5 Land rich but water poor

The prospects for agricultural intensification in Southern Africa

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Introduction

Given the prognosis for population growth over the coming decennia elaborated in Chapter 3, the pressure on the natural resources of Southern Africa (Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe) is likely to grow. Add to this the keen interest of outside agents in gaining a foothold in the region for export-oriented food production (20 million ha have been appropriated in Africa over the past decade according to the New Partnership for Africa's Development (NEPAD) program of the African Union) and the stage is set for pressure on land to increase dramatically (Chapter 3). Available arable land in the 1960s estimated by the FAO (Rakotoarisoa et al., 2012) in Southern Africa ranged from 1.35 and 0.94 ha/person in Zambia and Namibia, respectively, to around 0.30 ha/person for Swaziland, Malawi and Mozambique. In 2001–04, these values had dropped to 0.5 and 0.4 for Zambia and Namibia and to between 0.3 and 0.2 ha/person for the rest of Southern Africa. With the exception of South Africa and Namibia, there are still prospects of expanding the area of arable land (NEPAD, 2011), but the low quality or protection status of this land are constraints.

This chapter will look at the land and water endowments of the Southern African states and assess their quality and the impact of their use as well as their management. An assessment will be made of the options to intensify their use without depleting them in order to ensure their availability for generations to come.

Land and land cover

According to the World Bank database (2016), the total land area of contiguous Southern Africa covers 4.7 million km², 54% of which is currently cultivated or used by (agro) pastoralists, well above the world average of 38%. The fraction of land under agriculture varies widely from 75–80% in South Africa and Lesotho to as little as 32% in Zambia. The remaining countries hover around the regional average of 50%. There is a strong rainfall gradient running from > 1500 mm yr⁻¹ NE to less than 50 mm yr⁻¹ at the Namibian coast. Rainfall

in excess of 1000 mm yr⁻¹ is typical for the northern halves of Zambia and Mozambique as well as northern Malawi. Less than 500 mm yr⁻¹ is seen in most of Namibia, Botswana, parts of southern Malawi and the western half of South Africa. Most of Namibia, South Africa and Botswana receive less than 250 mm with extremely high potential evapotranspiration rates of over 2500 mm yr⁻¹. The band between these regions experiences between 500- and 1000-mm rain per year (Hijmans et al., 2005). Land cover is largely determined by this gradient with forest dominating the > 1000mm rainfall belt in the north and east of Southern Africa and shrubby and herbaceous vegetation in the larger parts of Namibia, Botswana and South Africa that grows sparser as one moves further to the southwest (Bartholomé and Belward, 2005).

Land use and management

The agro-ecology of the region is largely determined by the rainfall gradient with semi-arid and desert-like conditions in the southwest and humid tropical conditions in the north and east, respectively. Most of South Africa falls in the subtropical zone. The natural vegetation is in accordance with the rainfall, as are the farming systems that have emerged over the centuries in these regions. Where rainfall allows, cereal production is dominant, covering more than 50% of the agricultural land in Southern Africa. Southern Africa is characterized by four ecozone bands oriented East-West, dissected by the maize-producing highlands that reach from Tanzania into Zambia, Malawi and Zimbabwe with a North-South orientation. North of this belt is the root crop and mixed cereal-root crop region that stretches from Angola through Zambia to Mozambique. South of this belt the climate is substantially drier, characterized by agro-pastoralism with millet/sorghum and livestock of equal importance and further south, pastoral zones dominated by livestock. The Namibian/South African tip of Africa is arid and unproductive in southern Namibia and the South African Karoo. The remainder is semi-arid to sub-humid and comprises large holdings and scattered smallholdings dominated by maize in the north and east, while the west is dominated by sorghum and millet. Overall, maize is the dominant crop (nearly 10 million ha) followed by sorghum, millet and wheat approaching 1 million ha each with the latter largely found in South Africa (FAO stat). The prime maize producers are South Africa (2.5 million ha) followed by Zimbabwe, Malawi, Mozambique and Angola with around 1–1.5 million ha each.

Garrity et al. (2012) compiled an in-depth analysis of the African farming systems. In their synthesis they argue that major challenges across the different farming systems are the pressure on land due to population growth, the rapid rate of soil fertility depletion and the poor access to input and output markets, even domestically. Land in Southern Africa is managed with widely different intensity but two farming systems dominate in terms of land coverage. The dominant maize-mixed system of Southern Africa has the potential to ensure food security with ample options for diversification. Yet, to date, this area suffers from more poverty than any other farming system in the region. The

agro-pastoral system exhibits low ecosystem productivity and economic risks due to rainfall constraints that can be mitigated through collective resources management and strategic intensification, particularly where water resources can be made accessible. Some of these strategies will depend on government support. The root and tuber-based systems of northern Angola is deemed high potential as it has growth options through a real expansion and mechanization. Also, the modest level of livestock productivity offers room for improvement in this zone.

Land degradation

Worldwide, land degradation presents a serious threat to agricultural productivity and food security and sustainable development goals (Vlek et al., 2017). The degradation processes can be readily observed, but quantifying the degree of degradation of larger regions is very difficult, particularly in Africa, as baseline data are often lacking and panel data from observation points are few and far between. Efforts have been made to use space observations to monitor the state of the land (Vlek et al., 2008; Bai et al., 2008; Le et al., 2016), but considerable discrepancies are seen among the reported states of degradation due to the methods employed in the trend analysis. However, there is consensus that land degradation is seriously affecting the ecosystem functioning of lands in Southern Africa, both due to land conversion, nutrient mining and overgrazing (IPBES, 2018).

Soil resources and productivity

Soils in the Southern African region are characterized by varying fertility levels depending on physiography, land use and land management techniques. The soils in the majority of the countries are generally poor with low soil organic matter (SOM) content and low water retention (Tamene et al., 2019). As a result, they are vulnerable to water and wind erosion, leaching and salinization if put under irrigation. For example, in Namibia, nearly all of the soils have clay contents of less than 5% and thus have very low water holding capacity (Liebenberg, 2005). In Botswana, 70% of the soils are sandy, geologically old and highly leached, poorly structured and infertile (Moroke, 2005). In Lesotho, more than 70% of the soils are acidic, have low organic matter, low pH and are infertile (Ranthamane, 2005). In South Africa, over 30% of the soils are sandy; 60% of the soils have low soil organic matter content and exhibit high levels of degradation and low productivity (Villiers, 2005). In Malawi, soil erosion and nutrient depletion are major causes of degradation and limited productivity. For instance, estimates show that Malawi loses in excess of 30 kg of N and 20 kg of P per hectare per year through erosion on arable land (Henao and Baanante, 1999). According to a study by Folmer et al. (1998), Mozambique is estimated to lose soil nutrients at a rate of about 112 kg/ha of N, 60 kg/ha of P_2O_5 , 116 kg/ha of K_2O annually through nutrient mining. Based on the recently

published ISRIC 250 m resolution soil property map, the majority of Namibia, Botswana and northwestern parts of South Africa show very low SOM while northern Angola, the majority of Zambia, Malawi and Mozambique have relatively better SOM content (Hengl et al., 2015). In some parts of the region where frequent fires are observed, there is an overall low SOM content in relatively good forest cover areas (Ryan and Williams, 2011). This observed low SOM could result from rapid turnover of SOM due to high temperature or to insufficient moisture limiting decomposition in arid and semi-arid areas (Liddicoat et al., 2010). Drier and warmer conditions predicted to occur in southern Africa in the future are expected to increase rates of soil C mineralization and the associated loss of important soil functions.

Soil management and conservation

Frequent droughts that have occurred in the region for over a century have exacerbated land degradation, and its impact on livelihoods and food security has worsened. This makes land management and conservation a pivotal but formidable task particularly during the critical moisture deficient periods. Governments, nongovernmental Organizations (NGOs) and in some instances, the private sector have made efforts to address the issue of land degradation and identified suitable remedial options. In Southern Africa, land tenure determines the willingness to invest in land and address sustainability in agriculture and rural livelihoods (Bond et al., 2004). SADC as a regional organization has also put in place specific operational units to address the land tenure, land degradation and land management issues in the region. Generally, fertilizer application is the primary soil health replenishing option in the region, and some countries have promoted this intervention with subsidy programmes such as in Malawi and Zambia. Although fertilizer input in the region is below the recommended levels, substantial gains have been achieved in terms of maize yield (Jama et al., 2017). Complemented with organic inputs, conservation agriculture and good agronomic practices, overall agricultural productivity can be enhanced. However, additional land management interventions such as terraces, buffers and agroforestry will be needed at the landscape scale, as intensification cannot be achieved sustainably at the plot/farm level if degradation continues to occur at the watershed level. Integrated watershed management interventions have shown positive effects, specifically in tackling soil erosion and its associated on- and off-site effects (Henry, 2015), but such initiatives remain rare.

Despite some isolated successes, numerous interventions targeted at reducing poverty through improvement in land resource management have not achieved their targets due to lack of coordination as well as rigidity of implementation which failed to recognize and incorporate indigenous knowledge and peoples' preferences (Msangi, 2006). In addition, weak land tenure systems combined with high poverty and low literacy levels common among the rural population in the region complicate improving land management (Msangi, 2006). Low technological capacity, poor governance and poorly conceived management

policies and their implementation further undermine the potential role of land management practices in tackling land degradation and enhancing food security (Henry, 2015). Some of the introduced technologies do not address the problems facing a specific area and, hence, lack relevance and applicability to different micro-environments. As a result, technology adoption and proper land management is limited in many parts of the region (Msangi, 2004). Despite the fact that most countries in the region have made notable efforts in promoting land management through policies that provide the basic foundation for managing land degradation, it is observed that their implementation remains a considerable challenge in achieving sustainability in the management of land and other natural resources in those countries (Mango et al., 2017).

Water resources and distribution

The nine SADC countries of Southern with more than 15% of the land area receive less than 7% of the continental annually renewable water resources (ARWR), estimated at 274 km³/year (UNECA et al., 2000, Thamae, 1997). The Zambezi basin in the northern part of the region claims over 40% of this resource (Dai and Trenberth, 2002; The World Bank, 2010). This precarious water situation is likely to deteriorate due to the change of climate, land degradation and the increasing water demand due to a growing population. Kusangaya et al. (2014) estimate the expected decrease of streamflow in most of the river basins to be between 18–75% by 2050, while a few basins may show increasing streamflow trends of between 5–38%. The Zambezi is predicted to lose 26–40% of its discharge. These predictions will have to be taken into account when planning the strategic and efficient use of water.

Approximately 7% of the ARWR in Southern Africa is withdrawn to satisfy societal needs, including agriculture (UNECA et al., 2000). However, increasing this fraction is complicated as water availability and water demand seldom match in space and time and will thus require investments in massive reservoir capacities and water transfer systems. South Africa consumes approximately 24% of its ARWR with the help of more than 500 reservoirs (Wikipedia, 2014), providing an aggregate storage space equaling two-thirds of the entire ARWR of the country for an average year.

In southern Africa at present about 85% of the water withdrawn from nature (rivers, streams, wetlands and aquifers) is consumed in agriculture (WWF, 2013), well above the global average (70%). The share of irrigation in Southern Africa remains well below 20%, which is the average share of land irrigated in developing countries (FAO, 2003). Almost three-quarters of irrigation in Southern Africa takes place in South Africa with its formidable and distributed storage coupled with an advanced network of inter-basin water transfer facilities providing the backbone to the irrigation of approximately 1,500,000 ha in the country (SADC, 2012). However, the water available for irrigation in South Africa is insufficient to irrigate the entire equipped area unless deficit irrigation

is a common practice. Even though the share of irrigated cropland is only slightly above 10%, it provides 30% of the crops (WWF, 2013)

Increasing the share of irrigated crops in agricultural production in the region would require the rehabilitation of many dilapidated irrigation perimeters (Liang, 2008), the construction of additional dams, transfer facilities and in-field infrastructure. With the most favourable dam sites already developed, such investment would be riskier. Relying on groundwater as the source of irrigation is not a widespread option in Southern Africa (Pavelic et al., 2013; Villholth, 2013). Recharge rates are erratic even in areas endowed with easily accessible and abundant aquifers. In most cases, increasing groundwater withdrawals would diminish surface water resources, which might threaten animal husbandry by eliminating drinking water supplies.

Theoretically, Southern Africa has room to increase withdrawals by 3% of the regional ARWR without violating recommended threshold of 10% (Rockström et al., 2009). With most other rivers already fully exploited, the best prospects are in the relatively water rich Zambezi basin, mainly in Mozambique and Zambia and some of Zimbabwe (NEPAD, 2013a, 2013b; The World Bank, 2010). Two mega dams on the Zambezi together can store the entire average annual flow of the Zambezi River. However, both reservoirs are operated for hydroelectric energy output (Magadza, 2006). Any new dam investment may have to consider and optimize the competing uses for the energy and agricultural sectors.

The natural resource constraints of Southern Africa

Southern Africa is well endowed with land resources, but with the ever-increasing demand for food and the slow adoption of sustainable intensification practices in agriculture, land degradation is a continuous threat to feeding Southern Africa in the future. Soil erosion, nutrient mining and climate change are all affecting agricultural productivity of the region. Sustainable intensification could alleviate this problem through the widespread use of fertilizers, which has been stuck at around 10kg ha⁻¹ for nearly half a century but should be combined with the restitution of agricultural residues to overcome nutrient mining. Mulching and green manuring are important components of this strategy. Erosion control would be improved through these practices as well but would benefit greatly from community initiatives such as land use planning and terracing. Doubling the rate of fertilizer application alone would add 100 kg of grain per ha which for the 10 million ha under maize would amount to one million tons of grain.

The limited role of irrigation in increasing food production in Southern Africa can be illustrated by the following rough estimations. Assuming that the average regional withdrawal rate can go above the recommended 10% to 20% of the ARWR, approximating the current situation in South Africa and that 85% of the withdrawn volume of 54.8 km³/annum is readily available

for irrigation, with an irrigation efficiency of 40% prevailing in developing countries (FAO, 2003). Finally, assuming staple crops require only 6,000 m³ water per hectare, the 18.6 km³/year net available irrigation water would suffice to irrigate 3.1 million hectares of land in the region. At present, there is already 2 million hectares of irrigated land in the nine countries considered. Thus, at a regional scale even this assumed, but unrealistic water withdrawal would enable the conversion of 1.1 million hectares into irrigated agriculture, roughly 44% of the irrigable land of the Southern African part (excluding Angola) of the Zambezi basin (FAO, 1997). Clearly, water rather than land is the limiting factor and more so, once we impose realistic assumptions of water extraction. In reality, the available water resources may dwindle because of climate change. Irrigation expansion will help but not solve the food security issues of Southern Africa. Even improvements of the quite moderate 40% water use efficiency would not revise this conclusion.

If food security in Southern Africa is to be realized from the land that is cultivated, it will be paramount that the quality of land is preserved in order to deliver the ecosystem services on which its population depends. To that end, both, land conversion and land degradation should be held in check. Land sparing of pristine ecosystems and regeneration of fragile lands through intensification of agriculture on resilient cultivated land should be the guiding principle of policies, investments and incentives for future development. These should aim to fully capture the benefits of locally available resources such as water and biodiversity but also ensure that the fertility of the soil is eliminated as a constraint to agricultural productivity. Policies to these ends should be put in place and enforced in order to ensure a stable and sustainable supply of food for the region.

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