is better left for the main text?

3. Introduction:

- a. Line 1: “South Africa remains committed to the ideals of the MDGs...” I think you might mean that SA is committed to improve “food security” since all of the policies you mention relate to food (which is not the only MDG). The various food programs mentioned in this first paragraph need references.
- b. “Climate change poses a challenge to food security...” Surely this is the empirical question that your paper seeks to answer? This statement seems to “put the cart before the horse”. In fact your conclusion seems to suggest that climate change is not a major determinant of future food security in South Africa (rather it is population growth, etc.).

- c. The discussion of energy versus irrigation needs references. Also I thought that energy plants “use” but don’t “consume” water... perhaps this isn’t true for coal power plants.
 - d. Surely we don’t need to know when the IMPACT model was run, unless there are changes in the versions of the models that could influence the results. If so this might be worth explaining in more detail to the reader.
 - e. “climate change... threatens food security everywhere”. This is an empirical question and therefore needs a reference to an empirical study that shows the statement to be true (or the statement should be dropped). In fact in the next paragraph you say that crop yields may go up in some regions of the world.
 - f. Your “two degree” threshold effect on food security needs a reference.
 - g. You might consider motivating the paper a bit differently. At the moment there is some discussion about South African policy interests and a conversation around generalized agricultural impacts. I feel like the strength of your study is its estimation of agricultural production impacts caused by climate change and the effect of these production changes on food security.
4. Regional impacts of climate change
- a. Should “global trends” be “global projections”?
 - b. Footnote 2: IPCC should have been abbreviated in the Introduction, not in this footnote. This footnote is quite long: could it not be brought into the text (or shortened)? Also the reference to the footnote comes before the mention of Figure 1 in the text (yet the footnote refers to the figure).
 - c. “GCM” has been abbreviated in three places at this point in the paper.
 - d. Explain what “A1B” scenario refers to? At the very least is this a better or worse case projection? Why did you only pick this SRES – why not A2 or B1?
 - e. “These figures illustrate the range of potential climate outcomes...” For this statement to be true there should be no significantly better or worse climate outcomes from any of the other 52-odd GCM-SRES projections. You could indicate the range of climate outcomes for your four scenarios using a climate moisture index or something similar.
5. Agriculture, food security and South African development
- a. A reference is needed for the statement about malnourishment in South Africa. Also perhaps give a figure to back up this statement... so that readers can gauge how malnutrition in South Africa compares to say China, India or Mali.
 - b. Should “depressed job markets” be “unemployment”?
 - c. The discussion on small-scale farming needs a reference. To my knowledge, the 300,000 small-scale farmers in South Africa account for only 5% of agricultural output (I think that is based on the 2002 Agricultural Census). So food security, which you say is increasingly an urban

phenomenon, is perhaps more dependent on formal sector food prices and markets (and hence on commercial farm production, which you do not discuss in the paper).

- d. Mention of the SA constitution seems a bit arbitrary, especially for an international journal audience.
 - e. I can readily accept that HIV/AIDS contributes to food insecurity amongst smallholder farmers in rural South Africa. But is this really the key driver behind *national* food insecurity? We need some references to support the singling out of HIV/AIDS over other potential contributors to food insecurity in South Africa. Also your HIV/AIDS prevalence rates need references.
 - f. “The projected changes in precipitation and temperature will hamper food production” This is again the empirical question you are seeking to answer in this paper and so this kind of statement should be reserved for your conclusions. Also your range of climate outcomes includes scenarios in which South Africa might become wetter... might this not improve food production?
6. Review of the current situation
- a. Title to this section: Do you mean “food security” situation? If so, why is this not part of the previous section on “Agriculture and food security in South Africa”?
 - b. South Africa is still a net food exporter (and a major exporter of certain products). Livestock value-added is only about a quarter of RSA agricultural GDP and so it’s unusual to single out livestock’s net trade position and ignore the rest of the agricultural sector (especially since your analysis uses IMPACT – a net trade model).
 - c. “...agriculture is unattractive to job seekers” – this is an empirical statement and so needs a reference. There is a huge body of literature on open unemployment in South Africa that could be referred to. I’ve always thought that unemployment in South Africa is primarily a demand-side problem, but you seem to be suggesting that in agriculture it is a supply-side problem (people don’t want to work in agriculture – perhaps you are thinking of small-scale farming rather than commercial farm labor?).
 - d. You need both Figure 3 and Table 1 since they seem to present exactly the same data. Also you could try to combine Fig 5 and 3 and Tab 1.
 - e. It might be worthwhile labeling the provinces in Figure 4 since you refer to province names when discussing in the text.
 - f. Fig 6: Rather than just present GDP trends, it might be worthwhile to reflect on what they mean for your analysis (as was done with the population growth and distribution data). For example, my reading of Fig 6 is that impacts on agriculture will have little effect on the rest of the economy (and this could also be used to justify using a partial equilibrium IMPACT model). Rising incomes per capita also imply that food insecurity should be declining in South Africa, which is somewhat contrary to the earlier discussion suggesting that food insecurity is a major problem.
 - g. “... in this report...” should be “in this paper or article”
 - h. “meaningful jobs” should perhaps be “decent jobs” – this also needs a reference to the literature

- i. US\$2-a-day poverty estimates need a reference (and again, without labeling at least one of the figures, the discussion of specific provinces is difficult to follow for readers unfamiliar with South Africa's geography).
- j. "resiliency" should be "resilience"
- k. Tab 2: It is not "clearly" evident from Tab 2 that literacy rates are improving since only data for 2007 is presented. Actually I think this is an unnecessary table and this whole section needs to be rewritten so that it doesn't just provide a disparate set of statistics but is rather motivated by the research question: is climate change, as opposed to other factors, the main determinant of food security in South Africa? This section (together with the sections before and two after it) is a fairly lengthy (and table and figure intensive) way of reviewing the various factors that could contribute to future food insecurity.
- l. Fig 8: What is the relevance of life expectancy for the research question? Some discussion is needed or else this should be dropped (see comment above).

7. Review of Land Use and Agriculture

- a. See comment 6.K – these sections need streamlining in order to be included within an academic paper.

8. Agriculture Overview

- a. See comment 6.K – these sections need streamlining in order to be included within an academic paper.
- b. Surely Tables 3, 4 and 5 can be combined. I was also surprised that you reference FAOSTAT when South Africa has its own Abstract of Agricultural Statistics (this is obviously a minor comment since FAOSTAT should be consistent with official statistics).
- c. Fig 12-17 – there are simply too many figures for an academic paper (and for the reader to digest). I would suggest picking the main staple crop (perhaps maize given Tab 3-5) and having a discussion around how the climate change projection maps might overlay with the spatial production maps. This could illustrate your processing of the evidence (at the moment the reader is simply given lots of data and expected to do their own inferring of climate change's implications).

9. Scenarios for adaptation

- a. This long quote may need indenting.
- b. Not clear if the difference between climate scenarios means different SRESs or GCMs (see comment on climate projection choices on next section).

10. Biophysical scenarios

- a. Figures 17 and 18 seem to be a repeat of Figures 1 and 2... I would suggest keeping 17 and 18 since these are the downscaled results used for the analysis and since the paper focuses on South Africa.
- b. It is very confusing which scenarios are being used. For example, Figs 1 and 2 are said to span the full distribution of climate outcomes for South Africa. They all reflect one SRES (A1b) modeled by 4 different GCMs. Now in the section on Climate Scenarios you say that you will use 2 GCMs and 2 SRES (A1b and B1), and these are now supposed to represent the range of climate outcomes (wet, dry, warm, cool). And then the analysis seems to change back to the original GCM.SRES pairings in Figs 17-25. Perhaps you are combining text from two different studies? (i.e., one at the global and one at the national level).
- c. Tab 6: Why present global temp and precip outcomes if your study is focused on South Africa (and if it seems that the selection of scenarios depends on the scale of analysis – see above).
- d. Fig 6 refers to Table S10.2 and Appendix 3, both of which don't exist. The paper seems to be based on a report and the text has not been revised (or it's information from two different reports).
- e. Page 28: How was the downscaling done for the climate projections? This definitely needs some discussion.
- f. Is climate change likely to lead to more extreme events in South Africa? Statement needs a reference given the debate around this issue.

11. Crop responses to climate change

- a. You say that rice and groundnuts are major crops and therefore modeled here, but Tabs 3-5 don't even show these two crops as being in the top ten crops produced in South Africa (and rice just makes it onto number 8 for consumption). Also this information is repeated in the next section describing the IMPACT model.

12. From Biophysical Scenarios to Socioeconomic Consequences

- a. "SPAM" needs to be spelt out.
- b. Since this is a study of South Africa, it might be alright if you just refer the reader to Figures 26 and 27 in Nelson et al. 2010.
- c. Table 7 and 8 could be combined.
- d. In your optimistic and pessimistic scenarios you combine high GDP growth with low population growth and vice versa. There is empirical evidence, at least at the country level, suggesting that higher incomes are associated with lower fertility rates, albeit also lower infant mortality. Perhaps this empirical evidence could be used to support this coupling of GDP and population growth rates.
- e. Does Figure 28 refer to South African GDP per capita? Not clear from the text or labeling. I think it must be South Africa based on the results reported in Table 9.

- f. "... U.S. can be seen in Table" should read "Table 9"
- g. Why is USA chosen as a comparison for South Africa, rather than say China, India or Brazil... or perhaps global GDP per capita?
- h. The figures could be reduced in number. For example, your climate change DSSAT results are only reported for 2050 and so it is perhaps unnecessary to report five yearly results from IMPACT. You could combine the five sub-figures for each crop into a single figure containing box-whisker plots for just 2040-50 or some similar period (i.e., you could get away with one plot for production, yield, area, net exports and prices). This refers to Figures 29-34.
- i. Sugarcane was not modeled using DSSAT and so it's surprising that it appears in Fig 33.
- j. Rather than report results for all crops, why not report overall food production and net export forecasts in South Africa, especially since this is the focus of this paper. You could weight your crop-level IMPACT results using the consumption shares for South Africa (or the shares that presumably appear within IMPACT). You might then focus on the crop-level results for just the main staples: maize and wheat. For example, why devote an entire one-page figure to groundnut forecasts when this crop is not very important for South Africa (as the authors say themselves when reporting the DSSAT results).
- k. The discussion of the impact results in the text is largely a repetition of what appears in the figures. Perhaps the discussion should interpret the results and consider the effect of climate change and implications for food security, which is the topic of this paper.
- l. How do you make the link between crop production and prices and child malnutrition? This is not explained in the paper and I understand that it generally viewed as being a very complex and country/context-specific relationship. Are you using fixed elasticities between FPU food availability and child consumption?
- m. There is no reference to climate change in the IMPACT results.

13. GHG emissions

- a. The emissions section is not very useful and doesn't link to the rest of the paper. For example, the results reported in Fig 36 are from another paper/source and not based on any analysis by the authors.
- b. "Within agriculture a number of opportunities exist and are being explored to reduce GHG emissions." What opportunities and who's exploring them? This section does not include one reference to support any of its assertions. I think it might be better to drop this section entirely from the paper.
- c. There is only one section but two headings

14. Conclusions

- a. Paragraph 1: You did not measure changes in poverty and so surely you cannot conclude anything about poverty effects directly from your analysis?

- b. “projected future changes in average...” – changes in what? Yields? Food production? Climate? Similarly “... gains of between 5 and 25%...” Gains in what? Yields?
- c. Why is it important for South Africa to reduce agricultural emissions if they are very small? This may be true but requires some explanation. I don’t think your analysis has contributed anything on this issue and so it is perhaps better to avoid making this statement (or reference other studies if you feel it is important).
- d. Final line: Do you have any particular policies in mind?