Impacts of Drought Induced Water Shortages in South Africa: Areas for Future Research

Report to the
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by

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- Impacts of Drought Induced Water Shortages in South Africa: Economic Analysis (WRC Report No. 2604/1/18);
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1. Introduction

At the beginning of 2016, South Africa experienced severe droughts, which had an impact on the economy. For instance, the agriculture, forestry and fishing industry contracted for five consecutive quarters. Part of this reason is because many parts of the country have experienced serious drought conditions. The industry experienced a decline of 6,5% in the first quarter of 2016, which was mainly the result of decreases in the production of field crops and horticultural products. The electricity, gas and water industry contracted by 2,8%. Electricity generated and consumed both declined. Similarly, the amount of water distributed decreased, partly driven by drought conditions and water restrictions in certain parts of the country.

Therefore, in South Africa, drought is a very important phenomenon that affects not only agricultural production but also society. It is a recurring phenomenon, with spatial and temporal characteristics that vary significantly from one region to another (NOAA, 2006; Runtunuwu, 2005; Loukas and Vasiliades, 2004; Wilhelmi and Wilhite, 2002). Droughts have significant impact on socio-economic, agricultural, and environmental spheres (Bhuiyan, 2004; Loukas and Vasiliades, 2004; Finan and Nelson, 2001). Damages due to drought depend on its intensity, duration, frequency and the affected area (Scripcariu et al., undated), and its effects are evident even in subsequent periods when precipitation occurs normally. Often, the economic impact of a drought is difficult to pinpoint because, unlike other natural disasters such as flooding, drought develops slowly and quietly, lacking highly visible and structural impacts for some time, meaning that developing drought conditions often go unnoticed until precipitation shortages become severe and impacts begin to occur (Hayes and Widhalm, 2013).

The literature is generally in agreement that the total economic effects of a drought can be divided into the direct effect, the indirect effect and the induced effect (e.g. Garrido and Hernandez-Mora, 2013, Hayes and Widhalm, 2013, Diersen and Taylor, 2003)[1]. The direct effect of a drought captures the immediate or physical impacts of water supply shortages on production. In the agriculture sector for example, the direct physical impacts could be manifested in the wilting of crops, yield losses and poor quality products. The indirect effect captures impact of the drought on sectors that are downstream or upstream of the primary production sector. The agriculture sector, for example, has businesses that are located upstream (e.g. input supply) and downstream (e.g. the agro-processor). A drought that directly hits the primary agriculture sector will have implications on primary and secondary sectors

[1] These studies do not use the same terminologies but they agree on what the total economic impact of a drought ought to measure.

along its supply chain, such as seed supplier, agro-processors, supermarkets, or the bio-energy industry. Finally, the induced effect of a drought captures the impact on consumers and businesses further upstream and downstream. Thus, for example, a drought that hits the agriculture sector will impact on the welfare of maize consumers and of enterprises whose operations rely on output from the agro-processor (e.g. retailers).

This report will highlight the literature that has been undertaken on the economic impact of drought in South Africa. The document will also explore where there are gaps in the literature regarding the impact of drought. Finally, a series of suggestions for future research are offered. This is because South Africa is a country that has often felt drought, and therefore the better we are in understanding its impact, the better we are in mitigating drought. For instance, there are several benefits of the accurate assessment of the socioeconomic and environmental impacts of drought (e.g. see Garrido and Hernandez-Mora 2013, Diersen and Taylor, 2003). Drought can be seen as a phenomenon that requires short term and long run responsive actions. A country requires effective short-run drought mitigation policies to smoothen production and consumption in the event of a drought shock. But much more important, a country requires long term socioeconomic resilience to future drought impacts, since mitigation and preparedness are keys to reducing future drought risks (Diersen and Taylor, 2003).

2. Review of past studies on economic impacts of drought in South Africa

To the best of our knowledge, only a few studies have attempted to assess the economic impacts of drought in South Africa. These include: BFAP (2016), Agri SA (2016), Hlalele, Makhatle and Motlogeloa (2016), Maré and Willemse (2016) and Pretorius and Smal (1992). Of these, most are focused on the agricultural sector and the rural economy. Much less work has been done around the impacts on the urban economy (including the secondary and tertiary sectors), thus justifying a more inclusive study like the current one.

- The main objective of BFAP (2016) was to evaluate the impact of the current drought on the South African economy, on commercial and smallholder producers, and on consumers. The study had the following specific objectives: (i) to determine the value of imports and exports of maize in South Africa, (ii) to determine the impact of drought on farm/agricultural businesses, and (iii) to determine the price effect on drought induced production decline.
- The main objective of Agri SA (2016) was to meaningfully contribute to the national discussion on South Africa's drought as it pertains to the agricultural sector. The

specific objectives were (i) to outline the effects of South Africa's drought crisis on the agricultural sector and (ii) to present proposals on actions to effectively support farmers as they recover from the crisis.

- The main objective of Hlalele et al. (2016) was to alert South Africa government authorities of the prevailing conditions of droughts impacts for possible drought relief assistance. The specific objective was to assess the economic impact of the current drought disaster on agriculture dependent formal and informal businesses in the Free State. Hlalele et al. (2016) found that about 80% of the businesses lost above 50% of their employees due to the drought in the Free State. Moreover, about 87% of these businesses lost over 50% of their revenue.
- The study by Maré and Willemse (2016) sought to answer the following questions (i) what are the implications of drought on the maize market for feedlot demand for weaners? (ii), what are the implications of drought on consumer demand for red meat? and finally, (iii) what are the implications of drought on the livestock farmers who supply red meat?
- Pretorius and Smal (1992) used the macro-econometric model of the South African Reserve Bank to simulate the effects of the 1992 drought on the following macro-economic variables: economic growth rate, investment, the current account of the balance of payments, inflation and employment. Following their simulations, Pretorius and Smal (1992) show that as a result of the drought, growth in real GDP might have been as much as 1.8 percentage points lower, as many as 69,000 job opportunities may have been declared redundant, average inflation rate could have been approximately 0.8 percentage points higher, and the current account balance of payments could have suffered a negative effect of about R1,200 million.

In some instances, instead of an overarching study of the impact of drought in general, there are short pieces of research for a particular sector in a particular area. For instance, the impact of the recent drought on the pulp and paper industry in KwaZulu-Natal was published. "The drought slowed production at the Siaccor mill for a few weeks and reduced earnings before interest, taxes, depreciation and amortisation [Ebitda] excluding special items of the South African business by R87 million [for the quarter to December 2015]," Sappi said in an interview with City Press (City Press, 2016)[2]. "Andre Oberholzer, a Sappi spokesperson, said the lower production at the Siaccor mill on the KwaZulu-Natal south coast, near Umkomaas, was due to the fact that Sappi had to slow down production to two-thirds of normal production rates over

[2] City Press, 2016. Drought fells R87m off Sappi's earnings.

October and November because of the low levels of water in the Umkomazi River, which prevented the mill from abstracting the usual amount of water."(City Press, 2016)[3].

For agriculture and in a small way agro-processing, are closely linked with water, and therefore shortages of water are easier to quantify. For other sectors, such as tourism, the impact of the drought is not necessarily quantified. There is however literature that mentions that there is an impact of the drought on the sector. For instance, drought has both direct and indirect impacts on the tourism/recreation sector, and can span all seasons. The direct impacts are reductions in water dependent activities such as rafting, boating, canoeing, or fishing resulting from lower water levels, as well as from shortened or shifted seasons (Thomas et al., 2013). Water restrictions can also pose challenges to water-reliant recreation. Intangible relationships such as decreased visitor numbers, cancellations in hotel stays, or a reduction in booked holidays are more difficult to quantify and link to drought. Changes in animal and bird migratory patterns affect wildlife viewing or hunting, causing reduced revenues for nearby towns and communities (Thomas et al. 2013). The ultimate outcome results in decreased tourist Rands for the local economy and a reduction in sales taxes, potentially leading to unemployment (Thomas et al., 2013).

Another sector where risks associated with water are mentioned, but not truly quantified is mining. Mining accounts for 2.5% of a country's total water consumption on average, even in semi-arid to arid countries like Australia, Chile and South Africa (Turton, 2008). In South Africa, mining uses about 3% of the total country water. Although mining utilises little water (relatively), sufficient water supply is critical to sustainable future mining activity. Shepherd (undated) indicates that water has become a key risk for mining companies in South Africa. Mines dewater, and use water for transporting extracted material, facilitating separation of minerals from waste material, transporting and storing tailings, supressing dust, and in other associated industrial uses such as cooling power systems and washing equipment. The Stats SA (2009) water accounts reveal that gold and uranium were the biggest water users, followed sequentially by chrome, manganese, other metal ores, platinum group metals, iron ore, and finally coal. Shepherd (undated) shows that severe water shortages result in the cut back of mines on the processing rates of their concentrators, which could lead to a reduction of tonnages processed or even the closure of some concentrators for short periods. Mines are vulnerable to drought to the extent that mines compete with other sectors of the economy for water, and authorities are likely to ask mines to cut back on usage of water before they ask communities to cut back (Shepherd, undated). However, mining is widely considered to have

[3] City Press, 2016. Drought fells R87m off Sappi's earnings.

the greatest impact on water quality. The direct costs of drought on the mining sector are multi-fold, including production decline, revenue losses, and increase costs for water treatment. Moreover, the drought induced water deficiency can indirectly affect workers' quality of life, lead to unemployment, starvation, disease, and risk of conflict, all triggering humanitarian and human development concerns. A decrease in water supply resulting from drought can lead to a limited market supply of minerals, thus directly impacting their market prices. The domestic market developments might also have repercussions for international trade and exported or imported quantities. All of these impacts are mentioned. They are however not quantified in terms of the economic impact for the economy of South Africa.

There is also a dearth of studies on the impact of drought on small businesses. One study was conducted on agriculture-dependent small businesses in the town of Thaba Nchu, where most small businesses surveyed were in the informal sector, and had a turnover of less than R50,000 per annum (Hlalele et al., 2016). The study found that 87% of businesses reported losing over 50% of their revenue due to the drought (Hlalele et al., 2016). There is also anecdotal evidence of the impact of drought on small businesses. For instance, newspaper articles cite businesses on the East Rand reporting losing clients due do water shortages[4], while guesthouse owners in Bela-Bela[5] also reported that they have been impacted. More comprehensive studies on the impact of water shortages on small businesses more broadly in South Africa are therefore required.

In terms of large businesses, the only potential report of reference is that of the Carbon Disclosure Project (CDP). However, this is also not a systemic view of large business across South Africa, only showcasing the members that have responded to their questionnaires regarding water usage.

Finally, in terms of water quality, again there is limited research. The economic impacts of drought in relation to water quality are under-researched and difficult to quantify, not least because of insufficient research on the economic impacts of deteriorating water quality even in the absence of drought. Secondly, understanding the impacts of drought on water quality is extremely complex, and again, under-researched in the South African context. The complexity is partly due to the number of variables to be taken into account in water quality, including dissolved oxygen, nutrients, sediments, dissolved organic carbon, pH, metals, organics and ecology.

[4] http://www.news24.com/SouthAfrica/News/east-rand-businesses-hit-hard-by-water-shortages-20151111
[5] https://www.enca.com/south-africa/drought-hits-tourism-bela-bela

Initial investigations by Andrew Slaughter (Institute for Water Research, Rhodes University) of three sites in the Crocodile Catchment indicate a complex water quality response to drought, depending on the land-use upstream of the monitoring point. His investigations, which are in an early stage and are not for publication yet indicate that the issue of drought impacts on water quality is complex and site specific.

3. Approaches to assessing impacts of policy interventions and shocks

Three non-econometric approaches can be used to assess the impacts of policy interventions or shocks. In “before” and “after” comparisons, the analyst will study a household before the intervention and what happens to the same household after the intervention. In “with” and “without” comparisons, the analyst collects cross sectional data that comprises households that have received the intervention and those that have not received the intervention. The “target” and “achievement” comparisons are self-explanatory. Given resources, one could also use robust approaches from econometrics (e.g. propensity matching strategies, endogenous switching regression) to isolate the causal effects of interventions. Since this study was conducted at a time of a drought episode (households were experiencing drought during the data collection), the only approach that was practical was “before” and “after” comparisons, where households were required to use recall in making statements about the most recent normal year. The key limitation with this approach is that attribution may be inaccurate without considering time trends or other factors that might influence economic results. Furthermore, the intensity of drought felt is not equal amongst regions across South Africa, and therefore an average cannot be drawn across the country.

The measurement of indirect and induced effects uses the direct impacts as the starting point, in combination with social accounting and impact analysis software packages like IMPLAN Pro, to derive forward and backward economic linkages in the economy. IMPLAN Pro for example can be used to create predictive models of local economies, which can then be used to analyse shocks to economic systems. IMPLAN Pro can use data from different industrial sectors including employment, value added activities and business to business transactions, to create a baseline economy. Impacts to the system, which could be increases or decreases in economic activity or investment, may then be compared to the baseline scenario.

Indirect and induced drought impacts have been analysed using linear mathematical programming models (Dono and Mazzapicchio, 2010; Peck and Adams, 2010), non-linear mathematical programming models (Jenkins et al., 2003; Booker et al., 2005), hydro-

economic models (Ward and Pulido-Velázquez, 2012), econometric models (Alcalá Agulló and Sancho Portero, 2002; Martínez-Cachá, 2004; Rubio Calvo et al., 2006; Lorite et al., 2007; Quiroga and Iglesias, 2009), computable genera equilibrium models (CGE) or input-output (IO) models (Goodman, 2000; Gómez et al., 2004; Berrittella et al., 2007; Pérez y Pérez and Barreiro-Hurlé, 2009), and choice experiments (Martin-Ortega and Berbel, 2010).

4. Measurement of the economic impacts of drought used in this research

For this study, the direct impact of the drought for the selected sectors (irrigated agriculture; livestock; mining; tourism; agro-processing; small and large businesses; water quality) was measured by comparing sector relevant indicators of performance in the most recent drought year and the most recent normal year.

For instance, to estimate the impact of drought induced water shortages on white and yellow maize grown under irrigation, a structured questionnaire was used to collect the following data: data on output (in tonnes and in value units), and data on inputs use (land area, number of employees, quantity and expenditure on irrigation water use, quantity and expenditure on fertilizer use, quantity and expenditure on herbicide use, quantity and expenditure on pesticide use, and quantity and expenditure on electricity use). Data were also collected on management actions taken immediately by the farmer in response to the current drought (i.e. short run responses) and management actions the farmer proposes to take in the long-run in anticipation of future drought incidences. This process was repeated for relevant sectors such as rainfed agriculture, and where appropriate, livestock, agro-processing, etc.

To estimate the impact of drought induced water shortages on the mining sector, a structured questionnaire was used to collect the following data: whether the firm had open cast or underground operations, whether the firm engaged in dry or wet mining, the management actions taken immediately by the firm in response to the current drought (i.e. short run responses) and the management actions the firm proposes to take in the long-run in anticipation of future drought incidences.

To estimate the impact of drought induced water shortages on the small and large business sectors, and tourism sector, a structured questionnaire was used to collect the following data: sensitivity of the sector to water shortages, the management actions taken immediately by the sector in response to the current drought (i.e. short run responses) and the management actions the firm proposes to take in the long-run in anticipation of future drought incidences.

5. Proposed research areas

This project attempted to estimate the economic impacts of drought induced water shortages on the SA economy using a mixture of quantitative and qualitative approaches. The quantitative approaches were used to measure the impacts on white maize output grown under irrigation, yellow-maize grown under rain fed conditions, extensive cattle production, extensive goat production and extensive sheep production. Qualitative approaches were used to measure the impacts on the mining sector, the tourism sector, the agro-processing sector, the small-businesses sector, the large businesses sector and water quality.

A full-scale analysis was hampered due to a lack of data available on the topic in South Africa. We hope, that this study provides a starting point for building a case for pro-active policy action to mitigate the potential impacts of drought induced water shortages. Policy needs to understand the scope and spread of drought damages from primary to industrial sectors to effectively respond: who is most affected, how large is the population of the affected, where are they located, etc. Policy also needs more accurate approaches to solve for the attribution problem, i.e. to isolate the impacts of drought from other sources of economic performance variations. To summarise, studies of this nature can be regarded as necessary to enable improved management of water as a scarce natural resource, inform water allocation decisions in times of drought and design adequate drought mitigation and prevention measures that help minimize impacts (Garrido and Hernandez-Mora 2013).

The problem is that government officials are often reluctant to allocate money and resources to mitigation because of limited information on the costs and benefits of drought mitigation programs. One has only to remember that the costs of a mitigation project are usually upfront while the benefits are more uncertain and harder to predict (especially in the event of a drought) to appreciate the dilemma facing the policy maker. It is thus important to compute the costs of droughts because the benefits of mitigation programs can be approximated by using the estimated costs of the disaster that would be otherwise avoided by the mitigation programs. In technical environmental economics parlance, this is called the avoided cost approach to environmental valuation. Thus, to understand the monetary benefits of drought mitigation programs, quantification of the economic impacts of drought need to be available. Such data can make long term drought mitigation policies pro-active.

In lights of the above comments, suggestions for a larger, study in the future include the following considerations:

- The most recent full study of the impact of drought on the broader economy of South Africa was done in 1992. The nature of the South African economy is fundamentally different now. Therefore, we need to repeat the National Accounts process taking the impact of the drought into account for 2015/2016.
- In addition to the National Accounts process, we need to consider the different hydro-climatic zones of South Africa. This is especially true for sectors that support the rural economy of South Africa, as drought impacts are likely to be severe in these areas, yet not reflective at a national scale when compared with urban areas. This study will need to look at understanding particular case studies for each sector in each region, and investigate the direct and indirect impacts of drought. This will include factors such as lost production, but also employment.

The most critical question that needs answering is: how does drought (and our projections for future climate) shift the economy of South Africa? This will be ramifications both for our agricultural rural economy and urban economy. It will impact upon our economic planning policies, and therefore it is important that we are able to translate the impacts of drought, and a changing climate into what this means for the economy of our country. It is important that we plan and predict possible changes, so that we can ensure a sustainable and equitable country that provides impetus for growth among a diversity of sectors.

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