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The Balance of Natural Resources: Understanding the long term impact of mining on food security in South Africa

Bureau for Food and Agricultural Policy BFAP

MAIZE TRUST

Table of Contents

Executive Summary

In the most recent State of the Nation Addresses (SONA, 2015a; 2015b) the President referred to a Nine Point Plan to revitalise the South African economy. Matters that took centre stage included agriculture in its role of promoting growth and food security and being one of the platforms through which increased equity can be achieved. However, the Nine Point Plan points also include advancing beneficiation (adding value to our mineral wealth). These two goals, set by the president, together with the reality of resource scarcity (especially land and water) imply competition for resources between agriculture and mining.

In the last decade South Africa has seen a rapid increase in mining activity, leading to concerns that expanding mining activities are encroaching on and utilising high potential agricultural land. This is especially true for Mpumalanga (mainly coal) and the Waterberg (mainly platinum). This report investigates the extent and implications of competition for natural resources between agriculture and mining in South Africa and seek areas of possible collaboration and prudent forward looking practical interventions that could lead to sustainable resource use.

The competition for natural resources is most visible where mining and agriculture compete for high value agricultural land. Increasing mining activities could, however, in future also increasingly affect agricultural production through the reduction in the supply and quality of water resources, through environmental degradation and through mining-related pollution that impacts both nearby and future agricultural activities. The competition between mining and agriculture for scarce natural resources can increasingly affect the economy, food production and resource availability if not managed carefully. The historic unidirectional conversion of productive land from agriculture to mining raises serious concern with respect to the future management of and the options for the sustainable use of natural resources. These natural resources (such as land, water and clean air) are essential for human well-being and for the production of food. At the same time, the revenue that is earned and the jobs that are created by the mining sector are essential for the economic growth of the country. The competition for resources therefore imprints on a much larger issue - it has become an issue impacting on the national security of the country defined in a broad sense to imply an economically, politically and socially well-functioning and resilient society.

There is a lack of public awareness and dialogue around the serious impacts that the conversion of productive agricultural land to mining and its related activities can have on higher level national security concerns. There is therefore an absence of strategic planning, policy and action required to avoid the breach of national security concerns. This study seeks to stimulate this much needed dialogue by providing an initial, high-level assessment of the extent and impact of expanded mining activities on agricultural production and food security in South Africa. In particular, this report addresses each of the following aspects:

- it offers a brief context of each of the sectors from a historical, legal, economic and environmental perspective;
- it provides a national perspective on the extent of competition for natural resources between the two sectors by examining high-level spatial evidence of current and potential mining and agriculture production areas;
- it assess the implications of expanded mining activity for the agricultural sector, food security and national security in South Africa; and
- it recommends strategic guidelines and policy options which will be helpful in managing the trade-offs between agriculture and mining, thereby enhancing rather than threatening national security.

A three-phased approach was used to construct this report. Phase 1 consisted of a desktop review of literature and applies the spatial data and analysing capacity of BFAP's newly developed Integrated Value Information System (IVIS) to assess current and potential future competition and complementarities between agriculture and mining in South Africa. In the second phase, a scenario planning session was held including key stakeholders and experts from the agricultural, mining and environmental sectors. The aim of the scenario session was to provide a platform for stakeholders and experts from the different sectors to discuss the possible futures of mining and agriculture in South Africa. In Phase 3, the results of the scenario session were used to formulate future scenarios and assumptions for empirical analysis by BFAP's sector and household models that also form part of IVIS.

The first phase of the study underlined the basic principle that the conjunction of mining and agriculture forms the basis of human survival and societal development, and that the argument of the anti-mining lobby that mining as an activity should be eliminated is not realistic. For example, coal has been the primary source of energy supply for the country from the nineteenth century and currently between 77% - 85% of the power generated in South Africa is coal based (DOE, 2015). The renewable energy industry in South Africa is relatively undeveloped in comparison to the rest of the world, and given the nature of long term contracts tying some coal mines to supplying Eskom, the country will in all probability continue to rely on coal-fired power stations for the next 30-50 years.

In order to resolve the conundrum of the competition (as opposed to collaboration) between mining and agriculture one needs to restrict the debate to the basic natural resources of land, water and clean air, while not losing sight of the intricacies of this symbiotic interplay between mining and farming as this is not a zero sum game. The ability of mining to catalyse the establishment and development of commercial agriculture and the agricultural value chain can be defined in a number of ways, including *inter alia:*

- Leveraging mining infrastructure for lowering the barriers to entry and operating costs for farming in areas where there is mining activity (transport, bulk infrastructure, social, commercial, industrial and administrative infrastructure);
- Use of mining surface rights for farming (mining companies typically have large areas of land holdings that are secured for health, safety and regulatory reasons);
- The economic multipliers of mining serve to spawn secondary and tertiary sectors that support commercial agriculture;
- The use of pumped mine water for agricultural purposes (cheap, treated water);
- Mined intermediate inputs for agriculture (phosphates, lime, trace elements);
- The ready access to domestic supplies of intermediate inputs for primary agricultural and ingredients and packaging for the beneficiation of agricultural products; and
- The provision of grid-based energy from coal mining.

On the other hand, the inevitable tenets of conflict between the two sectors are, *inter alia*:

- Aggregate disruption of land use by mining vs chronology of land restoration and the net sterilisation of arable agricultural land by mining
- Competitive water use allocation vs the obligation of mines to treat run-off mine water to standards of utility suitable for agriculture
- Contamination of ground and surface water sources by mining activity
- Dust and other airborne emissions and their impact on the quality of agricultural produce, particularly deciduous fruit, citrus, bananas and table vegetables;
- The respiratory and oncological health threats to farmworkers resulting from airborne emissions from mines;
- Competition for unskilled and semi-skilled labour and the discrepancy ratio between mine wages and farm wages;

- Differential levels of labour organisation between the two industries; and
- Destruction of roads by heavy vehicles transporting bulk materials from both industries.

The area affected by mining is a multi-layered problem and IVIS was applied to analyse spatial data (spatial analyses available here). The research results show that the competition for land and water between mining and agriculture is acute in some of the most important agricultural regions in the country. Likewise these regions are major water catchment areas which feed, for example, the Gauteng metropolitan area. Within the hotspots identified the mine-owned land (surface and open-cast mining area) intersected by agriculture (grains and oilseeds croplands only) amount to:

- 365 806 ha in Mpumalanga (27% of cultivated fields in province)
- 125 223 ha in North West (5% of cultivated fields in province)
- 35 974 ha in Limpopo (3% of cultivated fields in province)
- 10 197 ha in Gauteng (3% of cultivated fields in province)
- 16 254 ha in Free State (0.01% of cultivated fields in province)

Hence, the total area of mine-owned land in South Africa intersected by agricultural field crops activities amounts to 553 565 ha, or some 3.5% of South Africa's available arable land, but concentrated in the high potential areas of the highveld. Apart from identifying the amount of potentially affected agricultural land, assumptions had to be made on a range of key exogenous variables in order to simulate the potential outcome of each scenario on the agricultural sector and food prices. Three plausible scenarios that were formulated by stakeholders from the agriculture, mining and environmental sectors are named Sound of Music (which is characterised by excellent governance and high commodity prices), Blood Diamonds (characterised by terrible governance and high commodity prices) and Gotham City (characterised by terrible governance and low commodity prices). These three future scenarios where simulated and their effect relative to the baseline summarised. In one of the extreme scenarios agriculture loses approximately 380 000 tons of maize production by 2024 and prices increase by more than 30% above baseline projections (Gotham City). The prices shocks can potentially be higher (Blood Diamonds) depending on the level of import and export parity prices.

Importantly, the potential outcomes of the scenarios were only simulated for the agricultural sector and for food prices; thus assumptions were made on a range of key exogenous drivers that should ideally be generated within a general equilibrium framework. While this falls outside the scope of this study, future research should address this since the scenarios provide an ideal platform for much broader analysis.

While the focus of this study was to seek the relevant factors that have to be considered for the harmonious and sustainable coexistence of mining and agriculture to the betterment of the country and the reduction of national security concerns, there are still some major gaps in our knowledge of the subject. Further key research questions are therefore identified that have to be answered in order to inform decisions by all relevant stakeholders regarding the allocation of resources, management of mine closure, and the value agriculture can add through collaboration with the mining sector.

An emerging theme is the need for **holistic assessment regarding the prioritization of natural resource use.** Not only do agriculture and mining need to come to terms with the resource scarcity in South Africa, but policy makers also need to understand its importance from a national security perspective. Further dialogue between stakeholders – public and private – is necessary to make informed decisions for the benefit of the country.

Specific recommendations relevant to governance, legislation and sector-specific operations, are listed below (in no particular order):

Recommendations for Governance and Legislation -

- The DMR, DAFF, DEA, DWAF and DRDLR need to coordinate and strategically align in governing the allocation of resources such as water and land. In this regard, greater clarity is needed on who in various spheres of government can make decisions to avoid long delays in project implementation and the high cost of compliance for those operating in the primary sectors. Streamlined, coordinated governance structures which are 'compliance-friendly' are needed.
- Dedicated revenue sources, such as the water pricing strategy and mine royalties, should be used appropriately and transparently within the local context to ensure that natural resources are managed sustainably.
- It is critically important to ensure that ample provisions are set aside in order to rehabilitate land adequately, especially if post-mining land use is agriculture.
- Legislative requirements regarding the EIA of mines need to be structured in such a way that the cumulative/regional impacts of mining in an area are accounted for.
- Clarity is needed on how the draft Bill on the Preservation and Development of Agricultural Land will factor into the SPLUMA framework.

Recommendations for Sector-Specific Operations -

- There is a need for an investigation of possible contractual arrangements which enable agricultural production on mine-owned land not destined to be mined.
- Where possible, agriculture should be prioritized as post-mining land use.
- Seeing that land rehabilitation is at its core a land-management activity, and therefore to some extent falls into the expertise of the agricultural sector, agronomic principles should form part of the mine's exit strategy to the benefit of both agriculture and mining.

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List of Acronyms

AGIS – Agricultural Geo-References Information System

AMD – Acid Mine Drainage

BFAP – The Bureau for Food and Agricultural Policies

CMAs – Catchment Management Agencies

COMSA – The Chamber of Mines South Africa

DAFF – Department of Agriculture, Fisheries and Forestry

DEA – Department of Environmental Affairs

DMR – Department of Mineral Resources

DRDLR-Department of Rural Development and Land Reform

DWAF – Department of Water Affairs

EIA – Environmental Impact assessment

ELUs – Existing Lawful Water Users

EMP – Environmental Management Plan

GDP – Gross Domestic Product

GCF – Gross Capital Formation

LUS – Land Use Scheme

MEC – Member of Executive Council

MPRDA – Mineral and Petroleum Resources Development Act

MPTs – Municipal Planning Tribunals

NEMA – National Environmental Management Act+

NFI – Net Farm Income

NLC – National Land Cover 2013/2014

NWA – National Water Act

NWRS1 – National Water Resource Strategy[1] (2004)

NWRS2 – National Water Resource Strategy[2] (2013)

SALA – Subdivision of Agricultural Land Act

SDF – Spatial Development Framework

SONA – State of the Nation Address

SPLUMA – Spatial Planning and Land Use Management Act

WMA – Water Management Area

WUAs – Water User Associations

Disclaimer:

Throughout this report, reference is made to the respective behaviour and impacts of mining and agricultural activities in general. However, in practice, both sectors are highly differentiated with regards to the types of commodities produced, the size and intensity of production, the management practices adopted, and the remediation strategies in place. In particular, we acknowledge that several mining companies and farmers have put large amounts of resources into running effective pollution treatment and rehabilitation strategies. However, there are also a substantial number of mines (including abandoned mines) and farms which have, intentionally or unintentionally, failed to implement effective strategies for reducing their negative impacts on society. Also, the environmental impacts of any human activity differ on a case-to-case basis, often depending on the sensitivity of ecosystems and resource constraints in the surrounding area. It is not possible, at a national level, to specify which mining and agricultural activities are responsible for the degradation and toxic load imposed on the environment. Rather, this report attempts to highlight the possible impacts of mining and agriculture as a whole on the economy and the environment in general. Therefore, it is important to note that the negative externalities referenced in this report are intended to highlight areas of concern for the South African public. However, these statements must be interpreted in light of differentiated sectors and are not intended to discredit the positive work that may already exist within each of these sectors towards reducing their negative environmental and social impact.

Secondly, in the presentation and interpretation of scenarios (section 4), a deliberate attempt has been made to use expressive and visual tools (for instance, the use of movie names to describe particular scenarios and the use of emoji to express the state of the 5 capitals under each scenario). While this approach may seem unconventional, it is intended to facilitate communication of the nature of each scenarios and their likely consequences.

1 Introduction

Historically, agriculture and mining have played instrumental roles in shaping the patterns of economic development in South Africa. Although their contribution to GDP has shrunk significantly (since 1980, the combined GDP contribution of the two sectors has declined from above 26% to 10.9%, with agriculture contributing less than 2.5% to GDP) as the economy has developed over time, these two industries remain at the heart of economic growth and the creation of job opportunities for unskilled workers (see section 2.2.5). The decline in the two sectors' contribution to GDP in relative terms should not be viewed as a decline in their importance, but rather as a testimony to the degree of industrial diversification that was made possible because of these two sectors' historic and current contribution to the economy.

With the sharp rise in the world's demand for minerals, driven mainly by India and China, the rate of expansion in mining activities over the past decade has been phenomenal. The areas where the expansion in mining activities in South Africa has and is taking place, ranges from desolate areas with limited agricultural potential, to areas with high potential agricultural land. In addition to competition for land, mining activities are increasingly also affecting agricultural production through the reduction in the supply and quality of water, through soil degradation and through mining-related pollution that impacts both on neighbouring agricultural activities nearby and on future activities. The historic unidirectional conversion of productive land from agriculture to mining raises serious concerns with respect to the future management of and the options for the sustainable use of natural resources. These natural resources (such as land, water and clean air) are essential for human well-being and in the production of food. The competition for resources therefore imprints on a much larger issue - it has become an issue impacting on the national security of the country defined in a broad sense to imply an economically, politically and socially well-functioning and resilient society.

1.1 Purpose, Scope and Approach of this Report

This work builds on a 2012 pilot study performed by BFAP which looked at the impacts of coal mining on maize production in a specific region of Mpumalanga Province. The results of the pilot study were staggering: in a total area of 79 967 ha, as much as 284 844 tons of maize is lost to mining per annum (and a further 162 736 tons per annum is potentially lost to prospecting). Modelling results indicated that the impact of coal mining in the pilot area alone could result in an increase of maize meal prices by approximately 5% in the long term.

Subsequent to the pilot study, a number of discussions were held and the need for a national study with a significantly wider scope was identified. As a result, this report represents a second round of research carried out by BFAP which aims to inform an understanding of the extent and impact of expanded mining on agricultural production in South Africa. In particular, this report aims to

- Offer a brief context of each of the sectors from a historical, legal, economic and environmental perspective;
- Provide a national perspective on the extent of competition for natural resources between the two sectors by examining high-level spatial evidence of current and potential mining and agriculture production areas;
- Assess the implications of expanded mining activity for the agricultural sector, food security and national security in South Africa;
- And recommend strategic guidelines and policy options which will be helpful in managing the trade-offs between agriculture and mining, thereby enhancing rather than threatening national security.

This study was conducted in three phases. Phase 1 consisted of a desktop review of literature and spatial data to assess current and potential future competition and complementarities between agriculture and mining in South Africa. In the second phase, a scenario planning session was held including key stakeholders (see the list of attendees in Appendix A) and experts from the agricultural, mining and environmental sectors. The aim of the scenario session was to provide a platform for stakeholders and experts from the different sectors to discuss the possible futures of mining and agriculture in South Africa. In Phase 3, the results of the scenario session were analysed using the 5 capitals in order to use them to formulate assumptions for the BFAP sector model, consequently simulating three plausible future scenarios and summarising their effect relative to the baseline.

In the next section each sector (agriculture and mining) will be contextualised as described above, followed by an overview of resource competition between the two sectors, a discussion of the analytical framework flowing from the scenario session and modelling results from the BFAP Partial Equilibrium model, then ending the report with key policy recommendations and guidelines. The thought process in compiling this report is illustrated in Figure 1:

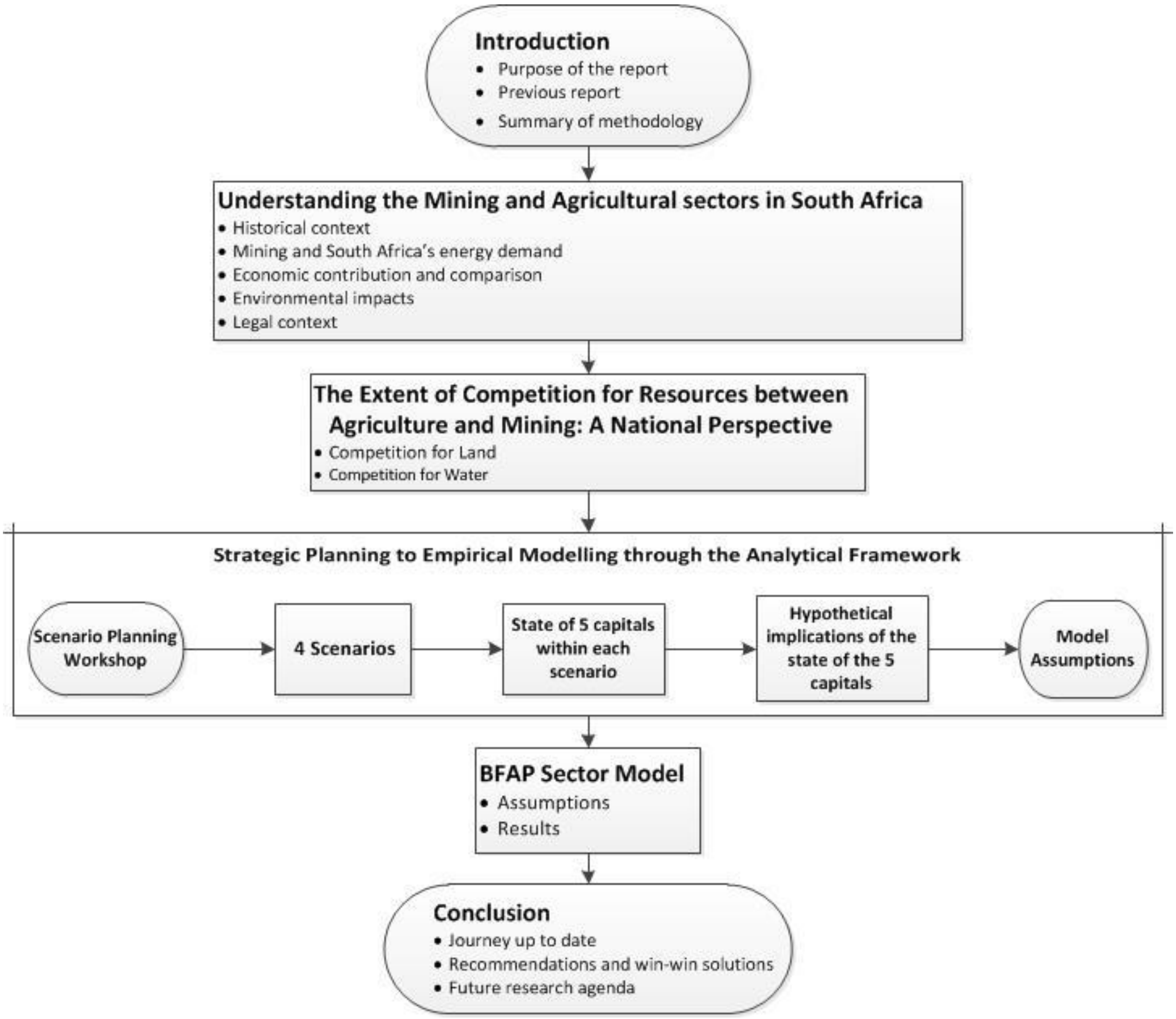


FIGURE 1 - THOUGHT PROCESS IN COMPILING THE REPORT

2 Understanding the Mining and Agricultural Sectors in South Africa

To evaluate the current and future coexistence of mining and agriculture in South Africa, it is helpful to orientate each of the sectors within the wider institutional context first. Consequently, this section offers a brief description of the historical, legal, economic and environmental context of the agricultural and mining sectors. Each of the latter perspectives provide some insight into the interdependencies and high-level drivers that will likely play a significant role in determining the scope for the coexistence of mining and agriculture as they face a resource-constrained future.

2.1 The Roles of Agriculture and Mining in the Development and Politics of South Africa

South Africa's economy has always been dominated by agriculture and mining. In 1912, just after the formation of the Union, the two sectors contributed 44% of GDP (agriculture 17% and mining 27%). By 1969 their relative shares were more equal, with agriculture contributing 10% and mining 12% for a combined contribution of 22% (Houghton, 1973: 259). Since then, agriculture has lost ground: its GDP contribution is now less than 3%, while mining still contributes some 9%.

But these two sectors have played a far more important role in the development of the South African economy than mere GDP numbers suggest. The discovery of diamonds and then gold on the Highveld at the end of the 19th century, the need to feed the rapidly growing urban population and the natural protection afforded to agriculture by the geography of the Highveld, and the institutional reactions of these two sectors shaped the path of South Africa's economic development, eventually giving rise to apartheid.

The great mineral discoveries of the late 1800s resulted in a rapid growth in urban population around first Kimberley and then Johannesburg. Bundy (1979) has shown how this triggered competition for the market amongst black and white farmers alike, both in producing the food and in transporting it to market. The farming constituency (which made up 15% of the economically active white population as late as 1950) reacted over the ensuing decades by lobbying for state support to white farmers, while farming among the other population groups was actively suppressed by the state in a number of different ways.

Historically, the political ties between agriculture and mining have waxed and waned. In the late 19th Century, for example, there was a political alliance between the Afrikaner Bond, the political home of the farmers of the Cape Colony, and Cecil John Rhodes whereby Rhodes secured the support of the Bond in Parliament in exchange for policies favourable to their interests (Tamarkin, 1996). These interests included support for an Afrikaans University, support to agriculture and restrictions on the expansion of the qualified vote to other population groups. Trapido (1978) characterised the political alliance between the Randlords of the Johannesburg gold fields and the largest Afrikaner farmers in the Transvaal and Free State Republics in the 1880s and 1890s as "an alliance between maize and gold". However, these alliances were both short-lived and could not withstand the pressure of the failed Jameson Raid (Morrell, 1988).

Notwithstanding, the similarities between the two sectors meant that they shared a wide range of interests. First, the resource base upon which both sectors were built is poor. In agriculture, the average yield of dryland field crops such as maize, wheat and soybeans is lower than in most parts of the world. For example, the industry average maize yield was below 2 tons per hectare as late as the

1990s, compared to 6 t/ha in the USA and 8t/ha in parts of Europe. The only reason why farmers could compete against imports was the high cost of transport from the harbours to the interior – the cost of transporting a ton of maize from the Gulf of Mexico to Durban is lower than from Durban to Johannesburg, regardless whether it is by road or rail. The grades of gold in South Africa are also much lower than the world average (e.g. Green, 1981). Of course, this is not the case with all of South Africa's vast mineral riches, but the fact of poor quality natural resources remains true.

Second, the conclusion was quickly drawn that cheap labour was necessary to extract profits out of these poor resources, this despite the fact that mining required proportionately more skilled workers than agriculture, at least until the large scale adoption of tractors and then combine harvesters after WWII. In agriculture most of the unskilled work was seasonal, while successive governments discouraged or prohibited black workers from remaining in the urban areas while at the same time they were encouraged (in large numbers) to work on the mines and the farms. This gave rise to the migrant labour system, which in turn resulted in the creation of the Bantustans from the 1950s.

Third, both industries are capital intensive, and part of the capital lies idle, not producing any cash return while it is being farmed or mined. In agriculture, of course, idle capital takes the form of land, which only produces a rent when the land is sold. In mining a large proportion of capital was also tied up in land until mineral rights were separated from land rights. But mines still have to hold on to vast reserves, which also do not produce a return until used.

Fourth, both sectors have experienced a decline in their contribution to GDP, as was seen earlier. This has affected their political power. The fact that the share of mining has declined far less is one of the reasons why the sector still carries a lot of political weight: agriculture started to lose its favourable political support around the early 1980s when Andries Treurnicht broke away from the ruling party of the time and took the lion's share of the white rural vote with him. Large scale commercial agriculture has virtually no political support in the current milieu in South Africa, while the rural, more subsistence orientated farming communities remain an important voting constituency for the ruling party. On the other hand, the mining sector has maintained its political clout: the uptake of mining shares by a new power elite made possible by i) the issue of share capital, ii) the unbundling of mines and iii) the internationalisation of mines by delisting in SA and listing abroad created opportunities for Black Economic Empowerment (BEE) that were not available to the agricultural sector. Furthermore, mine workers have long been unionised in South Africa while farm workers, like their counterparts in virtually every part of the world, are not.

Finally, both sectors have a considerable impact on the environment, but mining is an extractive industry, while agriculture, when properly managed, works with renewable resources. The environmental footprint of different mineral extraction processes differs – strip mining for coal is arguably more invasive than deep level mining - but the mining industry world-wide is known for its negative environmental impact. Likewise, conventional tillage crop production systems can erode topsoil considerably (le Roux et al., 2008). However, given mining's greater political power in South Africa, the playing fields are not level, as is attested by the amount of high potential agricultural land that has been lost to date.

Access to political power is probably the main differentiator between mining and agriculture in South Africa. Agriculture is a key to national and household food security, but mining works with a far more valuable commodity[1]. It is this political power that the agricultural sector has to contend with in the

[1] Maize sells for between R1500 and R3500 per ton, while strawberries sell for up to R30 000/ton at the farm gate, as opposed to gold, which sells for upward of R400 million/ton at present.

competition for land, and especially scarce high quality land.

2.2 Important Aspects of the Current Economic Environment

Section 2.1 showed that both mining and agriculture played an integral part in the economy, history and politics of South Africa. In this section, the latest trends in the agricultural sector, current institutional aspects of mining, and the contribution of mining and agriculture to the South African economy and South Africa's energy demand will be summarised.

2.2.1 Latest Trends in the Agricultural Sector

The agricultural industry has experienced major structural adjustments over the past few decades. The overall drive to increase productivity and to remain competitive in an open market can be found in two main phenomena, namely expansion and intensification.

This has especially been the case in the field crops and horticultural sectors. For example, the total maize area harvested has declined from 3.9 million hectares in 1994 to the 2.6 million hectares in the past season, yet the average total maize crop has increased to more than 11 million tons over the past five years. The reason for this is that yields have increased consistently as new technology was adopted mainly with respect to seed varieties (e.g. GM technology) and farming practices (e.g. rotational cropping and conservation practices). Furthermore, the area under irrigation also expanded by more than 50 000ha, which supported the overall growth in average yields. There has also been a general shift out of white maize towards yellow maize production as the growth in demand for feed has exceeded that for human consumption.

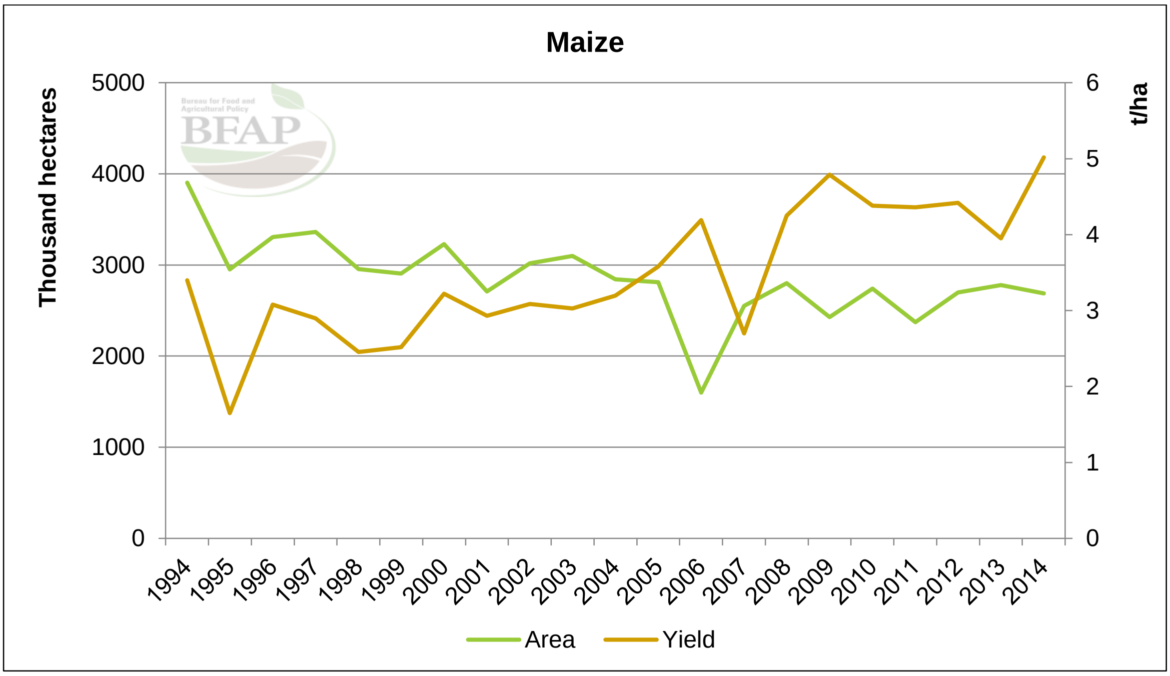


FIGURE 2 - MAIZE AREA AND YIELD
Source: BFAP, 2015

Apart from intensifying the maize industry, by producing more on less land, the field crops sector has also diversified by expanding the area under soybeans significantly in the summer rainfall regions and canola in the Western Cape. The increase in the area under production is supported by the rapid expansion in the processing capacity of these crops. It is expected that the total area under soybeans will increase to more than 1 million hectares by 2024. Figure 3 shows a spatial summary of area under dryland and irrigated cash crop production, overlaid with the national land capability.

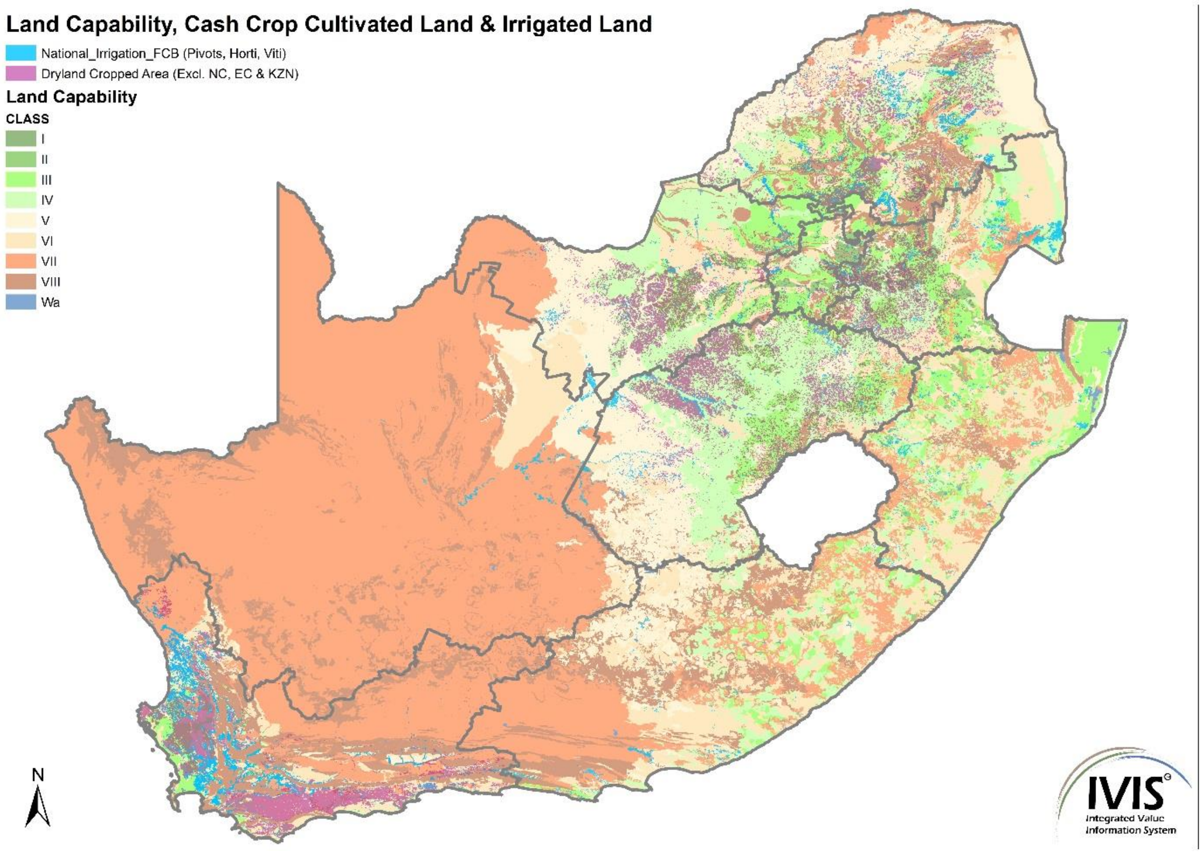


FIGURE 3 – NATIONAL LAND CAPABILITY, AREA UNDER DRYLAND CASH CROP AND IRRIGATION PRODUCTION

Source: AGIS (2008), DAFF (2014) & IVIS (2015)

AGIS (2008) identified 15 887 725 hectares[2] as having the potential to be cultivated or land in capability classes I-III, whereas the data gathered from Schoeman et al. (2002) presented in Table 1 below, is recalculated at 15 881 944 hectares.

[2] This figure was calculated from the land capability layer as presented by Schoeman et al. (2002). AGIS further went on to exclude the permanently transformed or built-up areas. They further excluded the land that falls outside agriculture according to Act 70 of 1970 (AGIS, 2008).

TABLE 1 - LAND CAPABILITY CLASSES PER PROVINCE

Province	High (II) capability arable land	% of Class	Moderate (III) capability arable land	% of Class	Combined (II & III)	% of Class
	Hectares		Hectares		Hectares	
Eastern Cape	78 787	4 %	1 191 729	9 %	1 270 517	8 %
Free State	12 701	1 %	2 241 476	16 %	2 254 177	14 %
Gauteng	389 310	21 %	704 595	5 %	1 093 905	7 %
KwaZulu-Natal	406 932	22 %	2 690 674	19 %	3 097 606	20 %
Limpopo	96 921	5 %	2 437 993	17 %	2 534 915	16 %
Mpumalanga	872 008	46 %	2 085 727	15 %	2 957 735	19 %
North West	21 941	1 %	1 755 342	13 %	1 777 283	11 %
Western Cape			895 808	6 %	895 808	6 %
Northern Cape						
Total	1 878 600		14 003 344		15 881 944	

Given the land capabilities and cropped area, Figure 4 shows the maize cropped area in South Africa.

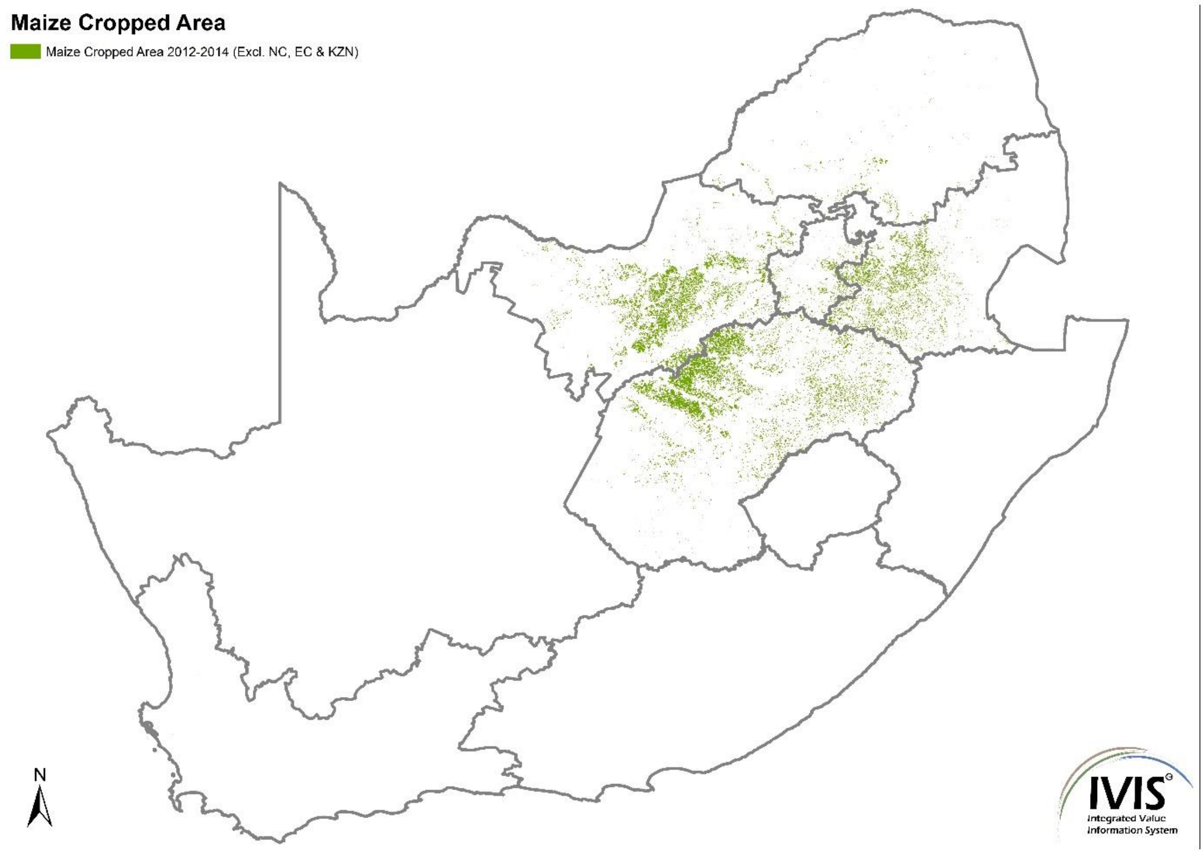


FIGURE 4- 2013/2014 MAIZE FIELD CROP BOUNDARIES
Source: DAFF (2014) & BFAP (2014)

2.2.2 Mining's Institutional Landscape

The institutional landscape of mining has changed fundamentally over the last two decades. This has both positive and negative implications for agriculture. At an industry level, the large and powerful companies that once dominated the mining sector in South Africa hardly exist today. At the time of the advent of democratic government in South Africa, six mining companies owned an estimated 70% of the formal economy in South Africa, including dominant positions in the food, beverage, and tourist sectors.

The decline of the mining sector has seen the larger mining groups (Anglo American, Goldfields, Glencore, BHP Billiton) relocate to other jurisdictions as well as the demise of four of the six pre-1994 major mining groups (Anglo Vaal, Rand Mines, Gencor and JCI). Many of the assets of these mining majors have reverted to inter alia small, often under-resourced black empowerment interests and foreign investors. The junior miners often do not have the institutional capacity to manage environmental rehabilitation and community relations to the same degree and effect as the larger companies.

2.2.3 The Interplay between Mining and Agriculture

The conjunction of mining and agriculture forms the basis of human survival and societal development, and the argument of the anti-mining lobby that mining as an activity should be eliminated is not realistic. In order to resolve the conundrum of the competition (as opposed to collaboration) between mining and agriculture one needs to restrict the debate to the basic natural resources of land, water and clean air, while not losing sight of the intricacies of this symbiotic interplay between mining and farming as this is not a zero sum game.

While there appears to have been a focus on the coal sector with regards to competition between agriculture and mining for land in the coal belt spanning Emalahleni, Middelburg and Ermelo in Mpumalanga, to confine the interrogation to the coal sector would be misguided. The relationship between farming and mining is much more intricate.

The ability of mining to catalyse the establishment and development of commercial agriculture and the agricultural value chain can be defined in a number of ways, including *inter alia:*

- Leveraging mining infrastructure for lowering the barriers to entry and operating costs for farming in areas where there is mining activity (transport, bulk infrastructure, social, commercial, industrial and administrative infrastructure);
- Use of mining surface rights for farming (mining companies typically have large areas of land holdings that are secured for health, safety and regulatory reasons);
- The economic multipliers of mining serve to spawn secondary and tertiary sectors that support commercial agriculture;
- The use of pumped mine water for agricultural purposes (cheap, treated water);
- Mined intermediate inputs for agriculture (phosphates, lime, trace elements);
- The ready access to domestic supplies of intermediate inputs for primary agricultural and ingredients and packaging for the beneficiation of agricultural product; and
- The provision of grid-based energy from coal mining.

On the other hand, the inevitable tenets of conflict between the two sectors are, *inter alia*:

- Aggregate disruption of land-use by mining vs chronology of land restoration and the net sterilisation of arable agricultural land by mining
- Competitive water use allocation vs the obligation of mines to treat run-off mine water to

standards of utility suitable for agriculture

- Contamination of ground and surface water sources by mining activity
- Dust and other airborne emissions and their impact on the quality of agricultural produce, particularly deciduous fruit, citrus, bananas and table vegetables;
- The respiratory and oncological health threats to farmworkers resulting from airborne emissions from mines;
- Competition for unskilled and semi-skilled labour and the discrepancy ratio between mine wages and farm wages;
- Differential levels of labour organisation between the two industries; and
- Destruction of roads by heavy vehicles transporting bulk materials.

The area affected by mining is a multi-layered problem. In Figure 5, the pink areas represent the visible footprint (or surface mining activity) of mining from the National Land Cover database (NLC) 2013/2014 (DEA, 2015). Land previously registered as farms that are currently owned by mining companies are shown in yellow-brown. The grey area represents the various mineral seams from the Council for Geoscience database (CGS, 2010). Note, however, that there are inconsistencies in this data: some mining activities (ownership and surface activity) are taking place beyond mineral-seam areas, while the visible mining footprint does not account for underground mining and it is known that agriculture does take place on some of these mine-owned farms. Section 3 deals with these issues in more detail. In order to give a clearer illustration of this problem, we have included Figure 6 which looks at Mpumalanga only.

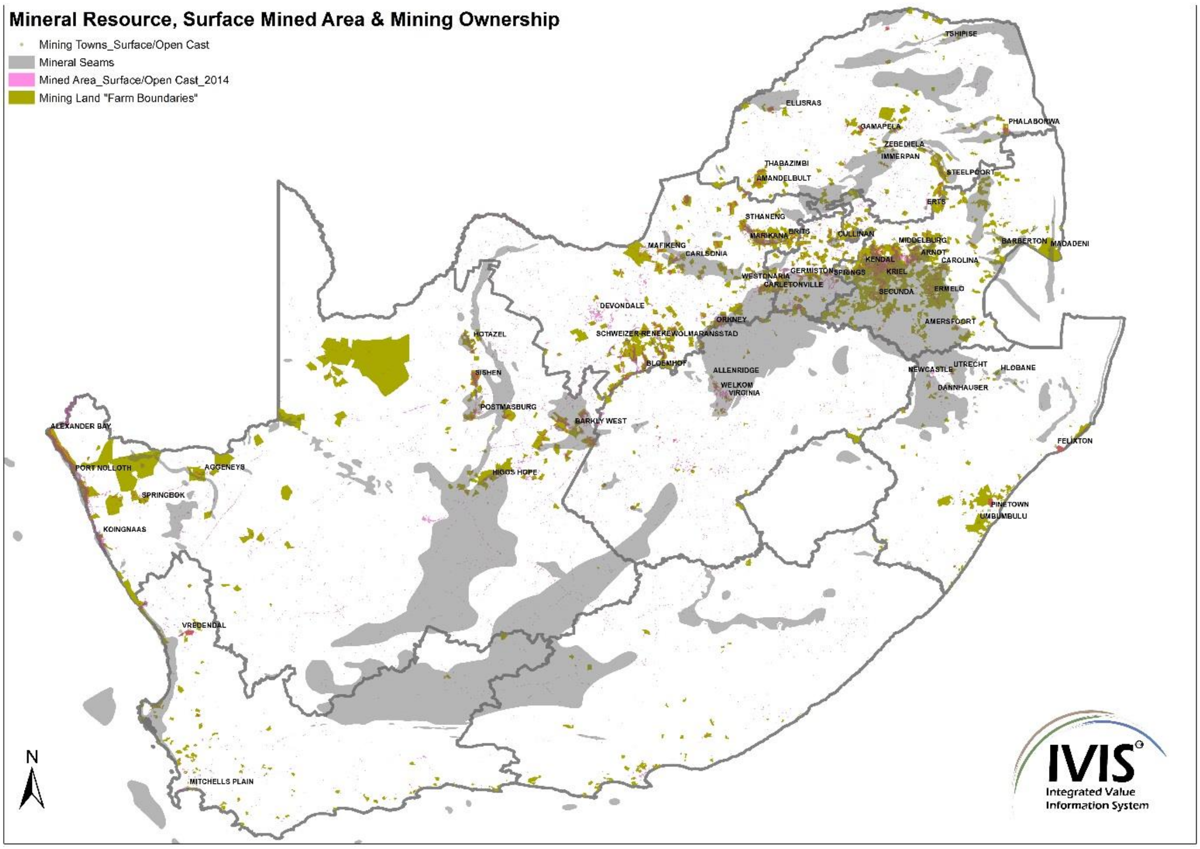


FIGURE 5 - MINING LAND COVER AND MINERAL POTENTIAL

Source: DEA (2015), DMR (2015), Council for Geoscience (2013) & IVIS (2015)

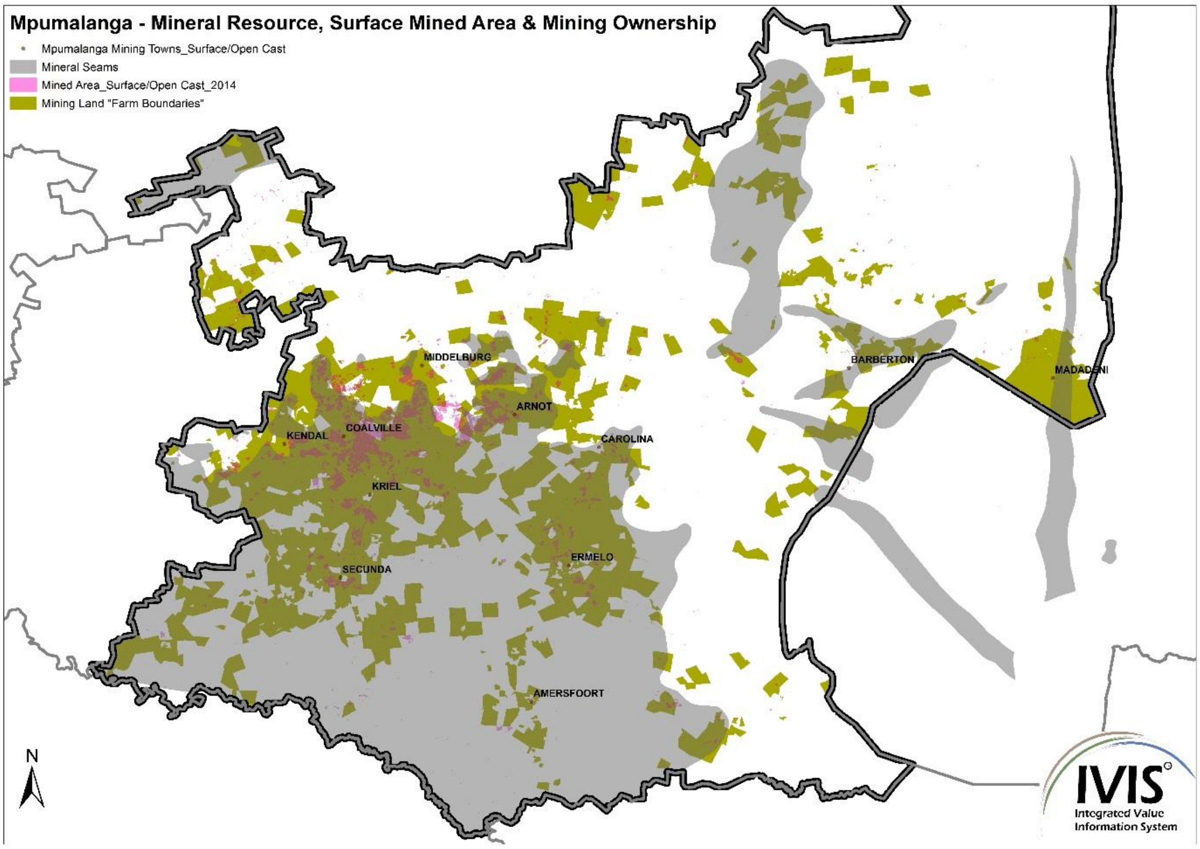


FIGURE 6 - MINING LAND COVER AND MINERAL POTENTIAL: MPUMALANGA
Source: DEA (2015), DMR (2015), Council for Geoscience (2013) & IVIS (2015).

It is clear from these maps that the true footprint of mining is hard to quantify: visible land cover classified as mining is only a fraction of the land owned by mining companies. Furthermore, transport and manufacturing plants related to mine commodity beneficiation are not necessarily classified as visible mine footprint but would not be in a certain spatial position if it were not for mining activities.

2.2.4 Meeting the Country's Energy Demand

South Africa produces an average of 224 million tons of marketable coal annually, making it the fifth largest coal producing country in the world. The country exports about 25% of this production and is the third largest coal exporting country globally. Of the domestic consumption, 53% is used for electricity generation by Eskom, the 7th largest electricity generator in the world.

At the same time mining has always been a driver of electricity demand and hence capacity in the power sector, and concomitantly this has driven the demand for coal. Eskom built a large number of power plants between 1960 and 1980 to meet the increased demand from the rapid development of deep level gold mining and the concurrent expansion of the steel and base metal sectors over that period. However, with the new capacity and the onset of the decline in the deep level gold mining sector during the 1980s and 1990s, the resulting excess in capacity led to the mothballing of some plants and the sale of electricity at very low rates to industrial consumers such as the aluminium producers in Richards Bay. As a result of this oversupply the construction of new power plants was held back for two decades. The rapidly growing demand for mineral commodities from 2000 (owing to significant Chinese economic growth) reversed this situation and by 2008 reserve margins of electricity supply fell to critical levels resulting in major blackouts across the country.

With the onset of the power crisis in South Africa in 2005-2008, Eskom and the Department of Energy had launched the New Build Programme which evolved into a comprehensive recovery plan, the Integrated Resource Plan 2010-2030 (the IRP) which was released in March 2011 and updated in 2013. The updated 2013 IRP is discussed in Box 1.

BOX 1: INTEGRATED RESOURCE PLAN

The IRP (DOE, 2013) details an integrated long-term strategy on energy generation and distribution up to 2030, and also provides various generation-mix scenarios up to 2050. The report placed particular emphasis on moving towards a greener economy in the long run. Given certain planned developments the strategic role of coal in South Africa is unlikely to reduce significantly in the foreseeable future. That said, coal as a source of energy has dropped from 90% to 77% over the last decade, so renewables are making a significant impact.

The 2013 report update lowered the anticipated 20 year projection of required capacity to 2030 by 6 600 MW with demand to 2030 being between 345 TWh and 416 TWh. Translated to capacity this effectively means a reduction in the country's aggregate capacity from 67 800 MW to 61 200 MW based on a planned GDP growth target of 5.4%.

As the country's GDP growth has not reached these anticipated targets, these demand projections could be further reduced. The original 2011 IRP had indicated that 11 400 MW of nuclear capacity (including Koeberg) would be required by 2030, with the first 1 600 MW of a larger 9 600 MW fleet being integrated from 2023. Under lower demand growth conditions, the IRP does not foresee a need for nuclear baseload until after 2035.

The 2013 revision provides for less coal, hydropower and wind, but more gas, solar photovoltaic (PV) and concentrated solar power (CSP) capacity. In the revised IRP, new coal generation capacity is reduced from 6 250 MW to 2 450 MW, while electricity from closed cycle gas turbine and open cycle gas turbine capacity is increased to 3 550 MW and 7 680 MW respectively. Hydropower imports are projected at 3 000 MW while solar PV and CSP is increased to 9 770 MW and 3 300 MW respectively. The allocation for wind falls from 9 200 MW to 4 360 MW.

The 2013 Revised IRP does anticipate the construction of a fleet of 1 000 MW and 1 500 MW of fluidised bed combustion coal plants using primarily feedstock from discard coal. The plan is supportive of regional hydropower, gas and coal projects and stepped up exploration for shale gas in South Africa.

Government is supportive of the current renewables programme with additional yearly private project increments of 1 000 MW of photovoltaic capacity, 1 000 MW of wind capacity and 200 MW of CSP capacity being planned.

Coal has been the primary source of energy supply for the country from 1880 when coal from the Vereeniging area was supplied to the Kimberley diamond fields. Currently between 77% - 85% of the power generated in South Africa is coal based (DOE, 2015). By contrast less than 1% of South Africa's electricity is derived from renewables. The renewable energy industry in South Africa is relatively undeveloped in comparison to the rest of the world, but the reality is that there are significant technical and regulatory barriers to its replacing coal in the short to medium term. Given the nature of long term contracts tying some coal mines to supplying Eskom the country will in all probability continue to rely on coal-fired power stations for the next 30-50 years. According to the Department of Energy, coal can be expected to remain the dominant source of electricity generation in

South Africa until at least 2030. The resources of near surface coal are extremely limited and as 60% of South Africa's remaining coal resources are underground, there will be a progressive shift from open cast mining to underground mining**.**

The negative impact of coal mining on agriculture therefore shifts from large-scale disruption of the surface areas in farming districts to a more contained physical disturbance in the form of discard dumps for the processing facilities linked to underground mines. Underground mines do however often result in subsidence of the surface topography which presents different challenges to the farmer. The issue of ground water sulphide contamination and the resultant percolation of acid mine drainage into river systems tends to be more severe from underground mines than it is for open cast mines. A coal-free energy supply is unfortunately not an economically viable option in the near term. The agricultural sector will consequently have to live with competition for resources from coal mines for the next two decades at least.

2.2.5 Contribution by Mining and Agriculture

Mining is South Africa's largest foreign exchange earner and has positive economic externalities on rural areas due to the development of electricity and road infrastructure to and from the mining sites. The agricultural sector acts as a supplier of food, earner of foreign exchange and the largest primary sector employer of the South African workforce. By implication, the two sectors contribute significantly to the supply of basic needs to South African society: access to markets, electricity, and affordable food. Agriculture and mining are also major users and thereby stewards of two critical natural resources: land and water.

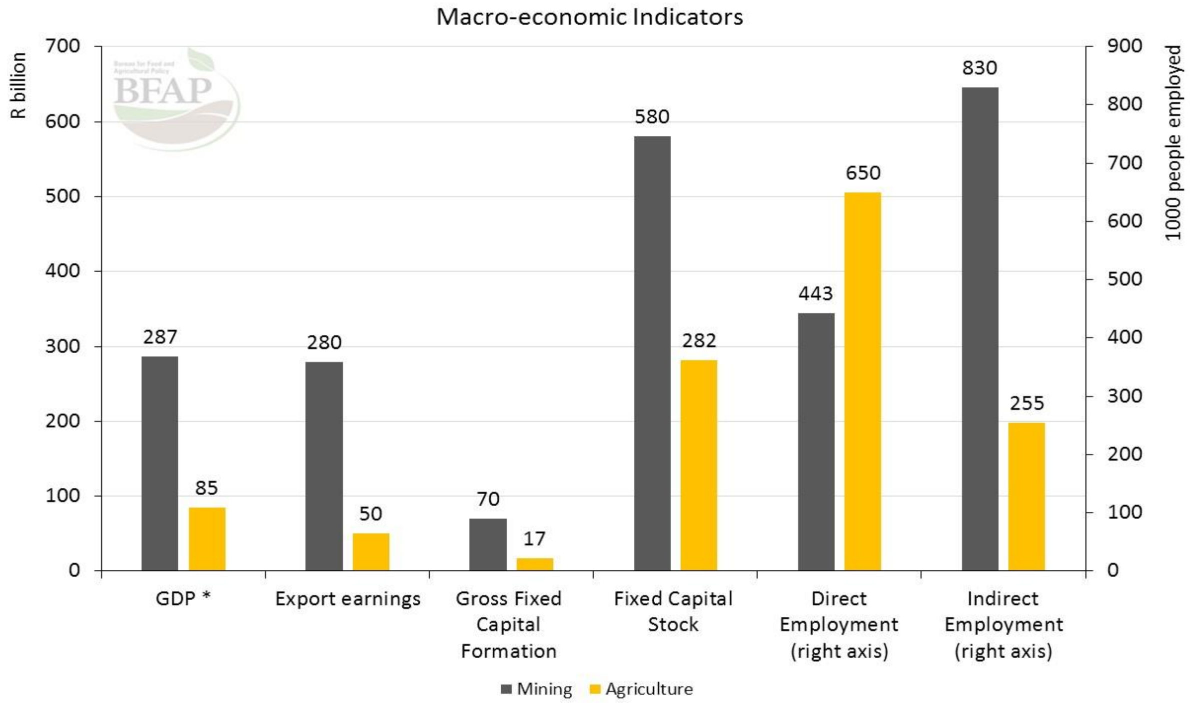


FIGURE 7- AGRICULTURE AND MINING ON KEY ECONOMIC INDICATORS

Source: SARB (2015), DAS (2014), COMSA Facts and Figures (2015), StatsSA QLFS (Q1, 2015)

The indicators to be considered in the measurement and comparison of mining and agriculture's contribution to the South African economy include contribution to GDP, employment, export earnings, gross fixed capital formation and fixed capital stock held by each sector. The indicators are summarised in Figure 7. In 2014 the mining industry contributed R286.61 billion to the national GDP (8.4%) while agriculture (Agriculture, Forestry and Fisheries) contributed only R84.66 billion (2.5%). In Box 2, the income generated by agriculture is explained in more detail. The current contribution to GDP by the two sectors is less than a third of what it was in 1912: 27% mining and 17% agriculture.

BOX 2: AGRICULTURE'S INCOME CONTRIBUTION BREAKDOWN

The total net farm income in real terms that is generated by the agricultural industry has increased significantly over the past two decades. It can be classified into three main sectors, namely animal production, horticulture and field crops. Historically, animal production has contributed the largest share to total agricultural income and this is expected to remain unchanged in future (Figure 8). Traditionally, the net income from animal production was followed by field crops and lastly horticulture. However, when international markets opened up for exports after 1994, the horticultural sector expanded rapidly and the depreciation in the exchange rate boosted the revenue in export markets. Income from horticulture increased to such extent that over the last decade it has exceeded that of field crops in most of the years. From Figure 8 it is also evident that the income generated by field crops is significantly more volatile compared to the other sectors due to the weather and more volatile grain and oilseed prices. In fact, all the major swings in the income from agriculture are induced by the field crops sector. This is again illustrated by the impact of the current drought that has slashed the yields of summer crops and the most recent statistics report a negative growth rate for agriculture.

Assuming normal weather conditions, real net farm income remains under pressure in the near term; while some recovery is evident in 2016 due to improved production volumes, stagnant commodity prices and the reversal of the declining trend in input costs will continue to put margins under pressure. The outlook for animal production is more positive given the favourable feed ratios and continued increase in per capita protein (mainly chicken) consumption. The same can be said for the horticultural sector given the continued depreciation in the value of the Rand, which will offer some support to domestic price levels and the expectation of increased export volumes. Real net farm income is anticipated to recover, increasing gradually from 2017 towards 2024, where the highs of 2014 will again be matched

BOX 2 CONTINUED..

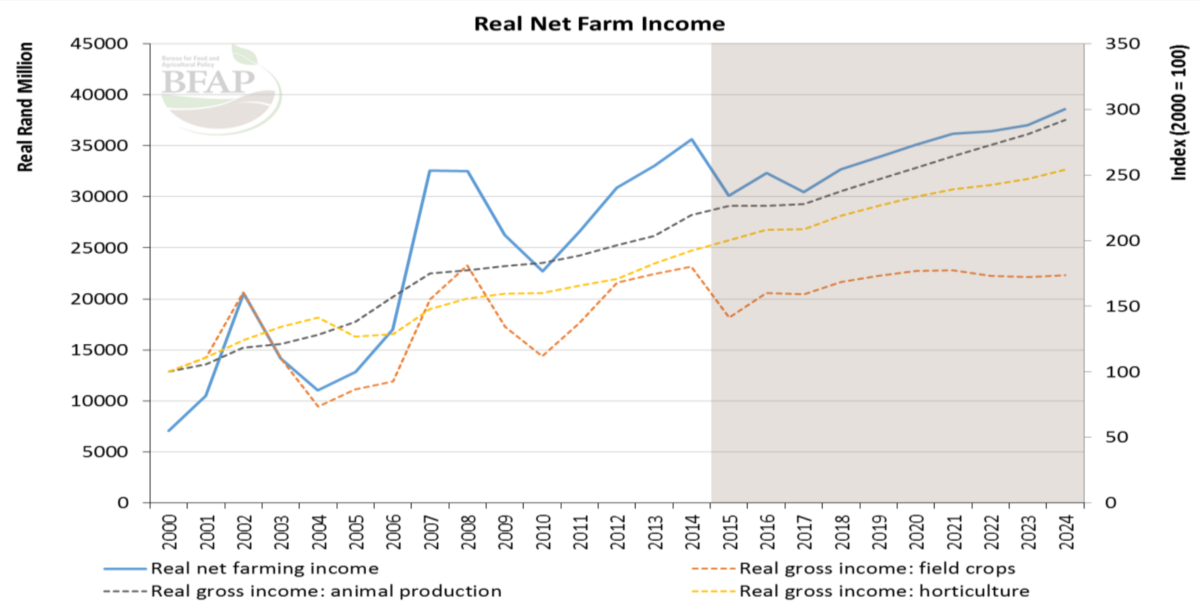


FIGURE 8 - HISTORIC AND PROJECTED REAL NET FARM INCOME (2000 TO 2024)
Source: BFAP Baseline 2015

It is often argued that the two sectors' contributions are significantly increased by adding contribution to GDP by the processing industries of both mining and agriculture. Greyling (2012) however states that this so-called market contribution (production linkages within the economy) of the agricultural sector decreased and that together with these linkages, the agricultural sector still contributed less than 10% to the national GDP in 2010 (Greyling, 2012). A decreasing contribution to national GDP of the primary sectors however, is common as economies develop.

Now considering capital and labour productivity indicators expressed as ratio of value added by the respective sectors to total fixed capital stock and number of workers directly employed. The results, summarised in Table 2, show that the mining sector's labour productivity is significantly higher than that of the agricultural sector: the value added per worker is more than 5 times higher. As mentioned in section 2.1, both sectors are relatively capital intensive with assets (like land) not actively producing a cash return. Per Rand invested, the agricultural sector creates three times more jobs compared to the mining sector, but it cannot afford "mining sector wages" given the lower value added per worker.

TABLE 2- FACTOR PRODUCTIVITY OF THE AGRICULTURAL AND MINING SECTORS

	Agriculture	**Mining**
Labour Productivity	R130 246.20	R646 975.20
Capital Productivity	0.30	0.49

Source: Own calculations based on SARB (2015), DAS (2014), COMSA Facts and Figures (2015), StatsSA QLFS (Q1, 2015)

Both the agricultural and mining sectors are major primary sector employers of the South African workforce. Some 650 thousand South Africans are directly employed by the agricultural sector (Figure 7) and value of R130 246 is added per worker whereas the mining sector adds almost 5 times that at R646 900 and employs 443 thousand workers directly. Agriculture is more labour intensive than mining and is therefore recognized by government as a key sector for job creation.

Indirect employment through agriculture and mining amounts to 255 and 830 thousand workers respectively. This indicator however, is difficult capture to accurately and may be biased: these numbers have been sourced from BFAP and COMSA respectively, institutions inherently biased to some degree toward the sectors they represent.

Figure 9 shows that over the past decade the number of workers employed in agriculture has decreased[3] and for mining the number of employees has slightly increased. As agriculture becomes mechanised the unskilled labour force is replaced by a smaller skilled labour force. The unit cost of labour (the labour cost of producing an additional Rand of farm output) has also decreased by 70% since 1993.

South Africa's mining labour costs are currently among the highest globally, contributing 45% to total mining expenses on average and above 50% for deep-level underground mines (PWC, 2013). In the light of labour unrest, multi-year wage agreements are likely to continue pressurizing margins. The relationship between mining companies and trade unions is also strained.

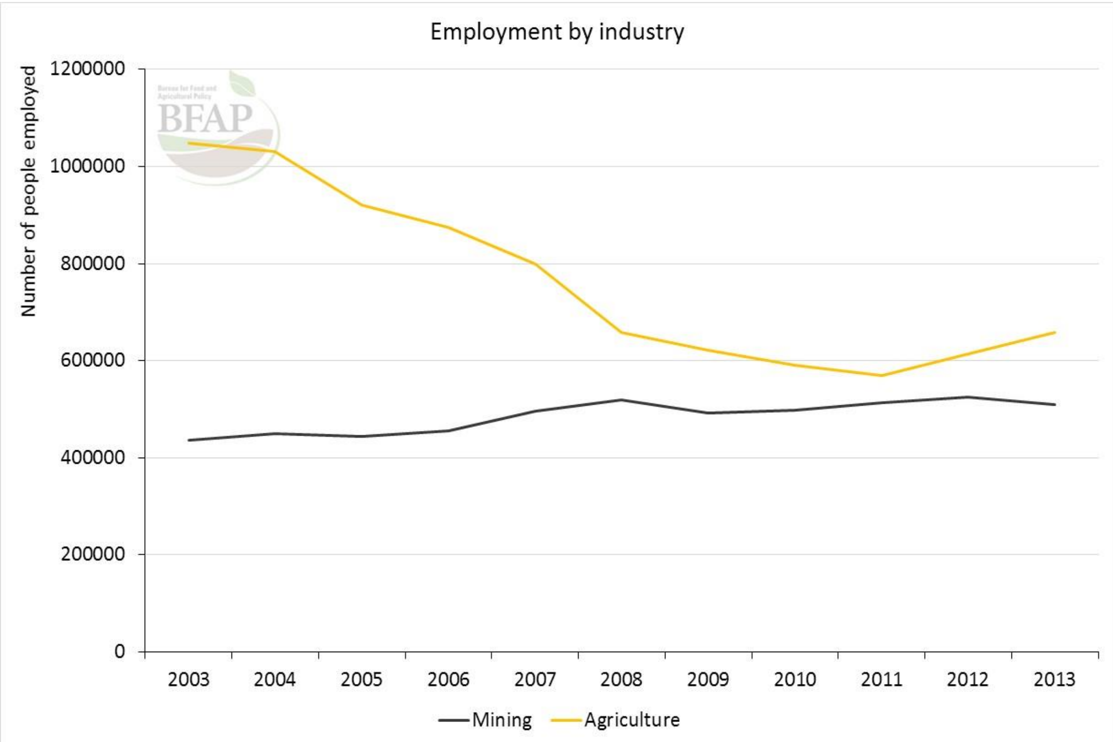


FIGURE 9- EMPLOYMENT BY SECTOR
Source: COMSA (2015), DAS (2015)

[3] The most recent data show an increase, which may be the result of an increased area under irrigation, but is still too short lived to draw meaningful conclusions)

The mining sector earned R69.5 billion through exports in 2013 (30% of total South African exports) while the agricultural sector only earned R17.5 billion, 5% of total exports (Figure 7). Even though higher value agricultural products like wine and fruit constitute a significant share of exports, basic food stuffs like wheat and chicken are imported and effectively afforded through earnings from the previously-mentioned net export commodities. The agricultural and mining sectors have maintained a positive trade balance throughout history. The top net exporting commodities in both the mining and agricultural sectors in 2014 are shown in Figure 10. Platinum, iron and steel, coal, gold, diamonds and some other metals represent 33.35 percent in value of all South African merchandise exports. On the other hand, citrus, wine, grapes, maize, apples and pears and some other high value fruit represent 4.32 percent in value of all the agricultural products exported by South Africa. The difference in the value of products produced by the two sectors is illustrated in Table 3.

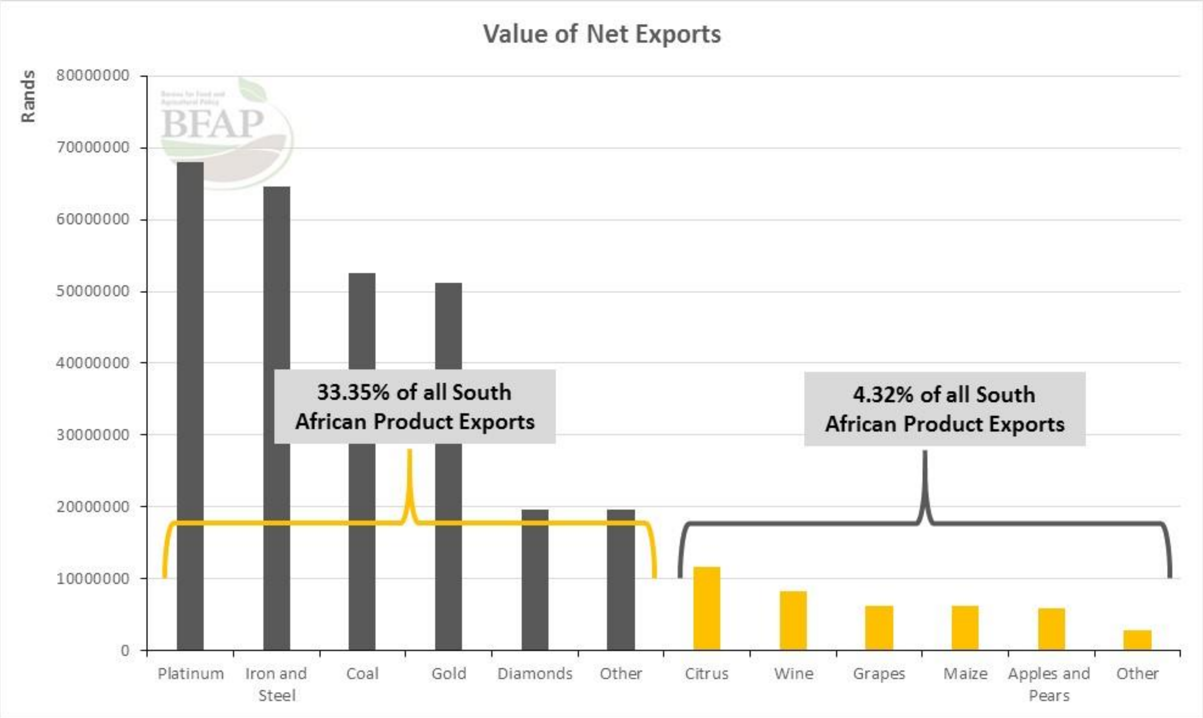


FIGURE 10 - VALUE OF TOP 5 NET EXPORTING COMMODITIES PER SECTOR
Source: ITC – Trademap (2015)

TABLE 3- UNIT VALUES OF TOP EXPORTING COMMODITIES

Agricultural Commodity	Unit value 2014 (R/ton)	Unit value 2014 (R/ton)	Mining Commodity
Grapes	R18 852.00	R10 445 000 000.00	Diamonds
Wine	R17 745.00	R437 401 242.00	Gold
Apples and Pears	R9 992.00	R317 207 308.00	Platinum
Citrus	R6 680.00	R715.00	Coal

Source: ITC – Trademap (2015)

Table 3 illustrates the fact that mining commodities are substantially more valuable than the highest-value agricultural commodities (with the exception of coal); which contributes to the political power mining possesses over agriculture, as previously mentioned in section 2.1. Given the indicators discussed above, agriculture and mining both contribute significantly to the South African economy. This section is not aimed to motivate favouring one sector above the other, but rather to demonstrate the significant contributions both sectors have and recognizing that both are vital. The fact that both agriculture and mining significantly contribute to the South African economy does however not eradicate their competition for the country's valuable scarce resources. The case study in Box 3 illustrates the long term economic realities of a mine and a farm on a given piece of land.

BOX 3: CASE STUDY COMPARING LONG TERM FIGURES FOR A COAL MINE AND A FARM

Mine X wishes to operate an open-cast coal mine in Mpumalanga. The total area of the proposed mining area is about 50ha and a further approximately 250ha will be directly affected by the mining operations. The mining footprint therefore affects 300ha of farm land, not a large amount by South African commercial farming standards. The agriculture area is referred to as Farm Y. The directly affected area is used for livestock grazing while closely adjoining areas of land are used for dryland production of maize, dry beans, soya and some potatoes. Agricultural production in this area is far higher than both national and/or regional averages due to good quality soils, high rainfall, and the use of precision farming techniques. Given this background, how do the numbers compare? Can agriculture, under these favourable conditions, compete with mining?

Table 4 provides a snap-shot of high-level inflation-adjusted data as well as the results of the two operations. It should be noted that the best possible case for all the agricultural production systems has been used in this analysis and not the conventional base case scenarios. It should further be noted that the results in Table 4, as indicated in the two left hand side columns, are shown over a 5 year period for Mine X and over a 50 year period for Farm Y. The farming operation's footprint is over 300ha, whereas that of the mine is over 50ha.

While the outcome of the financial analysis presented here clearly favours mining above that of the next possible land use, which is that of continued farming, the question does arise, is this alternative development appropriate? Does it necessary imply that if the financial evaluation favours one option that such an option should be the desired land-use option?

Clearly the answer to these questions cannot be a *carte blanche* yes because, among others,

i) The externalities have been excluded from this analysis, and
ii) The regional impacts of the mining operation have been excluded.

We address these two issues briefly below.

The externality effects relate to, among others, water use and pollution, noise and dust pollution, the emission of greenhouse gases, impacts on biodiversity and land use, the loss of food production, and the social impacts on household destabilisation through migrant labour, etc. By excluding the externality effects, and thus only focussing on the contribution to the financial capital and not the natural and social capital, the analysis is not only partial, but also biased. Unfortunately, this is the way in which most analyses of this kind are conducted. Clearly this is not a tenable situation. Neither is it in the best interest of the country to exclude externalities in the valuation process since the mine operation compromises not only current, but also future food production possibilities and the health and livelihoods of people and fauna and flora alike.

BOX 3 CONTINUED..

TABLE 4 - SALIENT FACTS OF THE MINING OPERATION OF MINE X ON FARM Y (INFLATION ADJUSTED FIGURES, 2014 = 100)

		Mine X	Farm Y: Best case scenarios				
			Maize	**Soya**	**Potato**	**Dry bean**	**Beef**
Footprint	ha	50	300	300	300	300	300
Capital cost	Rmil	R39.0	R0.0	R0.0	R0.0	R0.0	R0.0
Operational cost	Rmil/yr over 5 yrs for Mine X and over 50 yrs for Farm Y	R1 026.8	R4.1	R1.9	R28.7	R3.6	R 3.9
Gross revenue	Rmil/yr over 5 yrs for Mine X and over 50 yrs for Farm Y	R1 368.8	R10.5	R2.4	R35.9	R4.5	R 4.8
Net return over 5 yrs for Mine X and over 50yrs for Farm Y	NPV (Rmil) @ 6% discount rate	R1 322.5	R100.9	R7.9	R113.5	R14.2	R14.2
Net return over 5 yrs for Mine X and over 50yrs for Farm Y	NPV (Rmil) /ha over 5 yrs for Mine X and over 50 yrs for Farm Y	R26.45	R0.34	R0.03	R0.38	R0.05	R0.05
Net return per year	NPV R/ha/yr	R5 289 869	R6 725	R525	R7 566	R946	R946
Comparative financial impact	Soya = 100%	1,006,836%	1280%	100%	1440%	180%	180%
Employment	Jobs per year (total, including indirect effects)	15 210	179	83	1 197	148	180

2.3 Agriculture, Mining and the Environment

Natural resources are a common factor of production for both the mining and the agricultural sectors. Therefore, it is not surprising that the availability and quality of natural resources are especially influential in how mining and agriculture interact. Yet, the natural environment performs many more functions for society than simply acting as a resource base for production. In light of the broader issue of national security, it is also important to consider the environmental impacts of both the agricultural and mining sectors which have far reaching implications for the functioning and resilience of socio-ecological systems.

This section briefly outlines a few characteristics of the natural environment in which mining and agriculture operate in South Africa, as well as providing an overview of some of the major environmental impacts of each of these sectors. However, there is a wide range of environmental factors that are directly or indirectly associated with the mining and agricultural sectors. Given the scope of this report, we have limited our focus to natural resources which are primary inputs into both agriculture and mining. In particular, we have focussed on water supply and quality, as well as the integrity of land (with a particular focus on soil quality).

2.3.1 Water Resources

2.3.1.1 Water Availability and Regulation

South Africa is a semi-arid country that receives a mean annual rainfall of approximately 500 mm/annum; substantially less than the world mean annual rainfall of 860 mm/annum. However, South African rainfall is characterised by significant spatial variability, with some parts of the Northern Cape receiving less than 100 mm/annum, while parts of the KwaZulu Natal, Mpumalanga, and Limpopo provinces receive more than 1 200 mm/annum. As a result, there are large regional differences in terms of access to terrestrial water in South Africa. Variable access to water is also exacerbated by the seasonality and within-season variability of rainfall, as well as regional differences in terms of water infrastructure development and neglect. Groundwater is also used to augment terrestrial supplies, but water supply potential per capita is still only approximately 1 100 m^3 per annum, which is fractionally more than the international water scarcity threshold of 1 000 m^3 per annum.

The first National Water Resource Strategy[4] (NWRS1) showed that, in the year 2000, almost all of the available water yield[5] was fully allocated and more than half of the water management areas in the country were experiencing net water deficits (Figure 11) (DWAF, 2004). Figure 11 also indicates the limited opportunities for developing water infrastructure as a means of reconciling supply and demand. South Africa's developed water resource potential in the year 2000 was about 13 227 million cubic meters per annum, with a remaining economic development potential of only 5 400 million cubic meters per annum, primarily in the uThukela, Mzimvubu and Pongola basins, which are located

[4] The National Water Resource Strategy (NWRS) represents the South African government's official views, objectives and strategies related to the water sector. The relevant Minister is required to update the NWRS at least every 5 years. To date, two strategies have been published; the first in 2004 (NWRS1) and the second in 2013 (NWRS2).

[5] The figures given in the NWRS1 are not absolute amounts but rather reflect water available at a 98% level of assurance.

remotely from existing demand centers (DWAF, 2004).

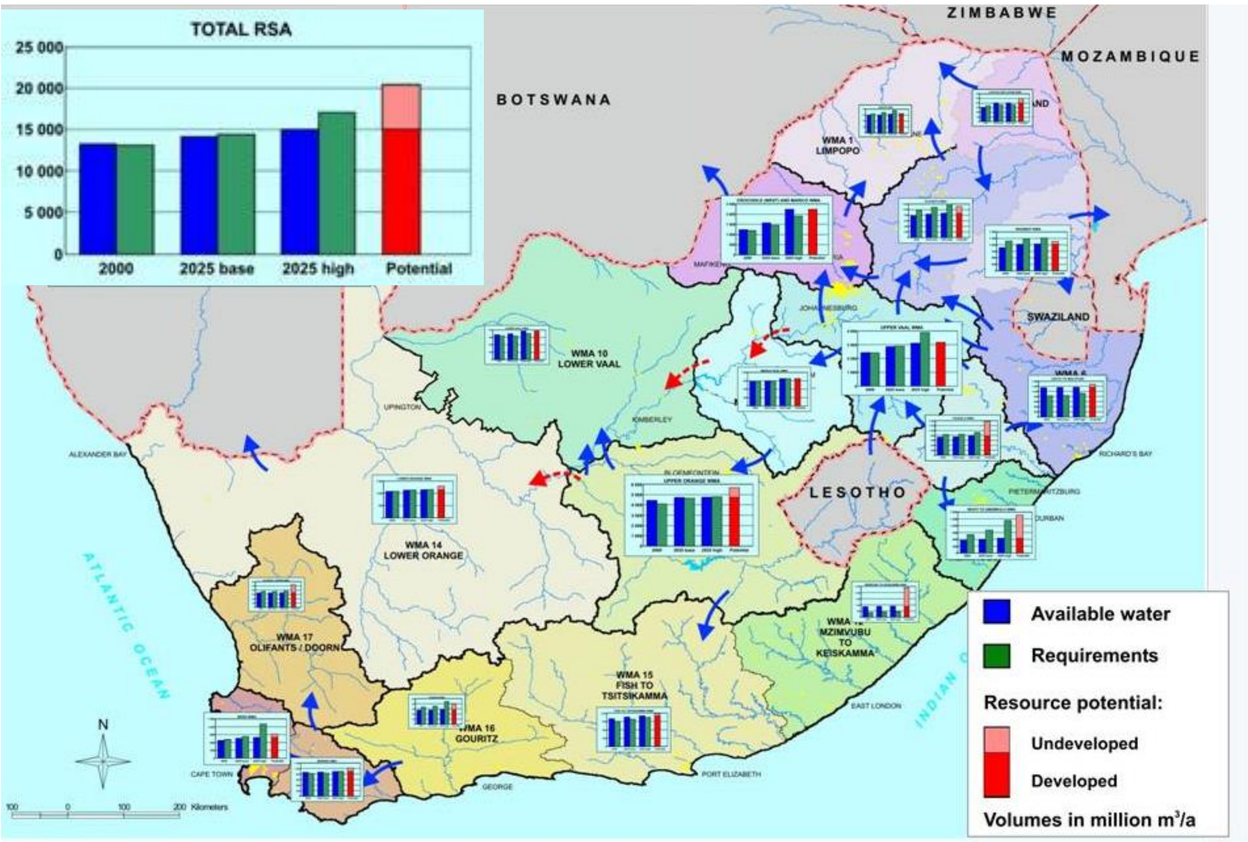


FIGURE 11- THE WATER BALANCE IN 2000 AND PROJECTED TO 2025
Source: DWAF, 2004

Gauteng houses the only large metropolis in the world that was not situated on a coast, a navigable river or some other sustainable water source. This is largely the result of the rapid establishment and expansion of surrounding mining towns during the 19th century gold rush. As a result, numerous inter-basin transfer schemes had to be developed to bring water from catchments with water surpluses to catchments with water deficits in the central Highveld region. The water transfers are indicated by the arrows in Figure 11 (these also include major water imports from neighbouring Lesotho by a phased implementation of the Lesotho Highlands Water Project). While additional water transfers are being planned, these are very costly and are generally not affordable for the agricultural sector and low value mines.

Without serious water conservation and water demand management interventions, the water demand will exceed the national available yield by 2025. Both the mining and agricultural sectors may face water allocation reforms and will increasingly have to balance their water needs from water re-use and water savings (DWA, 2013). South Africa's weather is cyclical and characterised by periodic droughts and floods which are exacerbated by climate change. Climate models indicate that South Africa can expect an increase in mean average temperatures and fewer rainfall days per year, coupled with more extreme rainfall events (such as floods and droughts) over the next century (DEA, 2013a).

In the context of variable water supply and increasing water scarcity in South Africa, the legislative and policy environment for water resources has undergone tremendous change in the last two decades. The cornerstone of South Africa's reformed approach to water resource management is the National Water Act (NWA) (Act 36 of 1998). Box 4 reviews some of the regulatory and institutional arrangements for water resource management as they exist under the NWA. Further aspects of environmental legislation, particularly as they relate to mining, are also explored in section 0.

BOX 4: THE NATIONAL WATER ACT

Under the South African Constitution, all citizens have the right to adequate food and water, as well as to a safe and protected environment which benefits both current and future generations. The NWA is a major component of the legal framework which enables the provision of these constitutional rights. In particular, the NWA focusses on the use, development, conservation, management and control of water resources. The NWA works in conjunction with the Water Services Act (108 of 1997) which stipulates how local government should supply water and sanitation services for municipal water users.

The guiding principles of the NWA are sustainable, equitable and efficient management and use of water resources. As such, the NWA represents a number of key differences to earlier water legislation. For instance, the NWA has replaced previous riparian water rights (which were linked with ownership of adjacent land) with allocated water rights (which vests the ultimate authority over water use and allocation with the state). The NWA also stipulates that a proportion of water available (known as 'the Reserve') must be kept in rivers to meet minimum requirements for the ecological integrity of water systems and basic human needs.

According to the NWA, water management responsibilities are delegated to local institutions known as Catchment Management Agencies (CMAs) which oversee a defined Water Management Area (WMA). Under NWRS1, the country was divided in 19 WMAs. However, due to limited capacity and poor functioning of most CMAs, the WMAs have recently been consolidated into nine larger areas as shown in Figure 12. The NWA also allows for the establishment of Water User Associations (WUAs) which represent single- or multi-sectoral water users who work together in water-related activities at a local level to achieve a common interest. For instance, irrigation boards will be converted to WUAs. CMAs and WUAs are expected to work together closely.

BOX 4 CONTINUED…

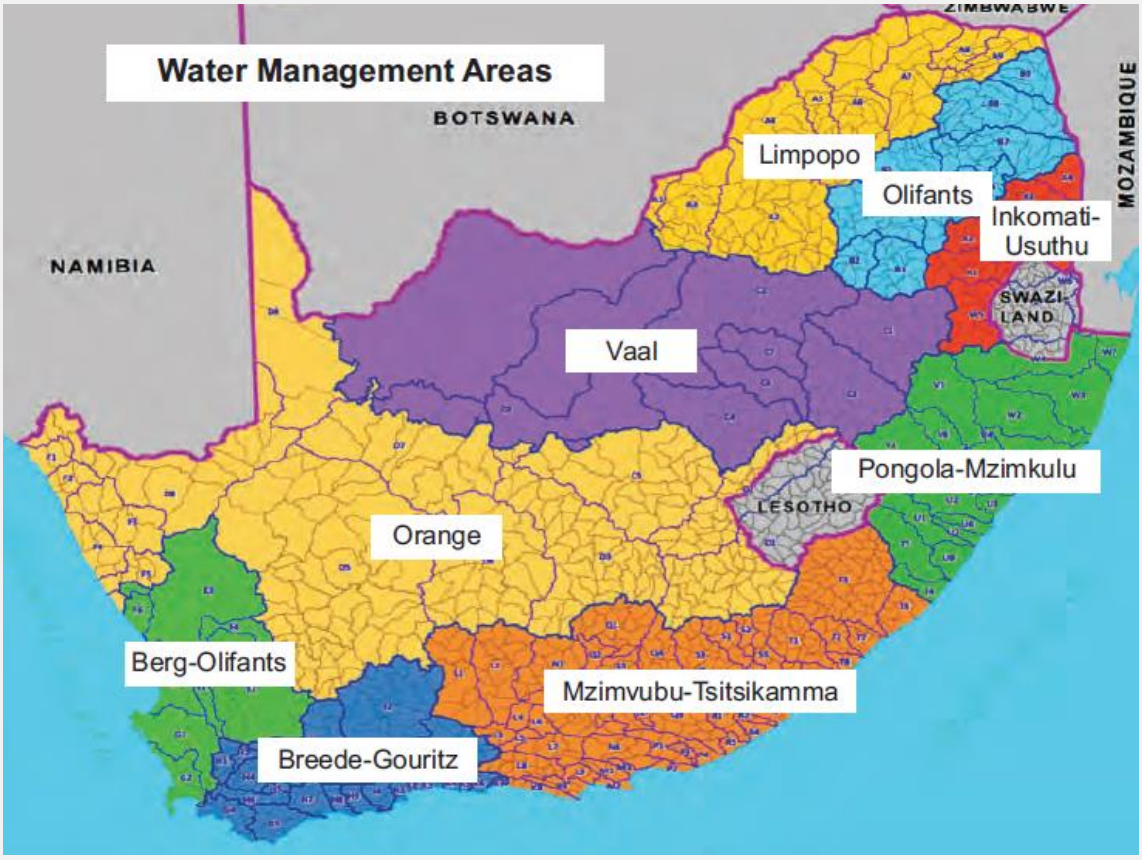


FIGURE 12- SOUTH AFRICA'S NINE WMAS AS GIVEN IN THE NWRS2
Source: DWA (2013)

Over and above the Reserve and small-scale water use, compulsory water licencing is required in water stressed catchments. Once the CMAs are operational, applications for licenses will be reviewed by the relevant CMA and allocated according to a schedule that prioritises the Reserve, allocations to previously disadvantaged people, 'existing lawful water users' (ELUs), and finally, to users that have minimal impacts and greater benefit for the broader public. 'Water use' is understood to include any activity that affects water resources, including the amount and quality of water available, as well as the natural environment surrounding the water resource. Current and future agricultural and mining firms are therefore likely to make up a large proportion of new and existing water users who will all eventually require a water licence. Additionally, the NWA allows for the development of a water pricing strategy which will generate revenue for the development and management of water resources.

The NWA also makes provision for ensuring integrated water resource management in accordance with international water obligations. Cooperation with regard to shared water resources is very important in South Africa since trans-boundary water systems contribute approximately 60% of the surface water to rivers in, or on the perimeter of, South Africa.

2.3.1.2 Water Use

Unfortunately, NWRS2 does not contain updated figures with regards to the water balance in South Africa. As a result, most of what is currently known, at least officially, about water requirements and availability at a national level is based on data from 1998 (Turton, 2008). Nonetheless, using the somewhat outdated figures in NWRS2, irrigated agriculture makes up roughly 60 % of the national water requirement and is the single largest water use in the country (Figure 13). In comparison, mining comprises approximately only 2.5% of the water requirement.

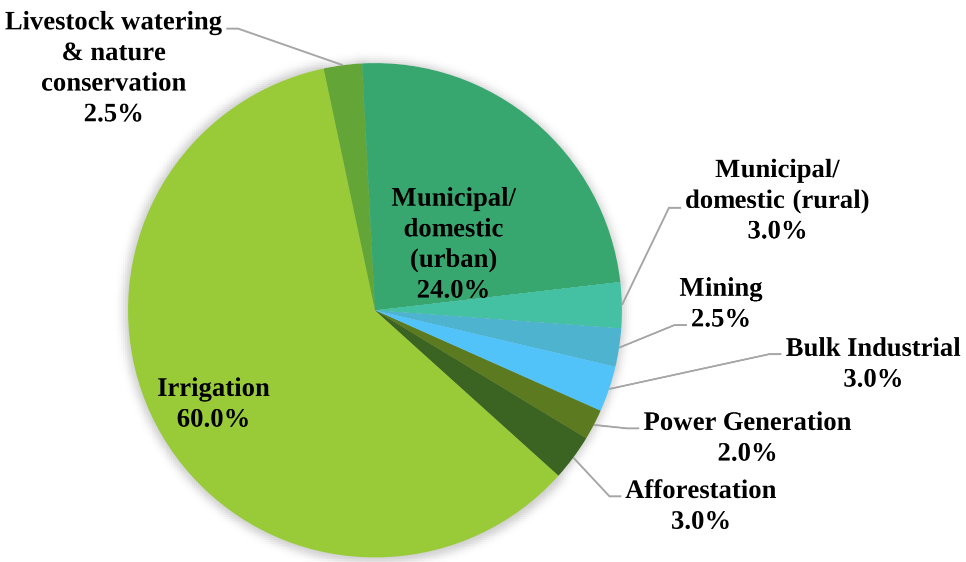


FIGURE 13- PERCENTAGE WATER USE BY ECONOMIC SECTOR
Source: DWA (2004)

With potential water shortages (see Figure 11 and section 3.2) and ever-increasing competition among water users, agriculture's dominance in South Africa's water sector has been scrutinised by policy makers; especially given agriculture's relatively low contribution to GDP. Thus, both NWRS documents explore the possibility of reallocating water from agricultural irrigation to higher value added industries, while importing water-intensive crops for South Africa's food security needs. The following excerpt from the NWRS1 (DWAF, 2004:47) captures this sentiment:

> "*South Africa is currently self-sufficient with respect to most of its food requirements, the bulk of which is produced by rain-fed agriculture. Whilst irrigated agriculture also makes a major contribution to the national food basket, particularly vegetable production, a large proportion of commercial production under irrigation is for export (such as sugar, citrus, deciduous fruits and table grapes), and of non-food products (such as wine and tobacco). In this respect, commercial irrigation contributes to food security through trade links, foreign earnings and employment creation, similar to many other sectors of the economy, but does not directly provide for food self-sufficiency. Since most crops grown under commercial irrigation represent economic use of water, such irrigation should be subject to the same allocation criteria as other economic uses, taking all forward and backward linkages into consideration, where preference is to be given to uses that achieve the greatest overall benefits for the nation. In certain cases it may be to South Africa's advantage to import more food or other products if the water and other resources consumed for its production in South Africa could be applied to other products that would create greater wealth and welfare and where the balance of impacts would be favourable*."

However, the argument captured in the above quote represents only one of a number of vantage points regarding the desirability and plausibility of importing food for meeting South Africa's food security needs. Box 5 attempts to offer an agricultural economic perspective on this argument, focussing specifically on irrigated maize.

BOX 5: RESOURCE COMPETITION AND THE LINK TO FOOD SECURITY

From 2007 to 2015 an average of 8.6% of the total area planted to maize (white and yellow maize) was irrigated, while these areas contributed an average of 19% to total maize production, ranging from 15% in years with good rainfall to 25% in years of drought (as was the case in 2015; see Figure 14).

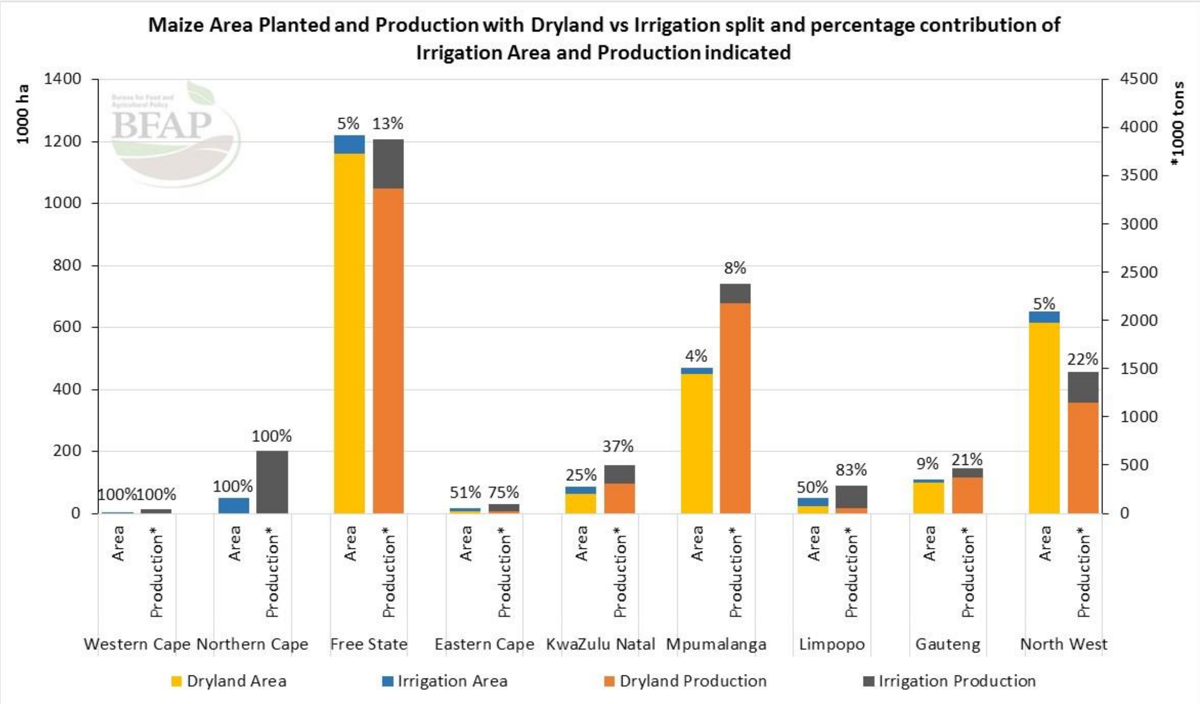


FIGURE 14- MAIZE AREA PLANTED AND MAIZE PRODUCED IN 2015 (PERCENTAGES OF IRRIGATION AREA AND PRODUCTION SHOWN)

Source: BFAP & GrainSA

Given possible water reallocation as suggested in the NWRS documents, the extreme scenario under which the share of maize production currently produced under irrigation is lost through the reallocation of water was modelled. This represents an average loss of 11% and 28% of white and yellow maize production respectively.

BOX 5 CONTINUED…

The BFAP Sector Model was used to quantify this scenario. An 11% and 28% reduction in white and yellow maize production was induced for all the outlook years: 2016 to 2024. Again, this reduction in maize production would be less (given irrigation technology developments) and phased in over time but the total shock was immediately imposed in order to illustrate the possible impacts of such an extreme scenario.

The resulting 10 year average annual price increase for white and yellow maize is 21% and 25% respectively. The maize meal price is projected to increase by an average of 10.5% over the 10 year outlook period. More than 2.5 million tons of irrigated maize production is effectively eliminated. The decrease in production is offset by decreased exports and stock levels as well as some decreases in feed and food demand. The model projects limited yellow maize imports in the first two years of the outlook as a result of the induced shock (average rainfall is assumed over the outlook); however, the market remains in a fine balance for the rest of the outlook and in years of below average precipitation, imports will likely be demanded.

A deficit in maize production (in drought years) could infringe on South Africa's food security. The balance of demand, in that case, will have to be imported, and these imports funded by increased export earnings of higher value agricultural or mining products. Since white maize is not widely produced in the international market, a limited number of options exist: either Zambia or Argentina. Zambia is the only country in the Southern African region producing consistent white maize surpluses in recent years. However maize is often viewed as a political crop in African countries, resulting in ad-hoc policies to protect domestic availability and affordability. Historically, export bans have been imposed in response to rising prices, whilst governments often intervene directly in the market through the purchase of strategic reserves. Continuous market intervention combined with exceptionally high transport costs has reduced the efficiency of trade, and consequently prices have been volatile historically (Figure 15). Increasing reliance on imports from within the region exposes the South African maize market to this volatility in supply and prices, increasing risk exposure.

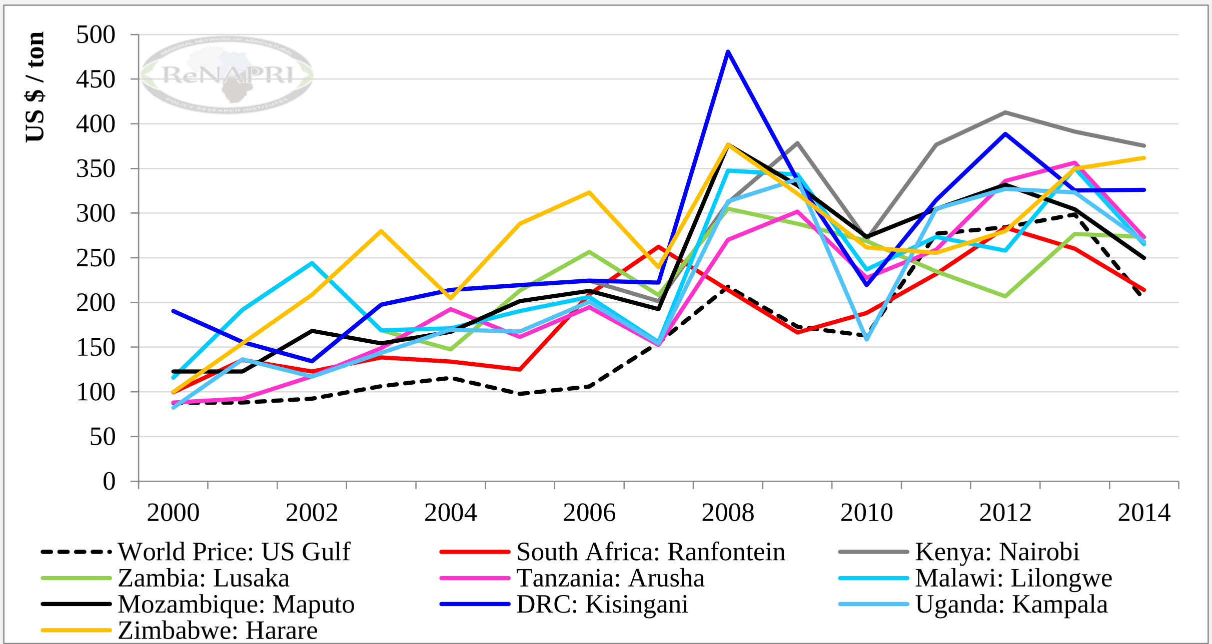


FIGURE 15 - MAIZE PRICES IN THE SUB-SAHARAN AFRICA REGION

Source: ReNAPRI Baseline 2015

BOX 5 CONTINUED…

Another factor to consider, when having to import maize are the added transport costs to move maize to the South African market (see Table 5). A net importer scenario would impact on the availability of maize and significant investment in ports, borders and supply chains would be necessary in order to physically move the maize if shortages exceed infrastructure capacity.

TABLE 5 - TRANSPORTATION COSTS OF A TON OF WHITE MAIZE

Route	Transportation cost per ton of maize (US $)
Lusaka to Randfontein	$120
Argentina to Durban	$54[1]

The bottom line is, that South African households' food security will not necessarily be enhanced by increased export earnings from high value agricultural products or the mining sector. The benefit to society of agricultural products cannot be reduced to the economic (or so-called 'wealth and welfare') benefits of farming only, when the allocation of water is considered, but has to be understood in light of the fact that domestic agricultural production of highly demanded starches such as maize improves domestic food security through the consistent supply of affordable food.

[1] - $33 transport cost between Durban and Randfontein and $21 freight costs from Argentina to Durban.

At the same time, policy makers have acknowledged the importance of agriculture for achieving food security for the poor and supporting rural economies (e.g. DWA, 2010; DWA, 2013). In particular, both NWRS reports prioritise the need to make water available to small-scale and emerging farmers. Hence, the few irrigation developments currently being undertaken by the government are mostly situated in the Eastern Cape (DWA, 2010). However, any additional demand for the remainder of the sector must be met through improved water use efficiency and water conservation (DWA, 2013). The NWRS reports also formulate demand-side management strategies which include pro-poor pricing and tradable water use authorisations which will enable "the migration… from the irrigation sector to other, higher value, sectors" (DWA, 2010:13).

The mining sector is one such 'higher value' sector. Therefore, in those regions where mining and agriculture share scarce water resources (such as in the Limpopo, Olifants, Inkomati and Upper Vaal catchments, to name a few), it is not unlikely that water pricing schedules will result in water being reallocated from irrigation to additional domestic usage and mining. However, the hydrological interactions between mining and agriculture are complicated by a number of additional features, including the type of mining activity, the quality of the ore, and the local geochemical and biophysical factors in which a particular mineral is situated. For instance, dewatering comprises a major water 'use' for the mining sector. However, dewatering could be used to make additional groundwater available for agriculture. Conversely, the major problem with dewatering is that it leaves cavities within the subsurface geology, which can result in subsistence and the creation of sinkholes and dolines. Sinkholes are a common feature in the Johannesburg region and their increasing occurrence poses a threat to housing and infrastructure, not to mention the safety of human lives (e.g. News24, 2011).

In addition to dewatering, water is used in mines to transport extracted material, facilitate separation of minerals from waste material, transport and store tailings, supress dust, and in other associated industrial uses such as cooling power systems and washing equipment. Water accounts for 2000 (Stats SA, 2009) reveal that gold and uranium were the biggest water users, followed by chrome, manganese and other metal ores, platinum group metals, iron ore, and finally, coal. While the quantities of water used in these activities are relatively small compared to agriculture, mining is widely considered to have the greatest impact on water quality; a crucial matter to which we turn next.

2.3.1.3 Water Quality

Water quality comprises the physical, chemical and biological characteristics of water that determine its suitability for various uses. Polluted water poses several major threats to human health, ecosystem functioning and economic activity. Therefore, management of both water supply and quality is necessary to ensure equitable and sustainable use of water resources in South Africa[6].

Both mining and agriculture have a significant role to play in water quality management as both have contributed to the deterioration of water resources in the country. The particular water quality issues associated with mining and agriculture depend on the types and management of activities, as well as the particular biophysical conditions in which they occur (which also tend to change seasonally). However, a number of typical water-related impacts have been outlined for each of the sectors in Table 6.

TABLE 6- SUMMARY OF THE WATER QUALITY ISSUES ASSOCIATED WITH AGRICULTURAL AND MINING ACTIVITY

Water quality issue	Agriculture	Mining
Eutrophication	X	
Microbial contamination	X	
Salinization	X	X
Acid mine drainage		X
Suspended solids (turbidity)		X
Contamination with radioactive material		X
Toxicants	X	X
Altered flow regime	X	X

Source: DWA (2011), DWAF (2004)

Agriculture's primary impact on water quality stems from chemical run-off and soil erosion. Chemical run-off contributes nutrients from fertilizer application, salts, and a number of toxicants (herbicides and pesticides) which deteriorate water quality. Run-off from feedlots has also been shown to contribute pathogens to water resources (DWAF, 2004; Dabrowski & de Klerk, 2013). Agricultural water pollution tends to be diffuse (that is, it does not reach rivers from a specific point), which poses substantial problems in terms of monitoring the contribution of particular agricultural activities to water pollution and enforcing water quality regulations.

Perhaps the most well-known water quality issue in mining is acid mine drainage (AMD), which

[6] Water quality and quantity are interactive. For instance, water quality issues exacerbate limited availability of potable water in some regions, while, at the same time, regional and seasonal lows in water supply worsen the effect of water pollution because of inhibited dilution and functioning of aquatic biota which play an important role in assimilating water pollutants.

poses a major environmental problem in parts of South Africa. AMD is associated with lowered pH and increased levels of metal toxins in surface and groundwater (see Box 6). AMD can occur long after mining has ceased, and therefore requires indefinite water treatment.

Other typical water quality problems associated with mining include increased salinity, turbidity and contamination from tailings dams. Tailings dams (which are used to store slurry waste material after the extraction of minerals from ores) present a number of problems to water sources via seepage. Gold mining, for instance, involves various methods that use cyanide to dissolve gold in crushed ore materials. Once the gold has been extracted, the waste slurry (including the cyanide, other chemicals and sediment) is pumped into tailings dams for storage.

BOX 6: ACID MINE DRAINAGE

AMD is associated with mining in the vicinity of sulphide-bearing (or more specifically, pyrite-bearing) ores. Pyrite is typically found in the geological strata containing South Africa's gold, copper and coal. When sulphide materials are exposed to air and water, the pyrite oxidises to form sulphuric acid and ferric hydroxide. The acidic solution dissolves minerals in the surrounding materials, further decreasing the solution's pH and elevating its salt content. A common feature is the leaching of surrounding minerals which contaminates mine effluent with toxic substances such as arsenic, copper, aluminium, lead, radium, uranium, amongst others. With time, the solution contaminates ground water and surface water bodies. In streams and rivers, AMD is readily identified by a rusty orange film that develops on the river bed. The orange film, known as 'yellow boy', occurs when the AMD is neutralized to a pH above 3 and causes ferrous oxides to precipitate out. AMD can occur at a number of points during the mining process, although it seems that the greatest threat is posed post-mining, when dewatering and treatment cease (WWF-SA, 2011). AMD is also associated with underground and opencast mines, and may be released from any part of the mine that comes into contact with oxygen and water, including underground tunnels, tailings, waste piles, etc.

Many of the tailings dams along the Witwatersrand and Far West Rand were purposefully built on top of dolomites for structural stability; the result has been infiltration of AMD into the karst aquifer that runs below Gauteng and the North West Province and has contaminated the groundwater.

The pH and salinity of AMD, its contamination with toxic metals, and the occurrence of yellow boy all have major consequences for aquatic ecosystems, agricultural productivity, and animal and human health (McCarthy, 2011; WWF-SA, 2011; Durand, 2012). For instance, a study of Sharptooth Catfish in the Olifants River in Limpopo Province showed that AMD in the upper catchment has resulted in the bioaccumulation of toxic metals in their muscle tissue, posing a threat to communities with a history of catfish consumption (Jooste, 2015). In another study, major uranium contamination of ground water was found in the West Rand and Far West Rand which could have detrimental effects on the health of people living in local municipalities (Winde, 2010). Furthermore, the study reviewed recent research on uranium toxicity, in which the author summarises:

> "*Data from animal experiments as well as epidemiological data now suggest that [Uranium] may not only be nephrotoxic but also neurotoxic (targeting the brain), genotoxic (causing DNA damage related to cancer) and may disrupt hormone balances by mimicking oestrogen at levels below currently existing drinking water limits. This is of particular concern since drinking water limits for [Uranium] in South Africa were found to be well above international standards*." – (Winde, 2010: 252).

While the chemical reaction that occurs in AMD takes place naturally during chemical weathering of rocks, the process is usually relatively slow and dilution and biological processes help to neutralise the acidic solution. However, mining substantially increases the opportunity for AMD formation by increasing surface areas for oxidation through the excavation and fragmenting of strata, especially if mines are situated below water tables (McCarthy, 2011).

Even though tailings dams are lined with plastic, perimeters are often breeched and the chemical solution is left to seep towards groundwater and surface water bodies (Durand, 2012). Cyanide is a highly toxic substance that is lethal in small doses to humans and animals. Durand (2012: 37) speculates that cyanide seepage is associated with increased deaths and miscarriages of animals in the Krugersdorp Nature Reserve and has also had a massive impact on the quality and biodiversity of terrestrial water systems in Gauteng and the North West Province in the last decade. A number of tailings dam failures in South Africa have also devastated ecosystems and taken human lives; most notably the 1994 Merriespruit Dam failure which collapsed onto Virginia in the Free State, damaging 200 houses and killing seventeen people (Van Niekerk & Viljoen, 2005).

Although mining contributes greatly to employment, GDP and the national trade balance, the sector also pollutes large quantities of water and the full costs of 'clean up' are not factored into the final profitability of mining. The economic burden of perpetual water treatment is likely to be exorbitant. Furthermore, the complex geology and hydrological systems in South Africa often mean that water pollution from mining is not visible for generations after, and once it is detected, there is no way of pinpointing the source and it will probably be too late and too costly to remedy—especially if the burden of clean-up is relegated to the state (which is already inundated and ill-equipped to deal with the backlog of some 6000 abandoned mines that need rehabilitation) (Movik, 2014; WWF-SA, 2011). Despite the provisions in the NWA for the 'polluter pays' principle and the prioritisation of water use through the use of licences, the ELU provision and the general lack of monitoring and implementation of the NWA mean that water pollution by mining persists and will continue to persist despite the importance of water to human well-being and economic growth (Movik, 2014; WWF-SA, 2011).

2.3.2 Soil Quality

Soil quality is defined as the "the specific capacity of a soil to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation" (Karlen et al., 1997:4). Soil quality is therefore a function of the unique combination of all soil properties of a specific soil unit, including physical, chemical and biological characteristics. Good quality soils underpin a range of ecosystem services (such as food production and habitats for animals and plants) which are critical for the viability and sustainability of agricultural activity. In South Africa, the availability of moderate to high potential soils is limited (comprising just 10.3% of the country's soils) and therefore, the sensible use and management of these soils is exceptionally important for food security.

Mining activities have a wide range of impacts on soil quality that result in a plethora of measurable as well as non-measurable losses affecting the ecosystem services originally provided. This section briefly touches on some of the most crucial issues associated with these impacts, but in-depth research on these topics is still lacking.

The most obvious impacts of mining are evident in the large areas of soil that fall within the surface footprint of new mining developments as well as those areas that have been affected in the past. Soil quality is affected from as early as the prospecting phase where the subject area of the prospecting permit is accessed for either core drilling or pit excavations, resulting in the physical disturbance of soil profiles, soil compaction and the degradation of natural or cultivated pastures that are also affected by the sudden traffic associated with prospecting activities. Once the mining right has been granted and project activities commence, the most serious impacts on soil quality begin during the construction phase of mining, especially in the case of surface mining. The disturbance of original soil profiles and horizon sequences of these profiles during earthworks is considered to be a negative deterioration for a number of reasons, the most obvious being that much of the surface areas disturbed either by excavation or construction of infrastructure are immediately lost to agricultural production.

The loss of production from the land can be calculated from baseline soil and agricultural potential studies before mining commenced. Although soil management and rehabilitation plans are part of the environmental authorisation process, there is no substantial scientific proof that the initial level of productivity can be restored.

In the case of ecosystem functioning, the extent of soil quality impacts is not easily quantifiable. One of the most significant impacts in this category is the effect that the disturbance of soil horizons through excavation activities has on the water storage capacity of soil profiles. Soil formation takes place over thousands of years and results in unique capabilities of a variety of soil forms to store water that accumulates during high rainfall years where it remains available to plant roots for uptake even during drier periods. These water storage properties of soil are optimised in drier production regions such as the Northwest and Free State Provinces. Even though land rehabilitation aims to replace the different horizons as closely to the original organisation as possible, in reality these unique water storage properties can never be restored to their original capabilities. This particular impact is especially destructive in the case of hydrological soils supporting wetland ecosystems.

Compaction of soil profiles is another major impact associated with mining activity. Soil compaction generally reduces the amount of water that plants can take up. This is because compaction crushes many of the macropores and large micropores into smaller pores, and the bulk density increases. As the clay particles are forced closer together, soil strength may increase beyond about 2000 kPa, the level considered to limit root penetration. Compaction also reduces the water infiltration rate and therefore aggravates run-off erosion. Soil compaction is unavoidable as a result of heavy vehicles commuting on new and perhaps existing roads in the footprint area of the mining project. A number of research projects have shown that even though deep ripping of soil during the land rehabilitation process can be considered effective to alleviate compaction of the surface layer of soil, compaction of the subsurface soil layers is very difficult to address.

Mining activities also result in large volumes of waste from mining processes, oil and fuel spills from onsite vehicle operation, as well as waste generation from construction and operation of mining infrastructure. Soil contamination with hazardous chemicals, even at relatively low concentrations, can result in radical changes in soil chemistry. Soil contamination also has deleterious consequences for ecosystems, with such changes potentially altering the metabolism of endemic microorganisms and arthropods resident in a given soil environment. The result can be virtual eradication of some of the primary food chain, which in turn could have major consequences for predator or consumer species. Even if the chemical effect on lower life forms is small, the lower pyramid levels of the food chain may ingest pollutant chemicals, which normally become more concentrated for each consuming trophic level of the food chain. Contaminated or polluted soil can also directly affect human health through direct contact with soil or via the infiltration of soil contamination into groundwater aquifers used for human consumption, sometimes in areas far removed from any apparent source of above ground contamination.

Agriculture, too, can have devastating impacts on soil quality. Since the rapid development and use of agricultural pesticides after World War II, crop production intensified dramatically and these modern agricultural practices have resulted in significant soil and land degradation in many parts of the world. South Africa is no exception. South Africa’s conventional, intensive tillage-based production model of agriculture has increased production per hectare (as noted in section 2.2.1). These gains, however, came mainly as a result of an increasing reliance on capital intensive equipment (mechanization), which has partly culminated in a decline in employment and a loss of income to workers (Bhorat et al. 2011). It has also led to serious land degradation and a decline in soil quality in grain producing areas among others. According to Le Roux et al. (2008), the average top soil loss under annual grain crops in the country is 13 ton/ha/yr. This is much higher than the natural soil formation rate and implies that we are losing, on average, approximately 3 tons of top soil/ha for every ton of dryland maize produced every year (see also Botha & Fouche 2000, Laker 2004, Mills & Fey 2004). Other issues include:

- high dependence on fertilizer (Nitrogen (N), Phosphorous (P), and Potassium (K) fertilizers) with 60% of the cropland's top soil characterized by moderate to severe acidity (Burger 2010);
- high dependence on other agro-chemicals, such as herbicides and insecticides (e.g. the country is the largest importer of pesticides in Sub-Saharan Africa (Quinn *et al*. 2011)), which poses local health and environmental risks (Thiere & Schultz 2004).

As a result, conventional intensive tillage-based agricultural practices contribute to a breakdown in ecosystem functionality and ecosystem resilience and contribute to increased vulnerability to climate change (IAASTD) 2009).

The above highlights the importance of converting to conservation agricultural practices which include no-till, crop rotation and the introduction of cover crops. Some have argued that conservation agriculture is no longer a "nice-to-have", but is arguably one of the key survival strategies of the sector going forward (de Wit et al. 2015).

Similarly, the rehabilitation of mined land – when done correctly – has become imperative as it alleviates some of the damage done to soil quality through mining activity. Mine rehabilitation also represents a practice which could be beneficial to both mining (through reduced post-mining liability) and agriculture (through the reclamation of agricultural land, albeit at lower levels of yield potential). However, in practice, there are a number of issues in the way that mine rehabilitation is implemented (if it is implemented at all). Box 7 provides an overview of some of the major issues in mine rehabilitation and highlights key areas in which it can be improved for the mutual benefit of mining and agriculture.

BOX 7: REHABILITATION OF MINING LAND FOR AGRICULTURAL USE

The deterioration of soil quality by mining activity is clearly an area of concern in terms of the impact of mining on food security. At the same time, it is important to note that the largest impact of mining on the agricultural industry is often the exclusion of agricultural land not destined to be mined (see section 3). This land can often be cultivated, however the mining company remains liable for any activities conducted on such land, and this legal implication often results in land not being available for agriculture irrespective of it going to be mined or not. This agricultural land too is subjected to a process of natural degradation, but is fortunately easier to reclaim than land that is mined.

EIAs, EMPs and land rehabilitation are therefore crucial features of the legislative framework around mining activities – especially with regards to water and soil resources – that attempt to safeguard the long term interests of society. (The legislative framework for mining is further discussed in section 0). These processes are also of particular interest to agriculture, as mine rehabilitation is frequently performed with the intention of returning land to some level of agricultural use. However, in practice, there is a lack of evidence to suggest that mines are capable of successfully rehabilitating land to pre-mining levels of agricultural potential.

This section provides an overview of the current challenges with the rehabilitation approach used by the mining industry and highlights a number of key areas in which the success of this approach could be improved.

BOX 7 CONTINUED…

Complexity of Land Rehabilitation Science

The challenge to reclaim mined land is a complex and multidisciplinary science. For mined land rehabilitation to achieve some level of success, holistic thinking is essential, and planning mine closure without post-mining end land use as a major driver of rehabilitation is inexcusable. Rehabilitation of mined land is a science not well understood since it integrates many different scientific disciplines which encompass interrelationships over spatial and temporal scales that are often either neglected as part of planning, or just too complicated to correlate. The complexity of land rehabilitation science is exacerbated by the uncertainty of how long-term climatic changes could affect not only implemented individual rehabilitation aspects or activities, but also the functionality of the rehabilitated landscapes over time. This uncertainty requires attention to design rehabilitation criteria that can 'safely fail' instead of the previous and current design philosophy of 'fail safe'. Ultimately, mined land rehabilitation can be much more successful and sustainable if it is recognized as a multi- and interdisciplinary field in both spatial and temporal contexts, and receives the necessary attention it requires/deserves.

When the rehabilitation of surface mined land, or any other degraded land, is not addressed this way it will remain a major challenge, largely because mined land rehabilitation strategies are primarily based on engineering principles with insufficient recognition of associated agricultural principles. This holds true when the agricultural component of rehabilitation plans is most often written by environmental specialists with nominal agricultural background and implemented by engineering consortia once again often having insufficient agricultural expertise or inputs.

Issues Associated with Land Capability Classification and Post-Rehabilitation Management

It is important to distinguish between the rehabilitation of a waste disposal site, underground mine, opencast or surface mine. Each of these has their own set of objectives, challenges and criteria. To reclaim land back to "its original state" does not necessarily mean that the reclaimed land has an agricultural potential. The EIA process is responsible for classifying the land prior to mining, and if this information is insufficient, then the EMP will not be designed to meet an acceptable agricultural potential. If agricultural land prior to the EIA process is in poor condition and the actual agricultural potential is not ascertained correctly, the EIA process will unsatisfactorily record this, and the EMP will not provide good recommendations for rehabilitation practices.

Spatial economic planning, from a dryland agricultural production perspective, is subjected to the capability and suitability of the natural environment to sustain adapted production systems. Land capability provides a framework that combines soil, terrain and climate factors to assess the most intensive long-term use of land for rain-fed agriculture and, at the same time, indicates the permanent limitations associated with the different land-use classes (Collet, 2013). DAFF makes provision for eight land capability classes, as shown in Table 7. The land capability classification is an expression of the effect of physical factors for crop suitability and potential that require regular tillage, for grazing, for forestry and for wildlife without damage to the resource. In contrast, the mining industry makes provision for only four land capability classes which are predominantly listed as shown in Box 7 continued…

Table 7. Each of these land capabilities has a limited list of criteria to ensure the necessary soil properties essential to support specific post-mining land capabilities and associated land uses.

BOX 7 CONTINUED…

TABLE 7- COMPARING THE DIFFERENT LAND CAPABILITY CLASSIFICATIONS USED BY MINING AND AGRICULTURE RESPECTIVELY

Land Capability Class	Classification used by agriculture	Classification used by mining
I	Arable land suitable for very intensive cultivation	Arable land
II	Arable land suitable for intensive cultivation	Grazing
III	Arable land suitable for moderate cultivation	Wilderness
IV	Arable land suitable for light cultivation	Wetland
V	Grazing land suitable for moderate grazing but not for forestry	
VI	Grazing land suitable for moderate grazing	
VII	Grazing land suitable for light grazing	
VIII	Wildlife	

Soil depth is currently the only determinant of land capability class used by the mining industry which is not sufficient in describing the complexities of land capability. More attention is needed to the creation of a set of sufficient criteria in order to achieve better success with rehabilitation in future. However, this will contribute to a significantly higher rehabilitation cost initially, since more expertise and inputs are required pre and often post-rehabilitation. Table 8 highlights some of the key rehabilitation activities required to reinstate the different land capability classes with an expected agricultural potential. Although these activities contribute significantly to the initial rehabilitation cost, they will be offset against the enormous reduction in liability cost a few years later due to a more sustainably reclaimed environment.

TABLE 8- REHABILITATION ACTIVITIES THAT CONTRIBUTE TO HIGHER REHABILITATION COSTS OF DIFFERENT LAND CAPABILITY CLASSES

		Land Capability Class			
		Arable	Grazing	Wilderness	Wetland
Rehabilitation Activity	Judicious soil stripping	X	X	X	X
	Landscaping	X	X	X	X
	Deeper soil requirement	X	X		X
	Adapted to Shallower soils			X	
	Specific soil types	X			X
	Successional Tillage practices	X	X		
	Amelioration	X	X		
	Pre-revegetation fertilization	X	X		
	Post-revegetation fertilization	X	X		
	Native seed bank		X	X	X
	Biodiversity requirements			X	X
	Post rehabilitation maintenance	X	X	X	

BOX 7 CONTINUED…

Very often, the mining industry's land capability class II (Grazing) is misinterpreted with the objective to rather reinstate native grassland which will ensure good biodiversity and, to date, an unknown functionality and reclaimed land use value. The currently conventional seeded grasses, however, have the potential to serve as a planted pasture which can also be used for 'grazing' purposes. This land capability class however is reclaimed using agronomic principles and if managed like native grassland with no active management, the vegetation cover is deemed to fail (see Figure 16). The advantage of using agronomic principles to construct land capability class II is that soil is stabilized quickly until the ecosystem is more conducive to the re-establishment of native grass species. This is often the situation when the original topsoil is never preserved during the soil stripping process and the seed bank is lost. Both class I (Arable) and class II (Grazing) should be managed in the same manner until the reclaimed environment is stable enough for its proposed end land use.

Knowing the challenges of reclaiming certain land capability classes, in particular wetlands, the importance of not mining such an area is highlighted. This is due to very few successful projects known and/or recorded, and until research or case studies have shown some kind of success it should not be a consideration to mine these areas.

If post-mining end land use is decided upon at the beginning of the mine planning phase, land can be returned back to agricultural use more successfully by following a specific list of criteria to reinstate land with an acceptable agricultural potential. The current status of successfully reclaimed surface mined land in the country raises the question whether the current rehabilitation principles applied are understood and managed properly.

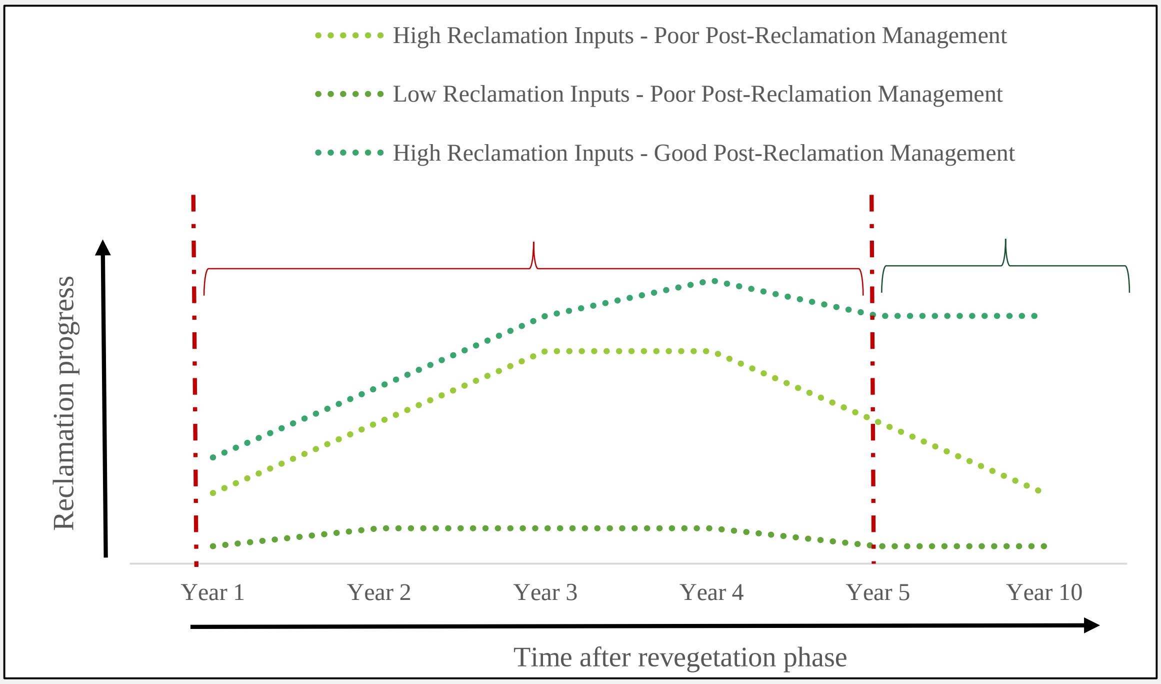


FIGURE 16- HYPOTHETICAL ILLUSTRATION OF REHABILITATION INPUTS VERSUS POST-REHABILITATION MANAGEMENT ON REHABILITATION PROGRESS (SUCCESS) AND SUSTAINABILITY FOR AN AVERAGE TO HIGH RAIN FALL ENVIRONMENT

BOX 7 CONTINUED…

By applying the correct principles, and by understanding the interrelationships between soil, vegetation, climate and animals, better ways of addressing associated challenges in achieving satisfactory land rehabilitation are possible. With attention to detail applied to all the biophysical elements of an environment that have been disturbed, ecosystem services can be reinstated with judicial management towards a more sustainable rehabilitation outcome. A land stewardship approach to land rehabilitation also remains important for sustainable and successful rehabilitation projects.

To ensure healthy, productive and sustainable vegetative growth as part of the rehabilitation process, pre-mined soils need to be classified properly, removed with care and experience, and placed back carefully using strict criteria in accordance to the most appropriate position in a reconstructed landscape. Once disturbed soils are replaced and assessed, some soil will require amelioration. This amelioration is essential to address many of the soil physical restrictions; i.e. soil compaction caused by incorrect soil management activities. This is then followed by initially re-vegetating the area with a locally adapted mixture of vigorous growing grass species, to provide good vegetation cover to stabilize the soil which has lost physical structure due to excavation, soil handling and replacement followed by good post re-vegetation management. The main objective of reclaiming surface mined agricultural soils is to reinstate the pre-mining agricultural potential as documented in the EIA. This relates to the land capability of an area, which is determined by its own set of soil quality criteria.

The sustainability of these reclaimed environments largely depends on the improvement and maintenance of good quality soil that serves as a growth medium for established vegetation for the determined post-mining land use. It is evident from current research that the principles of pasture agronomy play an imperative role in the journey to achieve sustainable land rehabilitation. To date the larger percentage of reclaimed surface mined land is returned to a mixture of agronomic pasture species as the interim measure until disturbed soils have acquired some level of stability, fertility and a condition more suitable for crop production or native grass species predetermined before mining commences.

It should be acknowledged that the major provinces impacted by mining are not only known to be the home to a large proportion of South Africa's arable farmland, but they also provide good quality natural and planted pasture to support the cattle industry to meet the increasing protein demands of the growing population. The latter statement however, is accidently and fortunately aligned to the current rehabilitation approach followed by most mining houses, nonetheless not always well planned or managed. Often the area classified as having grazing land capability post-mining, makes up more than half of the reclaimed area. In some instances, it can even have better agricultural potential than the original pre-mined land if managed and maintained judiciously. Nevertheless, the reinstatement of agricultural potential to support crop production on these reclaimed soils has been successful in certain areas where rehabilitation is conducted carefully and a land stewardship approach is followed.

Environmental pressure has and will become imperative in ensuring that land rehabilitation is conducted properly. It is also true for mining companies, for whom it is too important not to remain liable for this land forever. It is still important to remember that agriculture after mining is possible, but it will need to be regarded as specialised agriculture with higher input requirements initially. This forms part of the rehabilitation process, but will require intensive management post-rehabilitation to eventually achieve sustainable agricultural practices.

BOX 7 CONTINUED…

Lack of Coherent Research and Land Rehabilitation Norms and Standards

To reclaim mined land, it is imperative to follow a guideline. Currently the Chamber of Mines / Coaltech "Guidelines for the rehabilitation of mined land" (2007) is the only published guideline document. Many large mining houses do however have their own in-house rehabilitation guidelines that have partially been derived from the Chamber of Mines / Coaltech guideline document in conjunction with experience obtained in-field when complying with legislative requirements. Many smaller mining companies however, often have no guidelines or even a dedicated team to meet the rehabilitation objectives and/or legislative requirements. The situation becomes even more serious when noting that non-registered mines do not comply with legislative requirements of land rehabilitation.

Land rehabilitation is a multi-stakeholder challenge and requires government departments and industry to reach consensus on practical land rehabilitation methodologies or best practice guidelines. The aforementioned objective is often challenged due to conflicting legislation, delayed government authorizations, insufficient expertise and often unachievable criteria. The first and foremost obstacle for land rehabilitation remains the absence of a set of norms and standards for various rehabilitation scenarios. For norms and standards to be compiled, very often credible information that is derived from research projects and/or proven case studies can assist in such a process. To acquire this information, professional societies such as the Land Rehabilitation Society of Southern Africa (LaRSSA) can provide a platform for such information to be shared, discussed, debated and finally accepted.

To add to the aforementioned discussion, research over the past few years on land rehabilitation has been fragmented and has delayed the development of a comprehensive, scientifically-sound body of knowledge on which to base decisions about best practice in the long-term management of reclaimed mined land. The absence of a body of knowledge creates pessimism about whether any set of rehabilitation interventions will ever be sufficient to ensure a sustainable rehabilitated system. To overcome these challenges, the Coal Mined Land Rehabilitation Research (CMR^2) initiative has established a Centre of Excellence on a former coal mine to investigate mined-land rehabilitation and post-mining use practices with the aim of providing a single, authoritative source of knowledge and expertise on these matters (please see www.cmr2.org for more information on the initiative). Unfortunately, there are many stakeholders responsible for the degradation of land through mining and poor agricultural management practices, and they are often likely to adopt a conservative, least-cost approach to rehabilitation, resulting in land that is of less than optimal value for future agricultural use or ecological function.

2.4 Legislative Aspects of Land Use in the Primary Sector

This section will discuss how regulations and legislature regarding land use and mine rehabilitation are applied in the South African context. Some regulatory challenges and the need for solutions are highlighted.

2.4.1 Context

The allocation of mineral tenures is a key structural issue that contributes to the preferential treatment enjoyed by the mining industry. In South Africa, as elsewhere in the world, the original goal of mining's preferential access was to encourage mining activity, bolstered by the dictate of conventional wisdom that mining constituted the most profitable, and therefore, best use of land. This approach persists to the present day. Because of this deviation from the common law approach to property ownership, there has always been conflict between the holder of a title deed who, in most cases, is the surface landowner and the mineral right holder who, in most cases, has the rights to access and sever the minerals beneath the surface by virtue of various licenses granted under applicable legislation (Southern African Legal Information Institute, 2013).

Historically, the regulation of mining activity in South Africa has focussed on the encouragement and safeguarding of entrepreneurial activity in the exploitation of the country's mineral resources. Nevertheless, the government has continuously exercised control over mining operations. This control was first entrenched in legislation with the passing of the Mining Rights Act (Act 20 of 1967) in 1967. In terms of the preamble to this act, the government held the exclusive authority to confer mineral rights in respect of precious metals. In this period, mining law consisted of a fragmented system of statutes that applied specifically to types of metals with degrees of divergence in their application to each. In 1991, the promulgation of the Minerals Act brought about a shift in the mineral law of South Africa, laying the legal groundwork for all mineral and prospecting rights in existence prior to the current dispensation under the MPRDA.

The main achievements of the 1991 Minerals Act were:

- To consolidate the country's disjointed mining law framework;
- To implement a uniform procedure for applications related to all mineral and prospecting rights; and
- Provide safeguards for the protection of business interests.

Under the MPRDA, the holder of a prospecting right, mining right, exploration right or production right conferred in accordance with the Act, has a preferential right of access to natural resources, irrespective of the surface use of the land (section 5 of the MPRDA). The appropriate Minister (currently of Mineral Resources) grants an ordinary prospecting right, provided that the requirements of section 17 of the MPRDA are met.[7] The duty of compensation for loss resides with the Minister, with the amount to be determined in accordance with article 25 of the Constitution.

In addition to the provision for an ordinary right, section 104(1) of the Act also provides for the granting of a "preferent right to prospect or mine" to a "traditional community" to prospect on community land. These provisions formed the basis of an unreported decision of the North Gauteng Provincial Division of the High Court in *Bengwenyama Minerals (Pty) Ltd v Genorah Resources*

[7] http://www.dejure.up.ac.za/index.php/volumes/44-vol-1-2011/articles/article-8

(Pty) Ltd.[8] The judgment contends with the determination of legal preference in instances where competing applications for prospecting rights have been submitted in terms of both sections 17 and 104 of the MPRDA. An attempt was made in this case to present the Bengwenyama community's application *ex post facto* as an application for a section 104 preferential prospecting right, however, pursuant to the Court's application of the "first come" principle set out in section 9(1)(b), the application was dismissed. This served to highlight a shortcoming in the MPRDA, which does not afford adequate protection to traditional communities unable to compete with established mining houses in the beneficiation of minerals.

In *Minister of Minerals and Energy v Agri South Africa (Centre for Applied Legal Studies as amicus curiae)*[9] the South African Constitutional Court had to determine whether the MPRDA expropriated rights that existed prior to its coming into force as held by Agri SA. Agri SA argued that by vesting all mineral rights in the state, the MPRDA expropriated existing rights sans any provision for compensation, thus rendering the MPRDA unconstitutional due to its contravention of article 25(2)(b) of the South African Constitution. The Minister disputed this, arguing that item 12(1) in section 2 of the MPRDA "gives a wider ambit on the one alleging expropriation to prove it." (Southern African Legal Information Institute, 2013) The Court overturned the decision of both the North Gauteng High Court and the Supreme Court of Appeal, with a finding in favour of the Minister.

Spatial Planning and Land Use Management Act (SPLUMA) theoretically places the management of local land use matters in the hands of the local government. In light of cases such as *Wary Holdings (Pty) Ltd v Stalwo (Pty) Ltd and Another*[10] it has already been established that cooperative governance is not as "cooperative" in practice as the Constitution envisages. SPLUMA aims to incorporate the principles of sustainable development into South Africa's spatial planning landscape and was signed into law by the President on 2 August 2013, being formally published in the Gazette on the 05 August 2013. The effect of SPLUMA can be summarised as follows:

- With regard to land use management (Department: Rural Development & Land Reform, 2014):
    - The Local Municipality is primarily responsible for Land Use Management;
    - The primary instrument is the Land Use Scheme (LUS);
    - The Municipality must, after public consultation, prepare, adopt and implement a LUS within five years of the Act being brought into operation;
    - The LUS must be consistent with and give effect to the Municipal Spatial Development Framework (SDF);
    - All land development applications must be determined within the context of the LUS;
    - An approved and adopted LUS has the force of law and binds all owners and users of land.
- With regard to land development management:
    - Land development applications are determined by Municipalities as the authority of first instance;

[8] 39808/2007 (TPD) (18-11-2008).

[9] [2012] 3 All SA 266 (SCA).

[10] 2008 (1) SA 654 (SCA) (28 September 2007).

- Municipalities are required to establish Municipal Planning Tribunals (MPTs) to discharge this function;
- Municipalities may co-operate to establish Joint Municipal Planning Tribunals;
- The Tribunals consist of municipal officials and suitably qualified external persons appointed by Municipal Councils;
- Appeals lay to the Executive Authority from decisions of MPTs.

SPLUMA determines that the decisions of the local authority cannot be overturned at the national level except in the case of agricultural land. In a notice which appeared in the Government Gazette on 13 March 2015, DAFF invited public comment on a draft Policy and a draft Bill, aimed at the preservation and development of agricultural land. The purpose of the draft Bill appears to focus on the custodianship of "agricultural land" and, *inter alia*, to regulate the subdivision and rezoning of what is termed:

- High Potential Cropping Land;
- Medium Potential Agricultural Land; and
- To provide for proclaiming so-called Protected Agricultural Areas.

The draft Bill is aimed primarily at repealing and replacing the Subdivision of Agricultural Land Act, 1970 (SALA), yet it also aims to regulate the subdivision and rezoning of certain land components which will fall under the jurisdiction of the Minister of Agriculture, Forestry and Fisheries. In terms of section 3 of the draft Bill, the custodianship of designated "agricultural land" will be assigned exclusively to the DAFF. In Section 3(2), DAFF confirms that, acting through the National Minister or MEC's at provincial level, as the case may be, DAFF will "approve; reject; control; administer; and manage" any rezoning or subdivision of agricultural land. It is as yet unclear what the implication will be with regard to municipal authority under SPLUMA.

With regard to the environmental aspects, the regulation of mining activities has been the subject to a long-standing "turf battle" between the national Department of Environmental Affairs (DEA) and the Department of Mineral Resources (DMR). The DMR has traditionally adopted the stance that the obtaining of a mining right or permit (collectively referred to hereafter as "mining right") trumped the need for any other authorisation required by any other law. This mistaken belief was clarified by the Constitutional Court in the decision of *Maccsand Pty Ltd and others v City of Cape Town and others*[11] where it was held that holding a mining right did not negate the need to obtain any further authorisations which may be triggered as a result of mining activities. More recently, it is accepted that various authorisations and permits may be required in addition to a mining right before mining activities may commence. It is for instance commonly accepted that, depending on the location, nature and extent of the activities, a water use licence under the NWA may be required and/or zoning approval is necessary where the zoning of the property does not permit mining. The position with regard to separate environmental authorisation under the NEMA for mining activities, and activities associated with mining that are separately listed under NEMA, is less clear.

Mining companies in South Africa are required to make financial provision in terms of the MPRDA, read in conjunction with the NEMA, for the rehabilitation of the mining areas on which mining activities are conducted (this has created an overlap with NEMA). From an administrative and practical perspective, mining companies are required to re-evaluate their rehabilitation liabilities and ensure that they sufficiently cater for any shortfall in the provision for such rehabilitation liabilities. In

[11] 2012 (4) SA 181 (CC).

this regard, the DMR insists that mining companies must be able to provide for any shortfall in the provision for rehabilitation liabilities upfront. For companies which merely provide for rehabilitation through a rehabilitation trust, this would imply that a cash contribution of the entire shortfall amount would need to be contributed towards the rehabilitation trust. Commercially, many mining companies (especially junior mining companies) are not in a position to make such contributions as this would lead to cash flow constraints for the already cash strapped mining companies (Naidoo, 2014).

While the objective of improving cooperative governance and streamlining or coordinating the environmental regulation of mining activities is obvious, the implementation of these provisions has been pending over four years now. The result is a perpetuation of the lack of clarity regarding environmental regulation of mining activities, which is ultimately a disservice to the mining sector and a disincentive to investors.

When the activities specifically related to prospecting and mining were incorporated into the NEMA listing notices in GNR 544, 545 and 546 in Government Gazette 33306 of 18 June 2010 (listing those activities which required environmental authorisation) it was on the basis that these mining activities would only come into force and effect on a proclaimed date and after the transitional periods provided for in the NEMA and MPRDA Amendment Acts had been completed. The transitional provisions of the Amendment Acts provided that the amended provisions of NEMA regulating mining activities would take effect 18 months after the date on which the MPRDA Amendment Act took effect. This places the Minister of Mineral Resources in charge of consolidating the MPRDA and NEMA, however, the DMR also holds the mandate of expanding mining activity. While the two objectives might not appear so at a *prima facie* consideration, in practice, this has created a conflict of interest for the Ministry (Mining Indaba, 2015).

2.4.2 Regulatory Challenges and Proposed Solutions

The major shortcomings of the current environmental and land use regulatory system may be summarised as a lack of clarity regarding authority at various spheres of governance, resulting in long delays in project implementation and high cost of compliance for those operating in the mining, but also agricultural sectors. Mining companies retain a preferential right of access to land, however, the duty of compensation resides with the Minister. The threshold for rehabilitation of land is not clearly defined in either the NEMA or MPRDA. It is not yet clear how the draft Bill on the Preservation and Development of Agricultural Land will factor into the equation. The current structures for financing rehabilitation fall generally short of what is needed to rehabilitate land sufficiently for agricultural use after the conclusion of mining activity. Goverment departments are severely constrained in terms of expertise in all relevant areas, from finance to spatial planning.

As proposed during the 2015 Mining Indaba hosted in Cape Town, the onus for reaching a solution to these challenges might well reside with industry and the financial sector. There is a greater need for cooperation between those operating within the primary sector to resolve conflicts related to resource allocation and to constructively inform government efforts at regulation.

3 The Extent of Competition for Resources between Agriculture and Mining: A National Perspective

Here we provide a synopsis on the extent of competition for natural resources between mining and agriculture, by way of high-level spatial evidence of current and potential mining production areas and their overlap with agricultural production areas. This section also uses spatial analysis to demonstrate the relative water scarcity in regions where agriculture and mining operate. The spatial analyses area accessible for interactive viewing here.

3.1 Land

Figure 17 shows mining land use[12] as well as dryland and irrigated agricultural production. The total land surface area of South Africa is a 122.3 million hectares, of which only 15.8 million hectares (12.4 percent) is considered to be potential arable land for farming and 22.5 million hectares (18.4 percent) of land is known to contain minerals. The visible spatial footprint for the mining and agricultural sectors was identified in the National Land Cover database (NLC) 2013/2014 (DEA, 2015), as shown in Figure 17. National mining land cover includes quarries, tailings dams, leach dams and all open-cast mining activities, as was captured by remote-sensing imagery analysis for the DEA. The total area covered by the NLC mining layers was calculated to be approximately 404 098 ha. This can be described as the amount of surface area directly utilised by the mining sector.

According to AGIS (2011) at least 13.1 million hectares of land was under some form of cultivation or was cultivated during each of the years between 2007 and 2009. Of the 13.2 million hectares of cultivated land, approximately 3.1 million hectares was planted to cereal or oilseed crops during the 2013/2014 production season; well down from its peak of 8 million hectares during the 1985/1986 production season (van der Burgh, 2015). The dryland (cash crop) portion of the total cultivated land is shown (green) in Figure 17.

[12] Mining land use is discussed in section 2.2.2 which explains the complexity in quantifying the true footprint of mining using mineral seems, surface mining activity and mine-owned land.

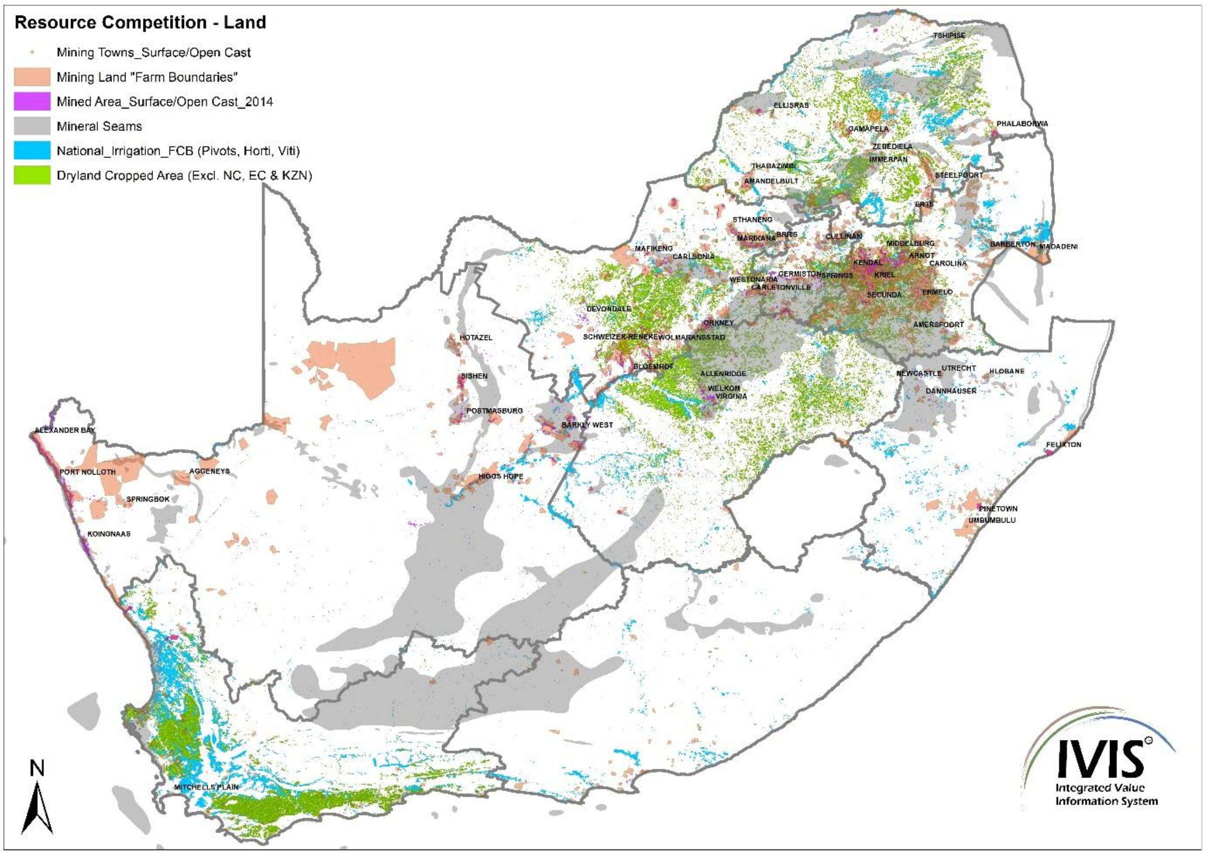


FIGURE 17 - COMPETITION FOR LAND: AGRICULTURE AND MINING
Source: DEA (2015), DMR (2015), DAFF (2014), BFAP (2014), CGS (2010) & IVIS (2015)

Over the past few decades, vast amounts of agricultural properties were sold or transferred from solely agricultural land to the property now having mining rights and being classified as a title deed registered as a mining farm/mining rights. From the available data (DMR, 2015) it is calculated that as much as 12 000 400 ha of agricultural land is now registered as mining land. While there are numerous inaccuracies and inconsistencies in this database, it remains the best in existence. In 2012, Mpumalanga alone had a total of 2.6 million hectares of land classified as being under "mining and prospecting" (BFAP, 2012). Furthermore, of the 2.6 million hectares, 670 000 hectares was regarded as high potential arable land (BFAP, 2012). However, based on additional data sources and recalculations, this 2.6 million hectares has increased to 4.4 million hectares since 2012. The full data summary of Figure 17 is shown in Table 8 below. Provinces such as the Northern Cape, Eastern Cape and KwaZulu-Natal were not included in this final summary output as limited surface area is currently affected regarding competition for land use between mining and agriculture.

TABLE 9 - DATA SUMMARY TO COMPETITION FOR LAND

	Province	All Cash Cropped/Cultivated/ Planted Pasture Field Boundaries (Excl. Sugar cane) - Hectares (Ha)	Mined Area (Surface/Open Cast) - (Ha)	Mining Properties / "Cadastral Farms" Area - (Ha)	All Mining Properties / "Cadastral Farms" Overlaid with Cropped Area - (Ha)
Focus Provinces	Mpumalanga	1 198 382	151 412	4 394 859	490 238
	North West	2 029 334	58 207	1 896 073	263 873
	Limpopo	1 459 875	28 900	729 787	88 036
	Gauteng	376 843	20 860	481 967	54 189
	Free State	3 816 375	23 670	114 150	23 554
	Western Cape	1 877 287	9 298	227 278	65 074
	National		403 233	12 127 071	

Source: IVIS (2015)

Figure 18 indicates the quaternary river catchments where the mining and agricultural / irrigation sectors are competing for local water resources.

- The green areas are less stressed and thus can facilitate co-development of both sectors
- The orange and red areas have medium to longer term water shortages which will most likely result in the stronger sector dominating the competition for water:
  - In orange areas, mining will most likely dominate due to high value commodity minerals
  - In the red areas, agriculture is most likely to dominate due to high value agricultural crops versus lower value mining commodities
- The purple areas indicate natural resource limitations which include the impact on water quality and extensive pressure on ecological instream flow requirements. Government will have to consider the environmental impact of each sector before allowing the competition to unfold.

3.2 Water

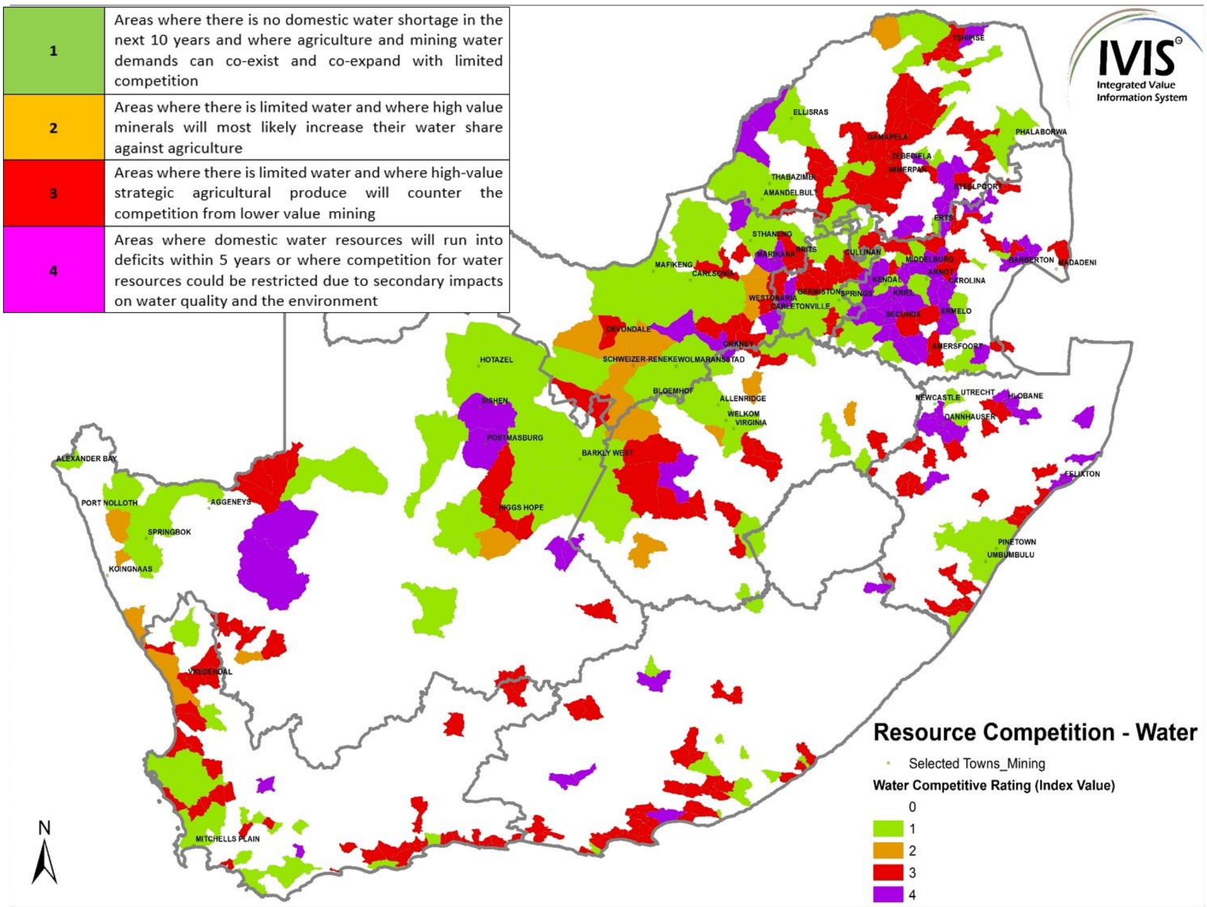


FIGURE 18 - COMPETITION FOR LOCAL WATER RESOURCES
Source: IVIS (2015)

Table 10 lists the affected area for each sector in each of the above water resource impact categories.

TABLE 10- EXPLANATION OF WATER AFFECTED AREAS

Legend			
Water Competitive Rating	**Description**	**Mining property area (ha)**	**Agriculture's land-use area (ha)**
1	Areas where there is no domestic water shortage in the next 10 years and where agriculture and mining water demands can co-exist and co-expand with limited competition	3 940 527	3 590 723
2	Areas where there is limited water and where high value minerals will most likely increase their water share against agriculture	407 576	754 872
3	Areas where there is limited water and where high-value strategic agricultural produce will counter the competition from lower value	1 440 651	2 255 280

	mining		
4	Areas where domestic water resources will run into deficits within 5 years or where competition for water resources could be restricted due to secondary impacts on water quality and the environment	1 373 385	1 017 797
		7 162 139	**7 618 672**

Source: IVIS (2015)

The 2012 pilot study evaluated possible impacts of coal mining on maize production in a specific pilot region in the Mpumalanga province. But besides the detailed pilot area calculations, some high-level provincial calculations were also made with anecdotal evidence and available data. Broad assumptions had to be made in this previous report, which stated that "a total of 326 022 ha will be lost to mining and a further 439 577 ha if the prospecting area is also transferred", this if all mining takes place as indicated by the DALA (Department of Agriculture and Land Administration) in McCarthy et al. (2009). The assumption there was that all property transferred/owned by mining would eventually be mined on the surface and land once used for crop production would be displaced.

Since the 2012 study, various new data sources have been added and refinements have been made to the analytical spatial methods used by BFAP. Here, we propose updated calculations to fully quantify the possible future conflicting areas, which we have named "hotspots"; i.e. these areas include the surface area where land-use competition is expected (Figure 19). Within the hotspots identified in Figure 19, mine-owned land / surface and open-cast mining areas overlap with agricultural cropped land (grains and oilseed field crop boundaries). By following this approach, we have attempted to prevent broad over-estimations or making unsubstantiated assumptions (such as all mining owned land / registered mining land would be completely surface mined). Prospecting was also excluded from surface area competition. An example of this process is demonstrated in Figure 19 and explained in the text that follows.

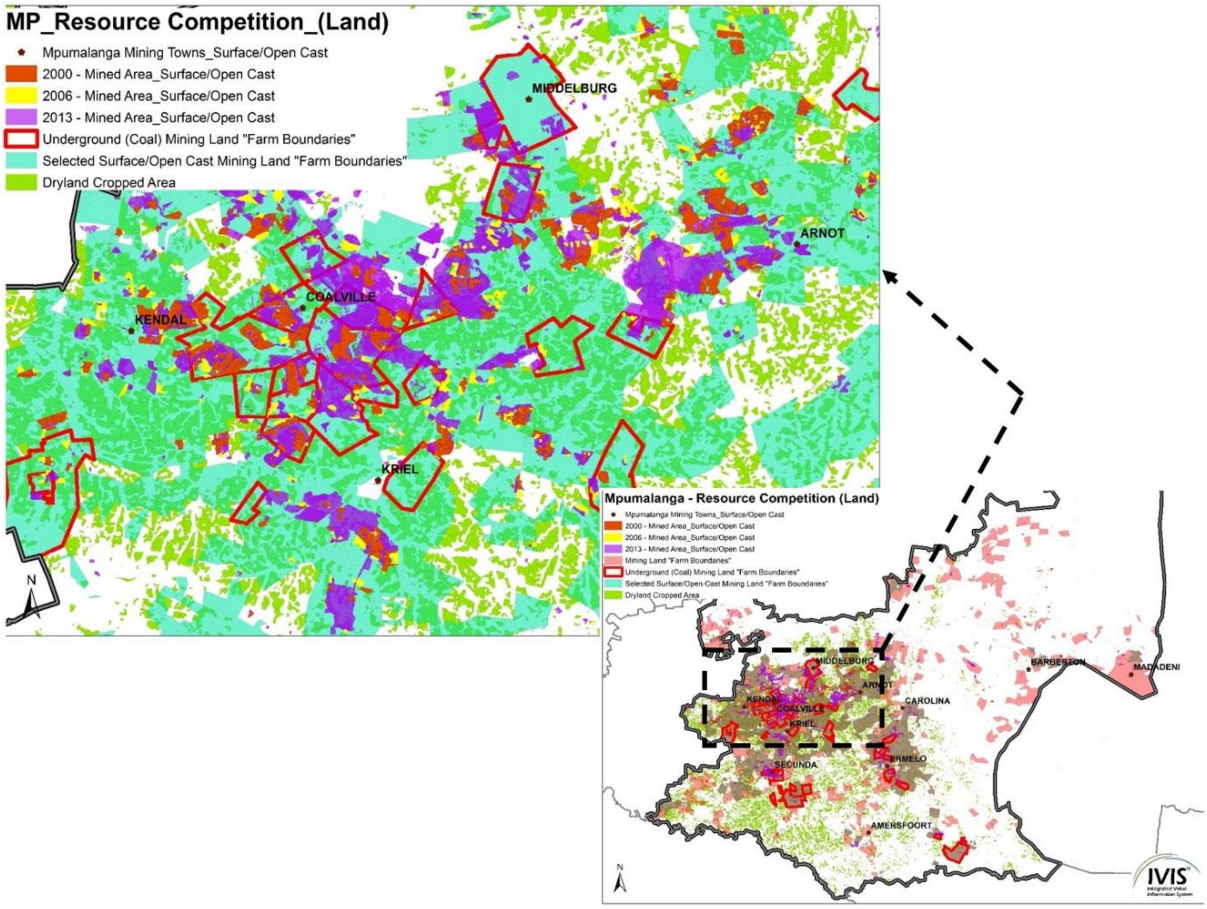


FIGURE 19: AGRICULTURE & MINING HOTSPOT AREA IDENTIFICATION EXAMPLE
Source: IVIS (2015)

The "hotspot" allocation process:

a) Following the panel (a) in Figure 19, the pink areas indicate the properties which have registered mining rights, which will be classified as a title deed registered as a mining farm/have mining rights. Not all of these mining "farm boundaries" will be surface mined or even mined in general, therefore
b) the surface area impacted / open-cast mining "farm boundaries" were selected by commodities (Coal, PGM's etc.), as well as those which were registered as underground mines using the DMR (2015) database (which we spatialized). Furthermore,
c) as shown by the red boundaries in the zoomed in panel (b), Figure 19, most of the registered underground mining "farm boundaries" have surface activity covering most of the area which is shown by:
    1) red – the year 2000 surface / open-cast mining activity
    2) yellow – the year 2006 surface / open-cast mining activity
    3) purple – the year 2013 surface / open-cast mining activity
d) A final selection was therefore made by:
    1) selecting the commodity specific mining "farm boundaries" (those which are known to have surface operations), then
    2) overlaying them with the existing and past national land cover imagery for mining, and finally,
    3) from the areas identified in (1) & (2), selecting the "hotspot" areas as the ones which also have dense cash cropped field crop boundaries on them.

The hotspot area selection process was the same for most of the provinces, except where it was seen that DMR “farm boundaries” data was insufficient (surface activity from the NLC is known for surface/open-cast mining). The provinces which had limited surface / open-cast area competing with agricultural land use were removed from the map. Furthermore in Mpumalanga and North West, water stressed areas exacerbate the competition for natural resources between agriculture and mining, which can also be seen in Figure 17. The resulting grains and oilseeds impacted crop area is summarised per province in Table 11.

3.3 Resource Hotspots for Mining and Agriculture

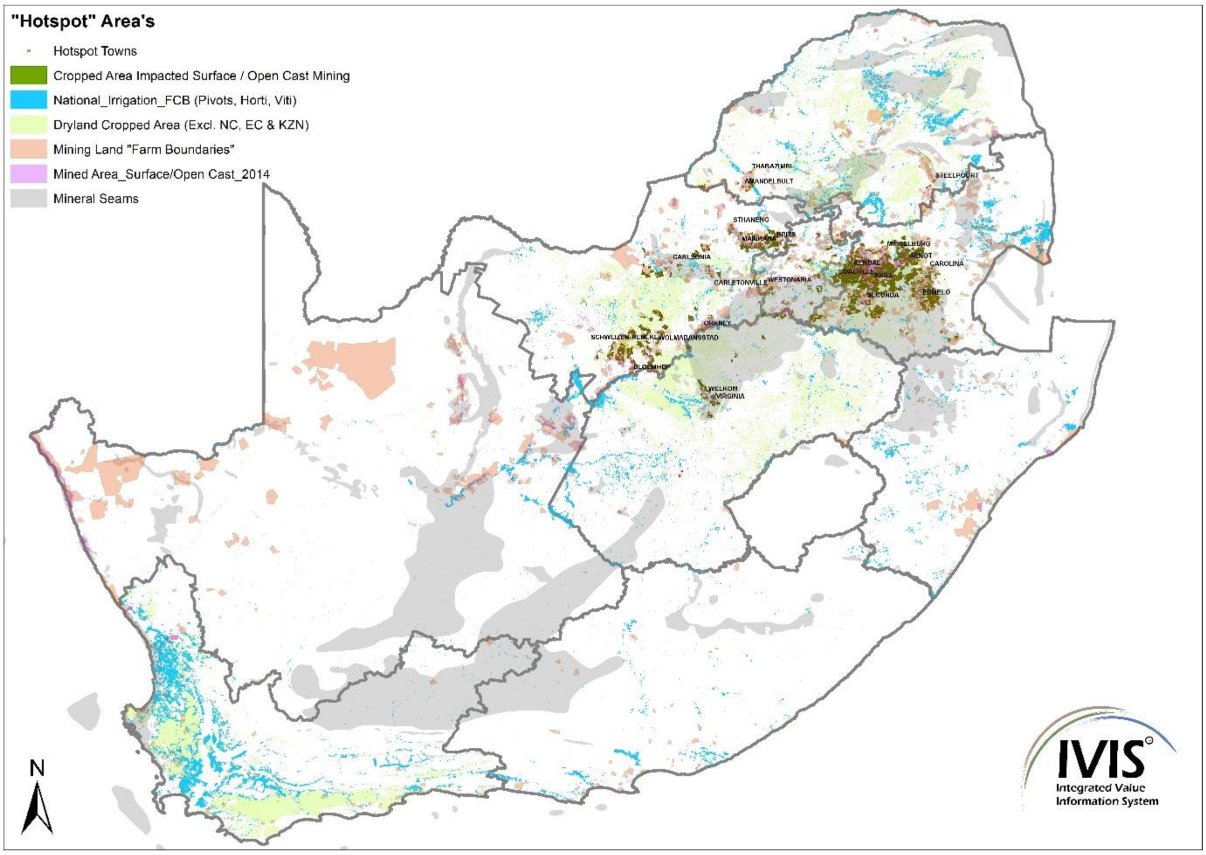


FIGURE 20- HOTSPOTS: MINING AND AGRICULTURE LAND USE OVERLAY
Source: IVIS (2015)

TABLE 11 – "HOTSPOT" CASH CROP IMPACTED AREA BREAKDOWN

	Total Crop Impacted Area	**Grains & Oilseeds Impacted (Dryland)**	**Grains & Oilseeds Impacted (Irrigation)**	**Grains & Oilseeds Portion of Crop Impacted Area**
	Hectares	*Hectares*	*Hectares*	*%*
Mpumalanga	365 806	263 875	9 796	74.8%
North West	125 223	73 752	8 279	65.5%
Limpopo	35 974	5 249	3 292	23.7%
Gauteng	10 197	4 393	655	49.5%
Free State	16 254	5 325	519	36.0%
Western Cape	Limited surface area affecting agriculture			
Northern Cape	Limited surface area affecting agriculture			
KwaZulu Natal	Limited surface area affecting agriculture			
Eastern Cape	Limited surface area affecting agriculture			
Total	**553 454**	**352 595**	**22 541**	**67.8%**

In this section an initial attempt was made to clarify, by using spatial data, the current extent of competition for land and water between agriculture and mining. However, understanding the extent of competition alone does not capture the problem sufficiently. Further empirical analysis is needed to understand the impact of resource competition between these two sectors on current and future national security.

4 Assessing the Implications of Competition between Agriculture and Mining

This section assesses the implications of competition for resources on national security, especially looking at the implications for the agricultural sector in more detail.

4.1 Analytical Framework

In this section the implications of expanded mining for national security in South Africa are explored at a strategic level. Concerns addressed in this report around the future co-existence of agriculture and mining are shaped by key drivers and assumptions around the two sectors' competition for natural resources and the impact each has on the South African environment, economy and social make-up. In order to gain clarity around those assumptions, a strategic scenario planning workshop was coordinated including experts in the spheres of mining, agriculture, environment, mine rehabilitation and government. Plausible futures for agriculture and mining were identified with "plausible cause and effect links that connect a future condition with the present, while illustrating key decisions, events, and consequences [in] the narrative" (Glenn, 2006: 2).

The great strength of a scenario exercise is that it can be used to look at today's challenges from different perspectives. The process of identifying and examining how current factors and trends might play out in the future helps participants focus on the likely impact of those trends on their areas of responsibility. Quite often, participants find that the impacts are going to be bigger – or happen sooner – than they had previously realised. Scenarios never predict the future. Rather they provide the means to consider today's policies, plans and decision-making processes in light of potential future developments.

The process and results of the scenario planning workshop are detailed in Annexure A. For the purposes of the workshop, participants agreed on the unit of analysis as:

"THE CONTRIBUTION AND CO-EXISTENCE OF MINING AND AGRICULTURE TOWARDS ENSURING NATIONAL SECURITY IN 2030-35".

This unit of analysis was used as a reference during the workshop and the topic around which the scenarios were built. Furthermore, it served as a tool in phrasing the research question of this report at an elevated level of national importance.

Key knowns and unknowns concerning the unit of analysis were identified and used to construct a game board where unknowns were ranked in terms of degree of uncertainty and impact on the unit of analysis. A scenario matrix was set up with axes representing governance and commodity prices, from which 4 scenarios were defined. Figure 21 gives a short description of the 4 scenarios.

	TERRIBLE GOVERNANCE	EXCELLENT GOVERNANCE
HIGH COMMODITY PRICES	**BLOOD DIAMOND** It's a dog-eat-dog world out there with cutthroat tactics when it comes to producing the 'yellow gold', be it maize or mineral. For a while the farmers had the upper hand because of food security concerns, but corruption and mining are a match made in heaven. Mind you, the panga swings… any more food price hikes, and riots will lead to a rethink. Pity the roads are unusable, never mind the water….	**THE SOUND OF MUSIC** The hills truly are alive with the sound of music as all stakeholders 'sing from the same hymn sheet'. There is fierce competition for land and mega-bucks to be made, but miners, farmers, government and investors all play by the rulebook; plus play nice with one another. Best of all is the brilliant management of scarce water, combined with the solid shift to renewable energy. It's time to yodel… wait, let's make that ululate!
LOW COMMODITY PRICES	**GOTHAM CITY** You don't need to be a Batman fan to recognise this dark and dysfunctional setting. The mining and agriculture sectors are bleeding profits, people and principles. Not that this makes the headlines, though. The crisis is all about out-of-control corruption, service delivery protests on steroids and 'water-shedding' in full swing. Some land lies fallow, some land degrades and some land is up for grabs, just because it is…	**BEAUTY & THE BEAST** The transformation and NDP pay-off has properly kicked in, and as expected, some old (fashioned) mining and agriculture stalwarts (aka the beasts) haven't survived into the new, albeit tough, era. If only the commodity cycle would tick up. It is punishing to make a profit, especially when policy, and even monetary, support goes only to those who work together *and* deliver the true triple bottom-line. Wilderness areas are a beauty to behold, though.

Figure 21 - Short Scenario Descriptions

The scenarios defined during the scenario planning workshop are, as all scenarios, not predictive. The scenarios essentially provide stories of various plausible futures. In and by itself such scenarios are not analytic. The scenarios, however, provide a basis for analytic discourse. Figure 22 illustrates the specific analytical approach that was used in using the scenarios to inform the modelling.

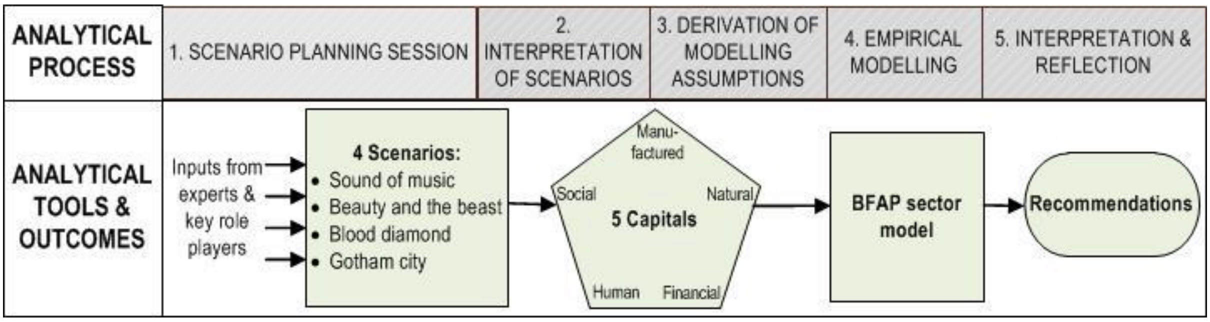


FIGURE 22- THE ANALYTICAL FRAMEWORK USED IN THIS STUDY

4.2 The Five Capitals

In order to use the scenario narratives to inform model assumptions (which would then feed into empirical modelling outcomes and tangible policy recommendations), it was necessary to first analyse the scenarios in a systematic way to provide criteria relevant to the model (step 2 in Figure 22). Given the fact that both mining and agriculture are embedded in the use of both manufactured and natural capital and also contribute greatly to further capital formation, we chose to use the '5 capitals' analytical framework for interpreting the results of the scenario session. The 5 capitals are defined as follows (Goodwin, 2003):

1. **Financial capital** includes various monetary assets that enable productive activity. Some examples of financial capital are savings and investments (including stocks and bonds).
2. **Social capital** encompasses the value of social relationships that enable people to work together. Common examples of social capital are the cultural norms and national laws that enable people to coordinate their activities within the economy.
3. **Human capital** is a term that describes the range of an individual's knowledge, skills and capabilities that make him or her a productive asset within the economy. Typical indicators of human capital are years of experience and education.
4. **Manufactured capital** is defined as physical assets that are generated by applying human productive activities to natural capital and that are used to provide a flow of goods and services. Typical examples of manufactured capital include infrastructure and processing capacity.
5. **Natural capital** includes the quantity and quality (stocks) of living and non-living natural resources which produce ecosystem services that underpin economic activity and human well-being. The management and allocation of natural resources greatly influences a healthy, functional environment.

In particular, we used this framework to describe the state of each capital under the four different scenarios (Table 12). We also used Table 12 to propose hypothetical consequences of each scenario for the economy, environment and society respectively (Table 13).

TABLE 12 - STATE OF THE 5 CAPITALS WITHIN EACH SCENARIO

(Please note that emoji are used to augment the definitions of the state of each capital; they are used for illustrative purposes only)

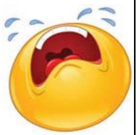
Scenario's / 5 capitals	Financial	Social	Human	Manufactured	Natural
Sound of Music	High levels of savings and investment 	Excellent social coordination to achieve economic productivity 	Skilled & healthy workforce 	Sufficient and well-maintained infrastructure 	Enhanced ecosystems and healthy, well-managed resource stocks 
Beauty and the Beast	Moderate and stable levels of savings and investment (driven by good governance) 	Coordination between formal sectors of society (e.g. business & government) driving economic activity 	Moderately skilled workforce supported by functional health services and access to basic education 	Insufficient but well-maintained infrastructure 	Functioning ecosystems with most resource stocks being used sustainably 
Blood Diamond	Moderate but volatile levels of savings and investment (driven high commodity prices) 	Social cohesion amongst a select few which drives a corrupt but active economy 	Moderately skilled workforce hampered by poor health services limited access to basic education 	Disparate supply and quality of infrastructure 	Partially-functioning ecosystems and unsustainable depletion of resource stocks 
Gotham City	Low levels of savings and investment 	Social disarray which hinders economic activity 	Unskilled, poorly educated workforce with almost no access to public health services 	Neglected & insufficient infrastructure 	Degraded ecosystems and rapid depletion of resource stocks 

TABLE 13 - HYPOTHETICAL CONSEQUENCES OF THE STATE OF THE 5 CAPITALS IN EACH SCENARIO

Scenario's / 5 capitals	Financial	Social	Human	Manufactured	Natural	*Notes / Generic Characteristics of Scenario*
Sound of Music	• Strong and steady economic growth • Exceptional public financial management • Ample foreign direct investment through positive investor's sentiment • Positive trade balance	• Excellent cooperation between different sections society. • Low crime combined with general sense of security • Widespread support for governance structures, with coherent and consistent policy. • Functional and stable land transactions	• Universal access to high quality education • High absorption rate leading to higher employment • R&D and technological innovation • Widespread access to good quality healthcare	• Improved infrastructure and maintenance thereof including roads, water, transport, and communication • Improved basic services provision for the poor	• Sustainable use of resources and sound land use planning • Consistent investments in rehabilitation of degraded ecosystems • Reduced pollution • Enhanced ecosystem services, integrity and resilience • Large-scale transition to renewable energy	• *Responsible, coordinated governance promotes sensible public spending and sustainable use of natural resources* • *A high commodity price environment provides ample and readily available finance and revenue, which in turn bolster the ability of the fiscus to provide public goods and services.* • *Stable macroeconomic environment* • *Trusting, resilient and cohesive society* • *Environmental sustainability is prioritized appropriately*
Beauty and the Beast	• Sound management of public finance management?? • Subdued investment • Healthy, stable GDP growth (although, most of the growth is coming from non-primary sectors) • Positive or negative trade balance • Limited investor's confidence	• Collaborative society, working together in order to stay afloat in tough times • Moderate crime levels • General support for governance structures • Few but sensible land transactions which facilitate sound land use planning	• Universal access to good quality education • Higher employment via alternative economic activity • Widespread access to health care of varying quality • Subdued R&D and technological innovation	• Well maintained infrastructure, however not expanding and stimulating new growth opportunities • Basic services provision improves slowly	• Some investments in rehabilitation of degraded ecosystems • Some pollution control measures in place • Adequate provision of ecosystem services • Some adoption of renewable energy	• *Sound governance and public spending, working towards sustainable resource use* • *Government and general business face budgetary constraints in the low price environment* • *Emphasise on secondary and tertiary sectors of the economy, rather than primary due to low commodity prices* • *Generally trusting society* • *Environmental protection is prioritized but is limited by constrained budgets*

Blood Diamond	• Generally low and sporadic economic growth • Squandering of tax revenue • Volatile investments favour a few, promising sectors, especially primary sectors due to high commodity prices. • Positive or negative trade balance	• Increasing levels of crime aiding a growing, corrupt economy • Inconsistent implementation of government policies • Land transactions through informal land markets	• Exclusive, unequal access to education • Increasing unemployment rate • Restricted access to healthcare • Limited privately funded R&D focussing on a few lucrative opportunities	• Infrastructure systems aid a select few in mobilising economic activity, and are being left abandoned everywhere else • Basic service delivery is low	• Unsustainable exploitation of natural resources, aiding some in producing wealth and others being ever worse off. • Lack of diversifying the energy mix leading to increasing ongoing crisis management. • Widespread degradation • Constrained ecosystem services hamper human well-being and restrict economic activity	• *Bad governance and unsustainable depletion of natural resources* • *High levels of inequality* • *High commodity prices, leading to economic focus on primary sectors.* • *Distrusting, lawless society* • *Passivity towards environmental challenges* • *Resources being polluted and diminished*
Gotham City	• Low economic growth • Corrupt public finance. • Decreased to no investment, debilitating smallest potential growth • Negative trade balance • Companies fight for whatever is left to gain.	• Divided, fearful sections of society • High crime levels, lawlessness abides with no sense of security • Distrust of governance structures with inappropriate, conflicting policies. • Non-existent land transactions, taking the form of land grabs	• Limited access to education • Prevalent, high unemployment rates • Diminished R&D capacity • Scarce access to healthcare	• No new large capital projects being undertaken • Totally neglected and derelict infrastructure • Diminished, inconsistent basic services provision	• Depletion of natural resources further exacerbating limited access to basic services • Heavily polluted environment • Rampant degradation • Failing ecosystem services resulting in severely constrained economic activity and vulnerability to natural disasters	• *Terrible governance and rapid depletion of natural resources* • *Low price environment limits availability of finance and revenue* • *Unstable macroeconomic environment* • *Suspicious, cynical and lawless society.* • *Neglected environment*

Formulating Table 12 and Table 13 using the 5 capitals provided a system for narrowing down the narrative scenarios to an analytical dimension in which assumptions for model work can be made (step 3 in Figure 22). These tables also highlight the fact that the coexistence of agriculture and mining can promote or detract from achieving national security. The management of all 5 capitals is crucial to achieving a nationally secure and sustainable South Africa (including energy and food security). South Africa faces resource constraints (section 3) in terms of the quality and quantity of land and water in the near future and agriculture and mining are both highly dependent on these resources for economic survival. Given what we've learned from history (section 2.1) and the case study (section 2.2), the two sectors will most probably react by either intensifying the competition for these precious resources, or find ways to collaborate in finding win-win solutions.

President Jacob Zuma, in the most recent two State of the Nation Addresses (SONA, 2015a and b) referred to a Nine Point Plan to revitalise the South African economy. Matters that took centre stage included the energy shortage and agriculture in its role of promoting growth and food security and being one of the platforms through which increased equity is hoped to be achieved. Two Nine Point Plan points include a) the revitalisation of agriculture and the agro-processing value chain and b) advancing beneficiation (adding value to our mineral wealth). These two goals together with the reality of resource scarcity (especially land and water) imply competition between agriculture and mining for these resources. Furthermore, several points are mentioned in the Nine Point Plan which require mining and agriculture to collaborate in achieving them: unlocking the potential of SMMEs, co-operatives as well as township and rural enterprises; resolving energy challenges; stabilising the labour market and scaling up private-sector investment.

The emerging two plausible forms of coexistence between agriculture and mining, namely competition or collaboration are further substantiated. A competitive coexistence in the Sound of Music and Gotham City scenarios was simulated to illustrate the implications for agriculture and food security in a best and worst case scenario. A collaborative coexistence could, however, not be modelled due to the multitude of ways that collaboration could plausibly be achieved (many of which may, as of yet, be unknown or unexplored). Some of these are discussed and mentioned in the report recommendations.

Next, in section 4.4 the BFAP sector model will be described, the assumptions for each scenario detailed and modelling results will be discussed.

4.3 Assumptions

Up to this point, context around the history, economy, environment, and regulatory aspects governing agriculture and mining were discussed. The extent of competition for resources (land and water) was illustrated. In assessing the impact of this competition, scenarios were discussed and used to inform the 5 capitals as an analytical framework towards formulating assumptions. This section expands on the discussions through an empirical illustration of the impact of a changing environment associated with the scenarios on the agricultural sector and food security, focussing on maize and its competing crops. The methodology underpinning the BFAP sector model will be discussed briefly before the assumptions related to two scenarios are defined, followed by a discussion of the results from each scenario.

4.3.1 The BFAP Sector Model and Baseline Simulation

The BFAP sector model is an econometric, recursive, partial equilibrium model of the South African agricultural sector. Presently, the model includes 42 commodities: for each commodity, the important components of supply and demand are identified and equilibrium established in each market by means of balance sheet principles where demand equals supply.

The model is used to generate a 10 year baseline projection for the South African agricultural sector annually, which serves as a benchmark against which the impact of alternative scenarios can be measured and understood. In generating the baseline projections, a number of critical assumptions have to be made regarding a range of economic, technological, environmental, political, institutional and social factors. One of the most important of these is that average weather conditions will prevail in South and southern Africa and around the world: therefore yields grow constantly over the baseline as technology improves. Assumptions with respect to the outlook of macroeconomic conditions are based on a combination of projections developed by the International Monetary Fund (IMF) and the World Bank. Baseline projections for world commodity markets were generated by the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri. Once the critical assumptions are captured in the BFAP sector model, the Outlook for all commodities is simulated within a closed system of equations. This implies that, for example, any shocks in the grain sector are transmitted to the livestock sector and vice versa.

The latest trends, policies and market information are taken into consideration in the baseline, which is constructed in such a way that the decision maker can form a picture of equilibrium in agricultural markets under the specified set of assumptions. Markets are extremely volatile and the probability that future prices will not match baseline projections is high, therefore the baseline does NOT constitute a forecast, but rather represents a benchmark of what COULD happen under a particular set of assumptions. Inherent uncertainties, including policy changes, weather, and other market variations ensure that the future is highly unlikely to match baseline projections. Recognising this fact, BFAP incorporates scenario planning in the process of attempting to understand the underlying risks and uncertainties of agricultural markets. In the current case, the Sound of Music, Blood Diamonds and Gotham City environments, as discussed in section 4.2 are used as three plausible future contexts sketching expectations of the agricultural sector operating within these environments.

While providing a useful tool in quantifying the impacts of various future scenarios, the BFAP sector model should be regarded as only one of the tools in the decision-making process for the agricultural sector, and other sources of information, experience, planning and decision making techniques have to be taken into consideration.

The macro-economic environment in South Africa remains characterised by significant volatility. The economic growth rate has been adjusted downward by the latest IMF World Economic Outlook to an annual average of 2.5% over the next 5 years, down from over 3%. The Rand continues to depreciate, which supports local commodity prices, particularly in sectors where South Africa is a net importer, but also creates pressure through increased input costs. While the cost of Brent Crude oil plummeted, the domestic impact was negated to some extent by the depreciation in the Rand and increases in fuel levies. Within this turbulent macro-economic environment, which impacts on commodity prices and the cost of key inputs, changing weather conditions, as well as political and policy influences in agricultural markets have added a great degree of uncertainty going forward. Nonetheless, the baseline is dependent on a plausible set of assumptions, which are summarised in Table 14. Furthermore, the baseline assumes that the current policies remain in place, essentially representing a ‘status quo’ outcome for the sector.

TABLE 14 - BASELINE ASSUMPTIONS

	2015	**2020**	**2024**
GDP growth rate	2.0%	2.8%	2.8%
Exchange rate (ZAR vs USD)	R12.32	R16.08	R18.00
Oil Price (USD/barrel)	$64.00	$89.22	$115.31
World Maize Price (USD/ton)	$187.38	$204.31	$195.92

Source: IMF, World Bank and FAPRI

In line with past projections, South African maize area declined marginally in 2015, as the expansion in yellow maize area was insufficient to offset the reduction in white maize plantings. The white and yellow maize balance sheets in Figure 23 indicates that the summer grain producing regions experienced exceptionally challenging weather conditions in 2015, causing yields to fall to decade lows, with the greatest impact in the Free State and North West provinces where more white maize is traditionally produced. Concerns related to domestic supply, combined with limited surplus markets for potential white maize imports have pushed prices up sharply, a case in point to what was discussed in Box 5 in section 2.3.1. Due to delayed rain, planting of the 2016 maize crop is slow to commence, raising concerns regarding the 2016 crop and the resultant price levels.

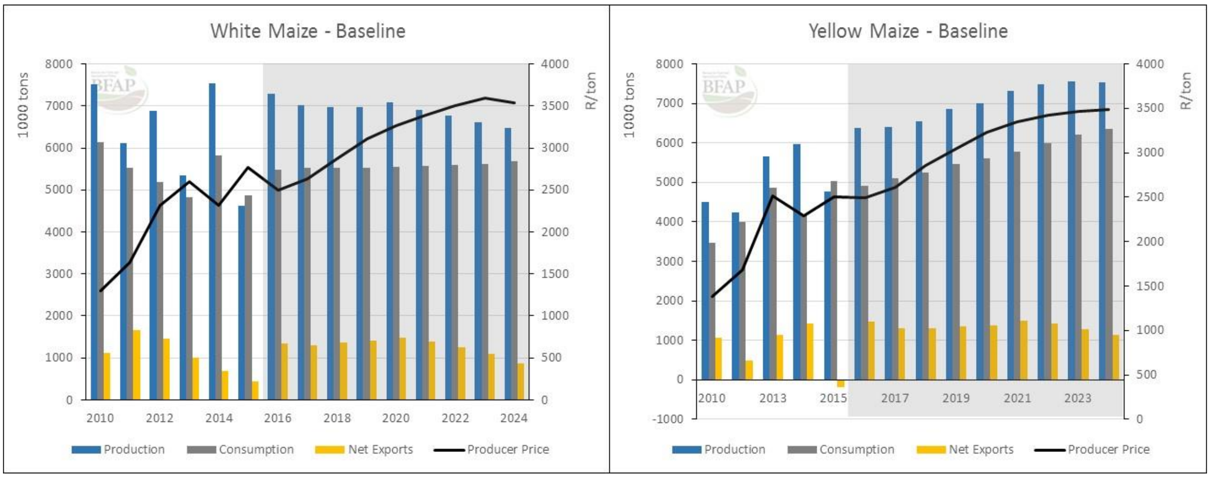


FIGURE 23 - BASELINE MAIZE BALANCE SHEETS

Source: BFAP

Meanwhile ample supplies in the global market prevented yellow maize prices from increasing to the same extent (Figure 24). Consequently, white maize is currently trading at a substantial premium to yellow maize.

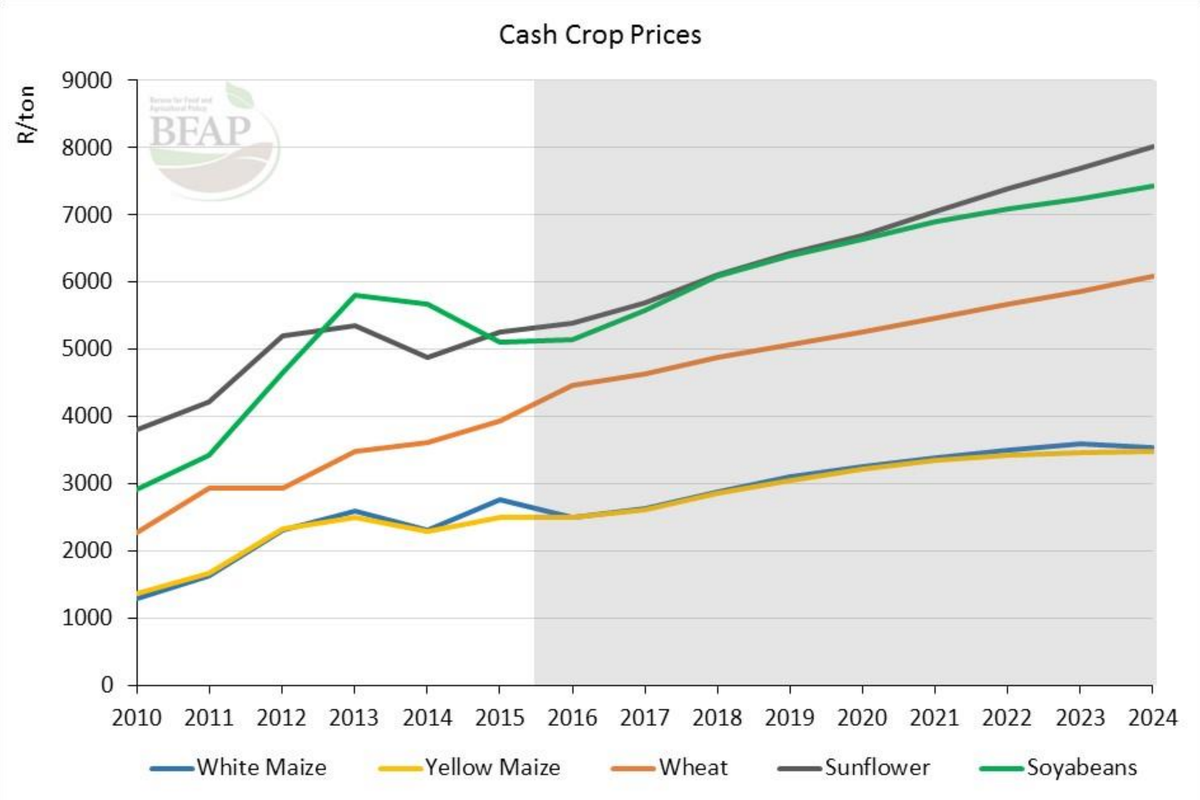


FIGURE 24 - CASH CROP PRICES - BASELINE
Source: BFAP

While considerable growth is projected in the animal feed sector which traditionally relies on yellow maize, the market for human consumption remains stagnant over the Outlook period and the premium is not projected to remain in the longer term, resulting in a continuation of the declining trend in white maize plantings. Nevertheless, a return to normal (as recorded historically) weather conditions will see South Africa remaining a net exporter, as growth in yields is expected to be sufficient to ensure ample supply for human consumption. Over the Outlook, the total area under maize is projected to settle around 2.4 million hectares (Figure 25). Soya bean area has also expanded rapidly in recent years (Figure 25) and despite the drought conditions in 2015, South Africa is expected to harvest a record soya bean crop of just over 1 million tons. Further area expansion is projected in 2016 and a return to trend yields would result in a crop of more than 1.2 million tons. By 2024, production is projected to surpass 2.1 million tons. The fine balance in the domestic sunflower market will be maintained over the Outlook and, given ample domestic crushing capacity, South Africa is projected to maintain a small net importing position. Over the long run, domestic wheat production in South Africa is projected to remain relatively stable around 1.6 million tons with yield growth offsetting the declining area. In the face of rising consumption levels, imports will continue to increase, surpassing 2.2 million tons by 2024. Wheat prices will find support from the depreciating exchange rate, as well as the variable import tariff applied when the international reference price moves below $294.

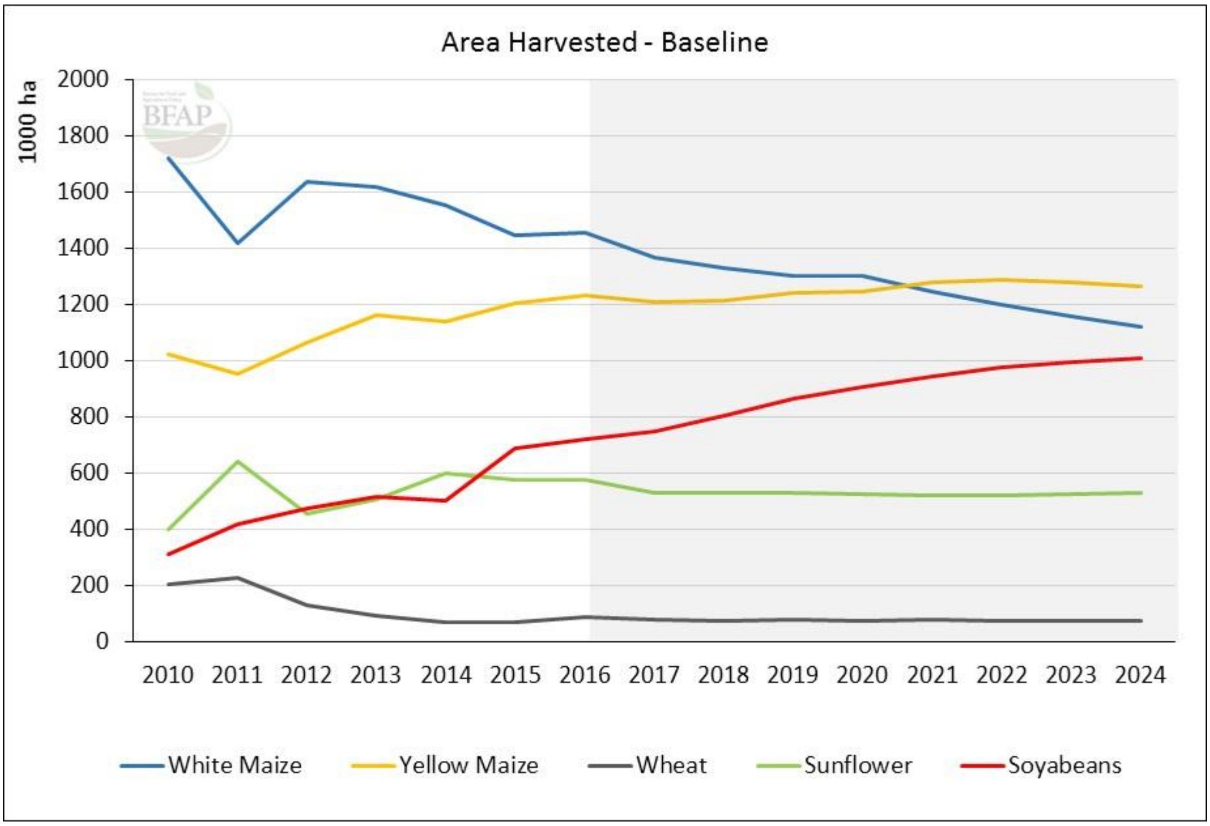


FIGURE 25 - CASH CROP AREA HARVESTED – BASELINE

Source: BFAP

In light of continuous growth in income levels and the associated class mobility of South African consumers, the demand for meat products has expanded rapidly over the past decade. As the cheapest and most accessible source of protein, chicken has dominated this growth. While a confluence of macroeconomic factors results in higher meat prices and slower consumption growth relative to the past decade, it remains significant over the next 10 years.

4.4 Analysing the Impact of Scenarios on Agriculture

4.4.1 Macroeconomic Assumptions

In order to relate the Sound of Music, Gotham City and Blood Diamond scenarios to the BFAP sector model, a set of exogenous assumptions related to each scenario had to be defined. While some external factors and uncertainties discussed in the various scenarios in section 4.2 could not be incorporated into the model, the assumptions regarding the macro-economic factors that could be modelled are presented in Table 15.

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TABLE 15 - MACRO-ECONOMIC ASSUMPTIONS: 9-YEAR ANNUAL AVERAGES (2016-2024)

	GDP growth rate	Exchange rate (ZAR vs USD)	Oil Price (USD/barrel)	World Maize Price (USD/ton)
Baseline	2.7%	R16.04	$90	$198
Sound of Music	4.0%	R12.88	$126	$252
Gotham City	1.2%	R22.50	$58	$154
Blood Diamond	1.2%	R18.64	$126	$252

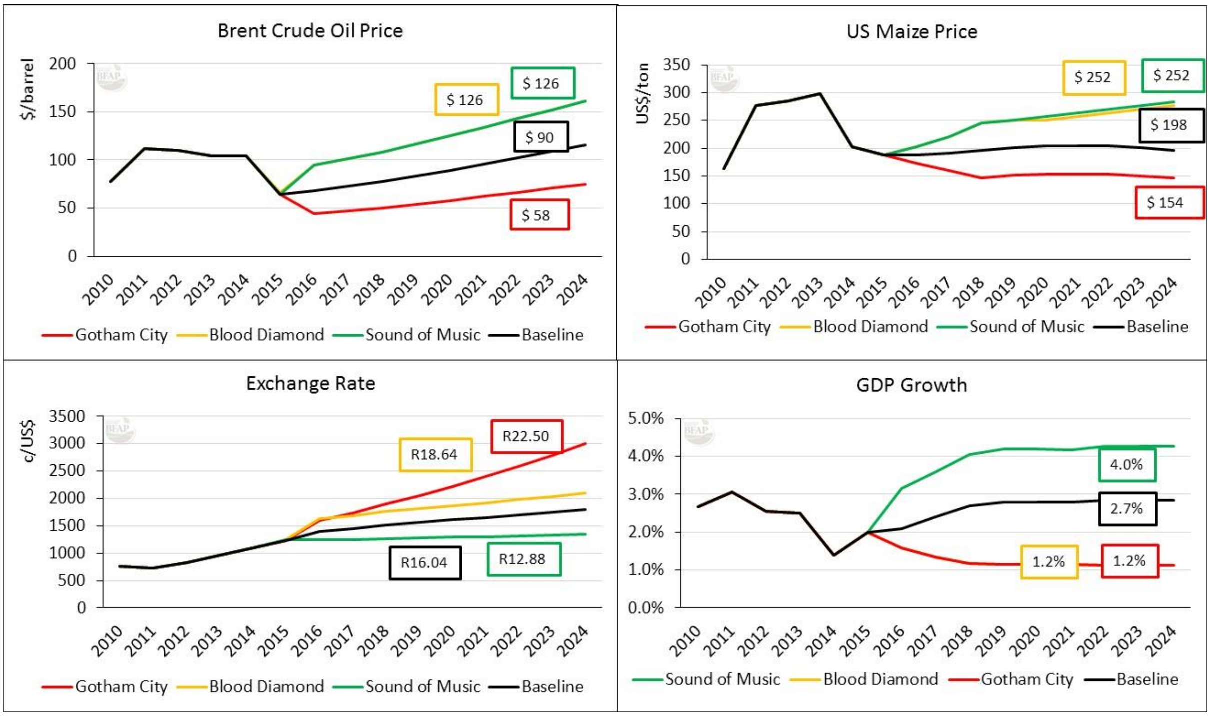

FIGURE 26 – MACRO-ECONOMIC ASSUMPTIONS: SCENARIO VS. BASELINE
Source: BFAP

For Sound of Music, a future characterized by excellent governance and high commodity prices, a high and steadily increasing average GDP growth rate and a strong and stable Rand-Dollar exchange rate are assumed over the outlook period, together with strong Brent Crude oil and world soft-commodity prices (

Table 15). In contrast, the Gotham City future is one characterized by terrible governance and a low commodity price environment. Hence a low and decreasing GDP growth rate, faster depreciation of the exchange rate and low international oil and soft-commodity prices are assumed. In Gotham City, consumers are to some extent supported by the low price environment. Blood Diamond however is characterized by terrible governance and high prices implying that a weak exchange rate, slow economic growth, high Brent crude oil prices and high food prices simultaneously aggravate food price increases. The scenario assumptions are graphically compared to the baseline in Figure 26. The boxes on the charts are indicative of the average annual value over the outlook period (2016-2024).

It is important to note that the South African Rand is a commodity based currency, implying that the high or low international commodity price effects are often counteracted by the simultaneous appreciation or depreciation of the exchange rate respectively. Consequently, the movements in international agricultural commodity prices in the different scenarios are not fully transmitted to the South African market. For example, while international prices are low in Gotham City, the weak Rand-Dollar exchange rate has an offsetting effect and the low prices do not get fully transmitted into the South African market. The converse is also true for the Sound of Music scenario. In Blood Diamond, the weak exchange rate increases the effect of the high price environment.

Within any of the 4 scenarios, competition and collaboration were identified as two modes of coexistence between the agricultural and mining sectors in section 4.2. Given that agriculture and mining compete for resources such as land and water, specific assumptions regarding resources have to be incorporated in the simulation of each scenario because the fact of scarce resources has to be faced irrespective of the macro-economic scenario the industries operate in.

4.4.2 Assumptions related to resource competition

Over the past decade, the commodity boom and Sound of Music-like circumstances resulted in many farm portions situated in South Africa's mineral rich areas being purchased by mining companies. Given the extensive acquisitions already recorded, it is assumed that the scope for further land ownership transfers is limited, yet much of the land that has been purchased remains under agricultural production.

In the Sound of Music scenario, strong hard and soft commodity prices lead to fierce competition for land between agriculture and mining. Prices are high enough, making it economically viable for mining to reach minerals further below the surface. Therefore mining expands within the areas that have already been acquired. While economic viability allows most mines to expand in deeper underground mining, this still includes some surface operation expansion. Consequently, it is assumed that 375 000 ha of high potential arable soils will be lost to mining by 2024 (The rounded sum of Grains and Oilseeds impacted dryland and irrigation areas, Table 11).

Excellent governance ensures that water allocation follows the plans set out in the NWRS, and the higher price of water excludes its use for cash crop irrigation. Water used by mining is treated by the mining sector (according to the "polluter pays" principle) and national water security is not threatened. Some of the land initially lost to agriculture is reclaimed but delivers low yields and is more suitable for grazing. However, maize yields continuously grow by an average of 1.9% annually over the outlook period (similar to the baseline), since funding is widely available for R&D and prices are high enough for farmers to adhere to best possible agricultural practices.

In Gotham City low commodity prices dampen competition for land: substantial expansion of mining operations is not economically viable, however the mines already own the farms and can access the mineral seams. Some companies therefore continue mining (extracting/stripping) what they can, on a long-term disinvestment strategy. Only 187 500 ha (half of what is lost in Sound of Music) of high potential arable soils will be lost to mining by 2024. With the cost of potential land reclamation falling on the agricultural sector who simply cannot afford it, the landscape deteriorates. Governance is terrible, therefore water pollution is disastrous and supply is not meeting basic domestic and ecological systems maintenance demand, threatening national water security. R&D capacity is diminished, water is not suitable or available for cash crop irrigation and only some yield growth is maintained due to improved seed varieties from international companies. Maize yields grow by an annual average of 0.95% over the outlook period.

In Blood Diamond governance systems have deteriorated. Resources such as land and water are being abused and distributed to an advantageous few. Black markets spring up everywhere, since with higher than ever hard and soft commodity prices, lots of money is still to be made. Strong prices lead to fierce competition for land between mining and agriculture, resulting in an additional 375 000 ha of agricultural cropland used for mining activities. The cropland transferred includes some of the highest yielding arable land in the country, causing stinted average maize yield growth of 0.95% per annum. Due to the lack of regulation, mines don't bother to rehabilitate land or curb water pollution. The cost of land rehabilitation falls on the agricultural sector, which cannot afford it and the unchecked water pollution inhibits the supply of water for domestic use.

TABLE 16 - AREA AND YIELD ASSUMPTIONS

	Cropland Area additionally Utilised by Mining in 2024	Average Annual Cash crop Yield Growth (2017-2024)
Sound of Music	375 000	1.90%
Gotham City	187 500	0.95%
Blood Diamond	375 000	0.95%

In simulating the scenarios, the total available cropland for the summer cash crop production region in South Africa was gradually decreased, so that the total area decline presented in Table 16 is implemented by 2024. No restriction was imposed on the area allocation to various crops as the sector model allocates area based on economic principles. Furthermore, the "high/low commodity price" scenario involved all commodity prices therefore relative prices were not widely affected.

4.5 Results

4.5.1 Sound of Music

Incorporation of the macro-economic, area and yield assumptions into the model results in a relative shift in the key fundamentals of the agricultural sector. The levels, changes and percentage changes of production, consumption and net exports of white and yellow maize under the Sound of Music scenario are summarized in Table 17 and Table 18.

TABLE 17 - WHITE MAIZE RESULTS - SOUND OF MUSIC

White Maize		2015 (current)	2016	2017	2024
Price	**Actual**	**2651.7**	**2307.3**	**2602.9**	**3831.2**
	change from baseline		-195.2	-27.3	290.3
	% change from baseline		-7.8%	-1.0%	8.2%
Production	**actual**	**4621.8**	**7432.6**	**6835.0**	**6134.0**
	change from baseline		153.4	-194.4	-349.2
	% change from baseline		2.1%	-2.8%	-5.4%
Feed Use	**actual**	**1044.2**	**691.5**	**703.3**	**877.8**
	change from baseline		-140.1	-148.2	-107.6
	% change from baseline		-16.9%	-17.4%	-10.9%
Human Consumption	**actual**	**4444.3**	**4547.1**	**4516.7**	**4408.3**
	change from baseline		-4.7	-49.6	-182.3
	% change from baseline		-0.1%	-1.1%	-4.0%
Net Exports	**actual**	**-169.9**	**1485.9**	**1357.9**	**846.9**

	change from baseline		125.2	36.4	-21.6
	% change from baseline		9.2%	2.8%	-2.5%

TABLE 18 - YELLOW MAIZE RESULTS - SOUND OF MUSIC

Yellow Maize		**2015 (current)**	**2016**	**2017**	**2024**
Price	**Actual**	**2587.9**	**2311.1**	**2639.5**	**3891.8**
	change from baseline		-184.0	25.7	399.7
	% change from baseline		-7.4%	1.0%	11.4%
Production	**Actual**	**4758.3**	**7035.1**	**6434.6**	**7624.8**
	change from baseline		649.5	39.8	89.1
	% change from baseline		10.2%	0.6%	1.2%
Feed Use	**Actual**	**3837.5**	**4602.3**	**4725.0**	**6274.8**
	change from baseline		241.7	177.3	412.1
	% change from baseline		5.5%	3.9%	7.0%
Human Consumption	**Actual**	**291.1**	**310.7**	**293.2**	**226.4**
	change from baseline		11.1	-1.6	-25.3
	% change from baseline		3.7%	-0.5%	-10.0%
Net Exports	**Actual**	**489.4**	**1742.2**	**1235.7**	**851.3**
	change from baseline		449.3	66.0	-67.3
	% change from baseline		34.8%	5.6%	-7.3%

Figure 27 illustrates the shift in prices. Under the Sound of Music, the premium for white maize in 2015 is eliminated from 2016 onwards and the two maize prices trade close to the baseline over the outlook up until 2022: despite the consistent growth in yields, the increase in white maize production cannot keep up with the increasing demand due to the loss in high-potential land and by 2022 the white and yellow maize prices start easing away from export parity levels. This results in autarkic price formation, driven by domestic supply and demand dynamics and the domestic white and yellow maize prices increase by 8% and 11% respectively at the end of the baseline period. The exports of white maize and yellow maize decrease over the outlook.

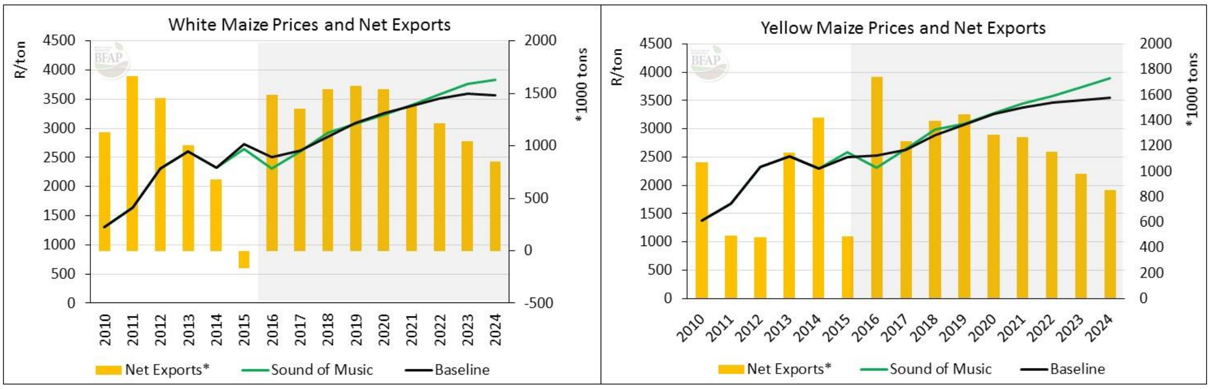

FIGURE 27 - MAIZE PRICES AND NET EXPORTS – SOUND OF MUSIC
Source: BFAP

The area shock imposed on the model decreased total summer cash crop area available, therefore similar to the baseline, the area planted to yellow maize remains relatively constant over the outlook period. White maize area decreases with yellow maize exceeding white maize area in the year 2021 in Sound of Music. The bulk of the area lost to white maize production is allocated to soya beans, while sunflower and wheat areas steadily decrease over the outlook (Figure 28).

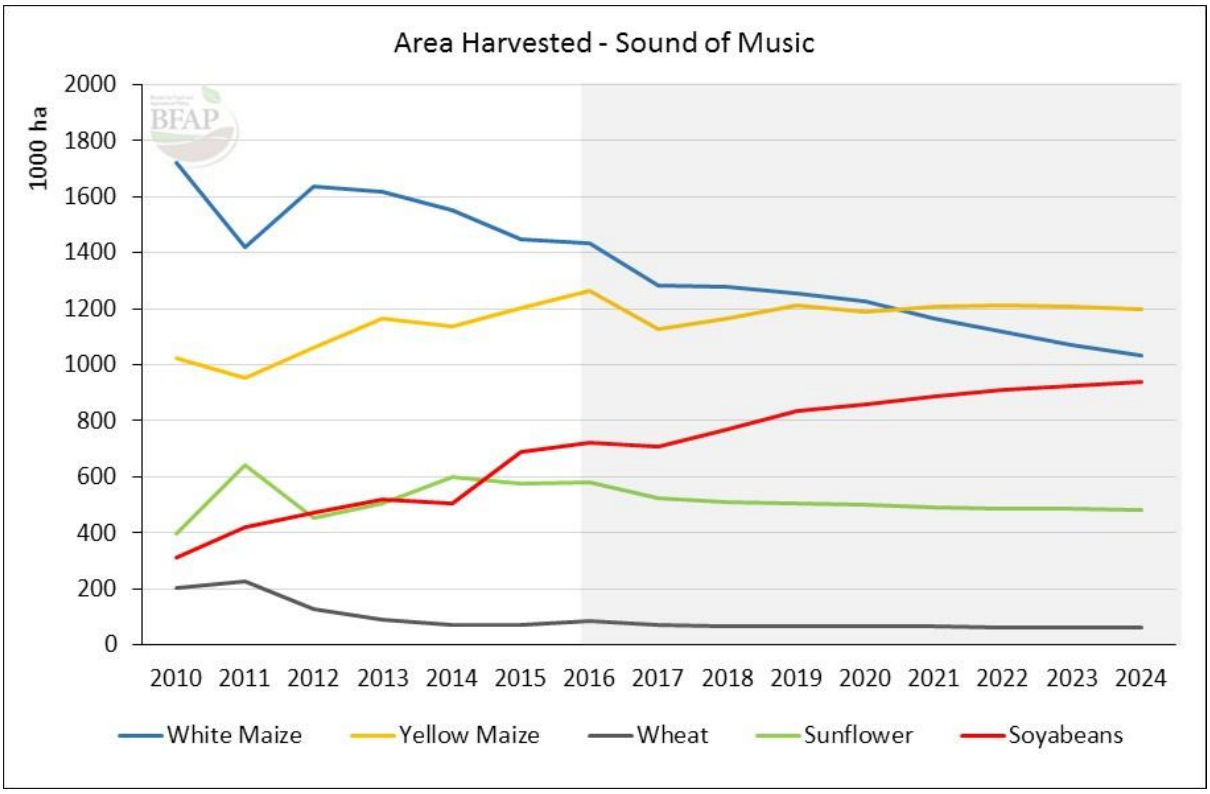

FIGURE 28 - MAIZE AREA HARVESTED – SCENARIOS
Source: BFAP

Human consumption of maize, wheat, chicken and beef are shown in Figure 29 including the percentage change in total human consumption of each commodity in the year 2024. Under the Sound of Music, GDP per capita increases, resulting in a reduction in the consumption of basic starches such as maize towards more convenient starches like bread (wheat). Furthermore, an increase in the consumption of animal proteins: chicken and beef is observed. This consumption change is typical of a higher income scenario with the annual per capita consumption of maize, wheat, chicken and beef averaging at 79kg, 65kg, 40kg and 15kg respectively, for the outlook period. Chicken imports increase significantly over the outlook due to strong growth in demand, the cost of feed increases and production does not keep up with demand for the most popular meat protein in South Africa.

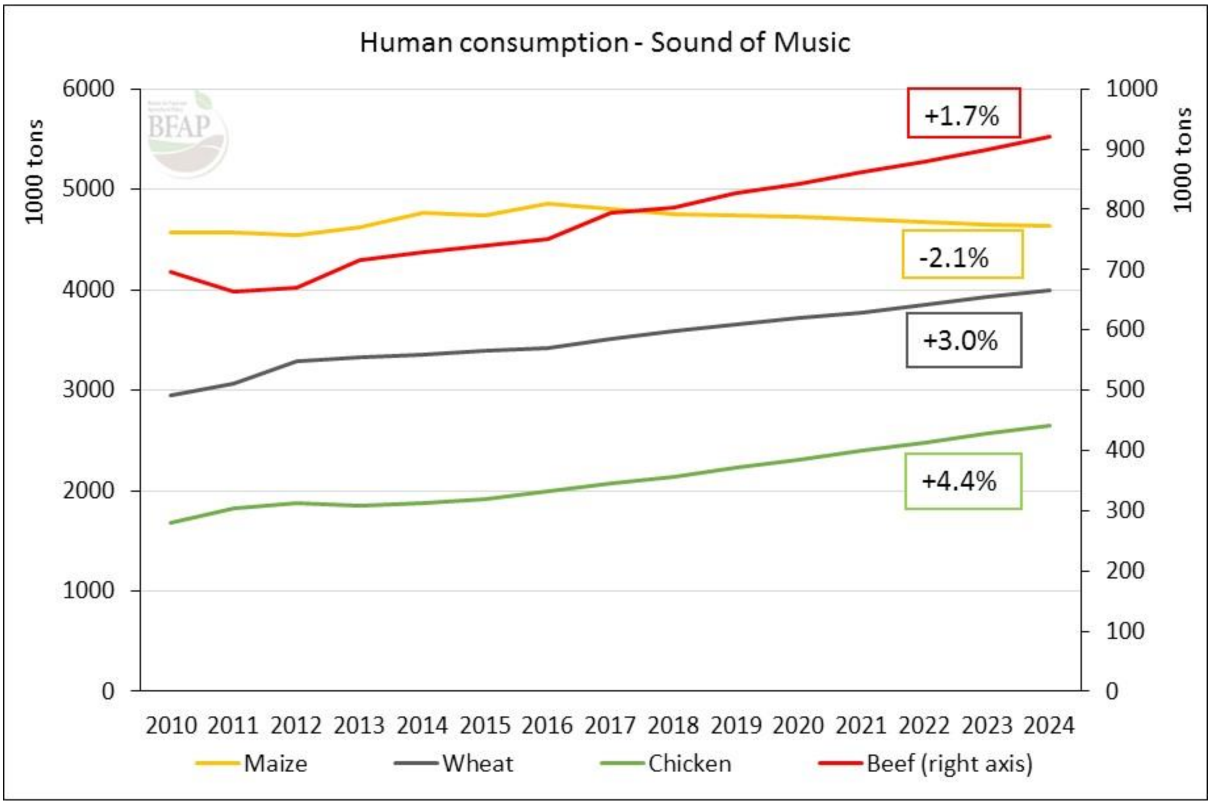

FIGURE 29 - TOTAL HUMAN CONSUMPTION (PERCENTAGE CHANGE IN CONSUMPTION IN 2024 SHOWN)
Source: BFAP

The BFAP healthy food baskets[13] were compiled in order to measure and compare the affordability of basic healthy eating that represents nutritional recommendations as well as average food purchasing patterns. The BFAP healthy food baskets were used to analyse the potential impact of percentage changes in maize meal, white bread and chicken retail prices on projected food affordability.

The costs of two different baskets were calculated: a more economic monthly basket with proportionally more staple food units and less animal food units and a second basket with more dietary diversity which has proportionally more animal foods and less starchy foods. It is important to note that both eating patterns are recommended by the South African Department of Health as 'guidelines for healthy eating' and include items from all the food groups (starchy foods, vegetables, fruit, legumes/beans, animal protein (fish, chicken, red meat, eggs), dairy, fat/oils and sugary foods. The costs of the food baskets were calculated for a single adult male as well as for a family of 4 (consisting of one adult male, one adult female and two children).

The base scenario assumes an average annual food inflation of 5.4% and projected annual CPI food inflation rates were applied to all non-simulated food items in the basket. The Sound of Music

[13] For more information on the methodology used in compiling the BFAP healthy food basket, consult the BFAP Baseline 2015 document, available at www.bfap.co.za

scenario ('High prices and good governance') included the year-on-year changes in the retail prices of the maize meal, white bread and chicken components within the baskets as shown in Table 19. These three food items are the top three food expenditure items among lower income consumers in South African according to the Statistics South Africa Income and Expenditure Survey 2010/2011, representing a significant 33% of their food expenditure.

TABLE 19 - PERCENTAGE INCREASES IN RETAIL PRICES - SOUND OF MUSIC

	Year-on-year % change	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Maize Meal	Baseline	17.79%	-8.59%	4.89%	9.15%	8.17%
	Sound of Music	14.20%	-12.99%	12.81%	12.34%	5.30%
White Bread	Baseline	2.18%	8.62%	4.82%	5.42%	4.67%
	Sound of Music	15.80%	4.70%	4.22%	4.66%	4.94%
Chicken: IQF pieces	Baseline	14.16%	5.67%	2.95%	6.53%	4.94%
	Sound of Music	14.74%	4.68%	4.53%	8.31%	4.27%

The white maize meal retail price is on average 1.5% higher in Sound of Music compared to the Baseline from 2016 to 2019, while the chicken price is higher (+1.4% on average) and the bread price is lower than the Baseline (-3.9% on average). The year-on-year percentage changes show that underlying trends are relatively similar. These selected retail price changes together with an average projected CPI food inflation of the rest of the basket components were imposed to obtain the results shown in Table 20 and Table 21.

TABLE 20 - COST OF DIFFERENT FOOD BASKETS - SOUND OF MUSIC

		Cost of basket - Rand / month					
		2014	2015	2016	2017	2018	2019
Staple dependent basket - Single male	Baseline	801	864	893	939	996	1052
	Sound of Music	801	873	892	949	1011	1063
Staple dependent basket - Family of four	Baseline	2839	3058	3170	3333	3531	3729
	Sound of Music	2839	3085	3165	3362	3578	3763
Diverse basket- Single male	Baseline	999	1073	1121	1178	1246	1314
	Sound of Music	999	1080	1119	1185	1259	1323
Diverse basket - Family of four	Baseline	3461	3719	3890	4087	4322	4557
	Sound of Music	3461	3738	3885	4110	4363	4587

TABLE 21- YEAR-ON-YEAR CHANGES IN THE COST OF DIFFERENT FOOD BASKETS - SOUND OF MUSIC

		Year-on-year % change in basket cost					Average year-on-year % change in basket cost 2016 to 2019	Average projected CPI food increase 2016 to 2019
		2014 to 2015	2015 to 2016	2016 to 2017	2017 to 2018	2018 to 2019		
Staple dependent	Baseline	7.9%	3.3%	5.1%	6.0%	5.7%	5.9%	5.4%
	Sound of	9.0%	2.2%	6.4%	6.5%	5.1%	6.4%	5.4%

basket - Single male	Music							
Staple dependent basket - Family of four	Baseline	7.7%	3.7%	5.1%	5.9%	5.6%	5.9%	5.4%
	Sound of Music	8.7%	2.6%	6.2%	6.4%	5.2%	6.3%	5.4%
Diverse basket- Single male	Baseline	7.5%	4.4%	5.1%	5.8%	5.5%	5.8%	5.4%
	Sound of Music	8.1%	3.6%	5.9%	6.2%	5.1%	6.1%	5.4%
Diverse basket - Family of four	Baseline	7.5%	4.6%	5.1%	5.7%	5.4%	5.7%	5.4%
	Sound of Music	8.0%	3.9%	5.8%	6.2%	5.1%	6.0%	5.4%

- From 2016 to 2019 the cost of the more staple dependent food basket for a single male and family of 4 increases by an average annual 6.3% to 6.4% in the Sound of Music scenario, compared to a 5.9% increase in the Baseline.
- From 2016 to 2019 the cost of the more diverse food basket for a single male and family of 4 increases by an average annual 6.0% to 6.1% in the Sound of Music scenario, compared to a 5.7% to 5.8% increase in the Baseline. Thus, the more diverse food basket is projected to have a slightly lower cost increase than the more staple dependent basket, which could be expected in the light of projected maize meal and bread retail price increases.

Assuming that a household spends about 40% of total income on food in 2015 under the Sound of Music scenario, only families from LSM 6 and LSM 7 (who earn on average R6 822 and R11 882 per household per month (SAARF AMPS 2013B) will be able to afford the monthly food basket), thus excluding about 40% of the adult population from an affordable healthy food basket. More severe food price increases (larger than a disposable income increase) would therefore impact directly on the affordability of a basic healthy eating plan – particularly for LSM segments 1 to 5 representing about 40% of the population

4.5.2 Gotham City

Selected results for the white and yellow maize markets under the Gotham City scenario are shown in Table 22 and Table 23.

TABLE 22 - WHITE MAIZE RESULTS - GOTHAM CITY

White Maize		2015 (current)	2016	2017	2024
Price	**actual**	**2735.1**	**2677.3**	**2662.3**	**4834.3**
	change from baseline		174.8	32.1	1293.5
	% change from baseline		7.0%	1.2%	36.5%
Production	**actual**	**4621.8**	**7126.3**	**7076.9**	**6155.5**
	change from baseline		-152.8	47.6	-327.7
	% change from baseline		-2.1%	0.7%	-5.1%
Feed Use	**actual**	**984.7**	**652.8**	**688.1**	**705.9**
	change from baseline		-178.9	-163.4	-279.5
	% change from baseline		-21.5%	-19.2%	-28.4%
Human Consumption	**actual**	**4423.7**	**4567.0**	**4633.3**	**4747.2**
	change from baseline		15.2	67.0	156.7
	% change from baseline		0.3%	1.5%	3.4%
Net Exports	**actual**	**-93.2**	**1361.3**	**1361.8**	**773.7**
	change from baseline		0.6	40.3	-94.8
	% change from baseline		0.0%	3.0%	-10.9%

TABLE 23 - YELLOW MAIZE RESULTS - GOTHAM CITY

Yellow Maize		2015 (current)	2016	2017	2024
Price	**actual**	**2502.7**	**2682.7**	**2648.8**	**4584.9**
	change from baseline		187.5	35.0	1092.8
	% change from baseline		7.5%	1.3%	31.3%
Production	**actual**	**4758.3**	**6428.0**	**6644.9**	**7495.3**
	change from baseline		42.4	250.1	-40.3
	% change from baseline		0.7%	3.9%	-0.5%
Feed Use	**actual**	**4811.9**	**4616.8**	**4832.0**	**6094.4**
	change from baseline		256.2	284.4	231.7
	% change from baseline		5.9%	6.3%	4.0%
Human Consumption	**Actual**	**296.2**	**288.3**	**292.7**	**182.6**
	change from baseline		-11.3	-2.1	-69.1
	% change from baseline		-3.8%	-0.7%	-27.4%
Net Exports	**Actual**	**-510.3**	**1310.6**	**1218.2**	**962.4**
	change from baseline		17.7	48.4	43.8
	% change from baseline		1.4%	4.1%	4.8%

Under the Gotham City scenario, white and yellow maize prices increase significantly above baseline projections towards the end of the outlook period due to the rapid depreciation of the exchange rate. In terms of supply and demand, the maize market maintains an increasingly finer market balance over the outlook (Figure 30), with white maize trading at a premium of R250 over yellow maize by 2024. However, the premium for white maize is not sufficient to increase average gross revenue for white maize above that of yellow maize, due to higher yellow maize yields. White and yellow maize net exports are projected to decrease over the outlook period. This decrease exposes the South African market to increased volatility since export decreases may not be sufficient to balance the market in years of below average precipitation.

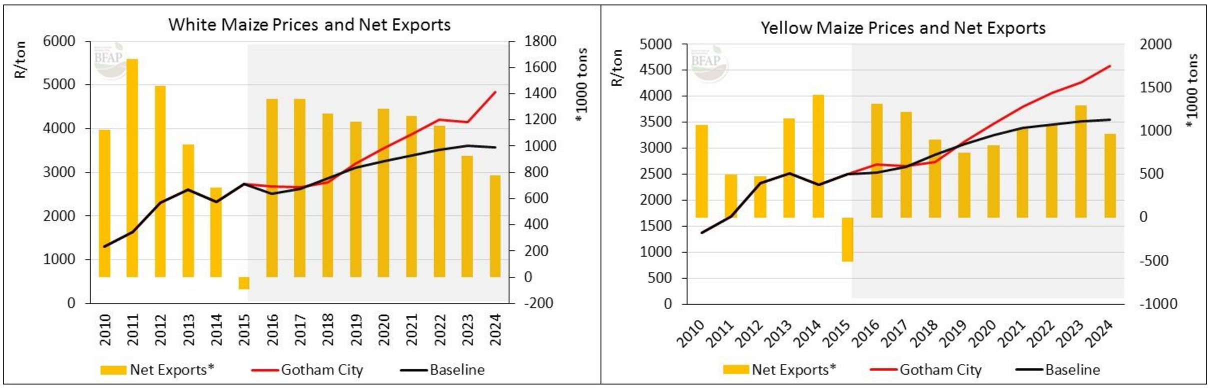

FIGURE 30 - MAIZE PRICES AND NET EXPORTS - GOTHAM CITY
Source: BFAP

Area planted to maize decreases from 2.65 million hectares in 2015 to 2.48 million hectares in 2024 due to the reduction in total available cropland in the summer cash crop production region. Yellow maize area exceeds white maize area from the year 2023. The combination of the decrease in total available cropland and the decrease in yield growth for the various summer cash crops results in an annual average 210 and 125 thousand tons decrease of white and yellow maize production. The increase in soya bean hectares is dampened compared to the baseline while sunflower hectares decrease steadily over the outlook period (Figure 31).

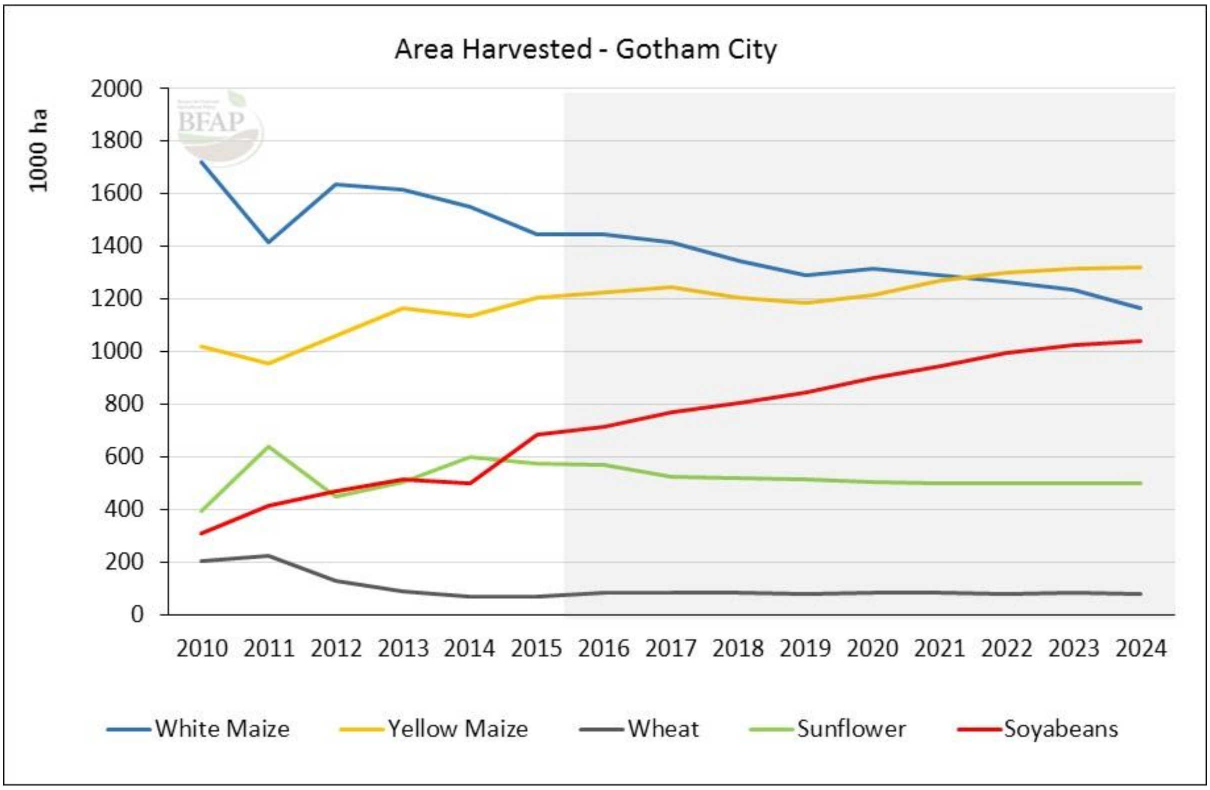

FIGURE 31 - AREA HARVESTED - GOTHAM CITY
Source: BFAP

Whilst maize production decreases, human consumption of maize increases by up to 3.2% in 2024. An increased reliance on basic starches as opposed to a refined starch such as bread (wheat) is observed. The average per capita consumption of maize and wheat is 82.5kg/capita/annum and 61.5kg/capita/annum over the outlook period. A decrease in animal protein consumption with respect to the baseline is observed: the average annual per capita consumption of chicken and beef is 37kg and 14kg respectively.

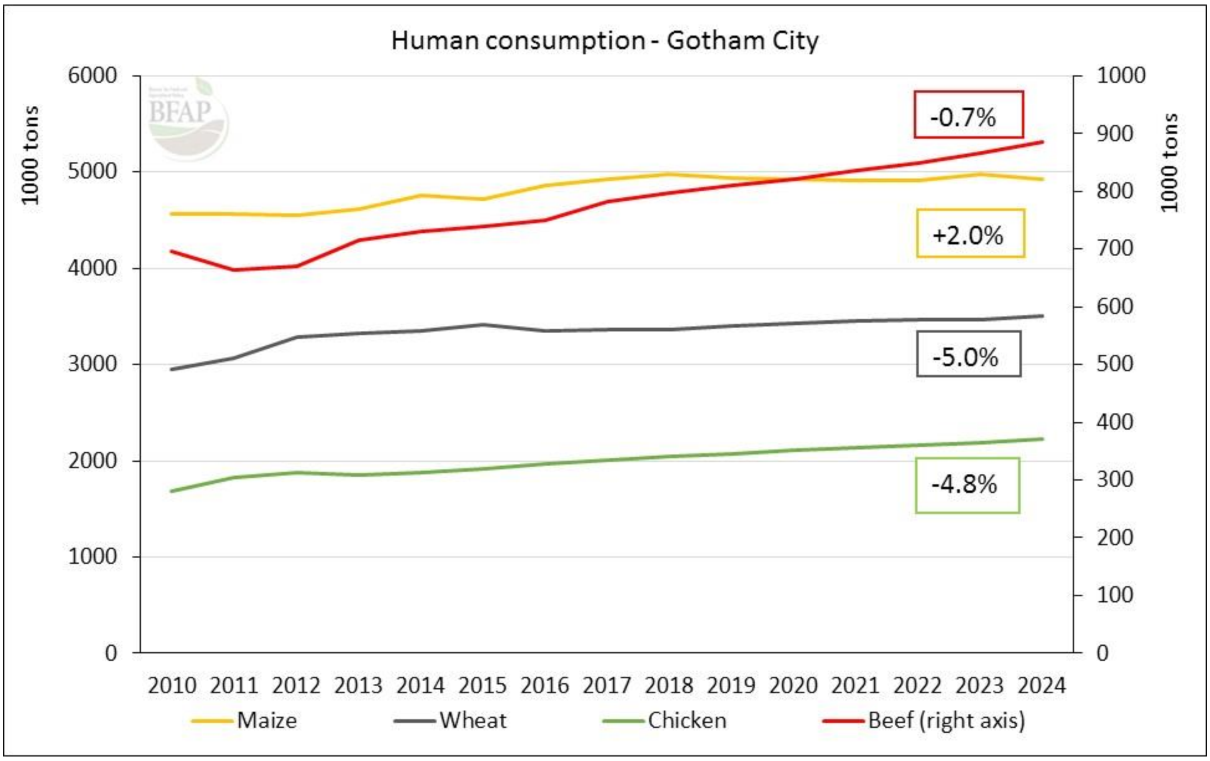

FIGURE 32 - HUMAN CONSUMPTION (PERCENTAGE CHANGES FROM BASELINE IN 2024 INCLUDED)
Source: BFAP

The BFAP healthy food baskets were used to illustrate the potential impact of a Gotham City scenario on food affordability. The costs of the staple dependent and more diverse food baskets were calculated for a single male as well as for a family of 4. The base scenario assumes an average annual food inflation of 5.4% whereas the Gotham City scenario included the year-on-year changes in maize meal, white bread and chicken components of the baskets as shown in Table 24.

TABLE 24 - PERCENTAGE INCREASES IN RETAIL PRICES - GOTHAM CITY

	Year-on-year % change	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Maize Meal	Baseline	17.79%	-8.59%	4.89%	9.15%	8.17%
	Gotham City	17.79%	-2.11%	-0.56%	3.80%	15.93%
White Bread	Baseline	2.18%	8.62%	4.82%	5.42%	4.67%
	Gotham City	2.18%	13.13%	6.60%	7.27%	6.51%
Chicken: IQF pieces	Baseline	14.16%	5.67%	2.95%	6.53%	4.94%
	Gotham City	14.16%	7.69%	1.22%	3.96%	6.46%

From 2016 to 2019 the white maize meal and bread retail prices are on average 2.0% and 7.9% higher in the Gotham City scenario compared to the baseline, while the chicken price is on average 0.3% lower. In general the year-on-year percentage changes in projected retail prices showed relatively similar underlying trends. These selected retail price changes together with an average projected CPI food inflation of the rest of the basket components were imposed to obtain the results shown in Table 25 and Table 26. In Table 25 the resultant costs of the various food baskets are shown when food prices increase at an average annual inflation in the baseline case and the maize meal, white bread and chicken components of the baskets increase by percentage changes given in Table 26 for both the baseline and Gotham City scenario.

TABLE 25 - COST OF DIFFERENT FOOD BASKETS - GOTHAM CITY

		Cost of basket - Rand / month					
		2014	**2015**	**2016**	**2017**	**2018**	**2019**
Staple dependent basket - Single male	Baseline	801	864	893	939	996	1052
	Gotham City	801	864	909	948	998	1070
Staple dependent basket - Family of four	Baseline	2839	3058	3170	3333	3531	3729
	Gotham City	2839	3058	3220	3361	3536	3783
Diverse basket- Single male	Baseline	999	1073	1121	1178	1246	1314
	Gotham City	999	1073	1113	1164	1224	1301
Diverse basket - Family of four	Baseline	3461	3719	3890	4087	4322	4557
	Gotham City	3461	3719	3869	4047	4256	4518

TABLE 26– YEAR-ON-YEAR CHANGES IN THE COST OF DIFFERENT FOOD BASKETS - GOTHAM CITY

		Year-on-year % change in basket cost					**Average year-on-year % change in basket cost 2016 to 2019**	**Average projected CPI food increase 2016 to 2019**
		2014 to 2015	**2015 to 2016**	**2016 to 2017**	**2017 to 2018**	**2018 to 2019**		
Staple dependent basket - Single male	Baseline	7.9%	3.3%	5.1%	6.0%	5.7%	5.9%	5.4%
	Gotham City	7.8%	5.2%	4.3%	5.3%	7.2%	5.9%	5.4%
Staple dependent basket - Family of four	Baseline	7.7%	3.7%	5.1%	5.9%	5.6%	5.9%	5.4%
	Gotham City	7.7%	5.3%	4.4%	5.2%	7.0%	5.8%	5.4%
Diverse basket- Single male	Baseline	7.5%	4.4%	5.1%	5.8%	5.5%	5.8%	5.4%
	Gotham City	7.4%	3.7%	4.6%	5.2%	6.3%	5.6%	5.4%
Diverse basket - Family of four	Baseline	7.5%	4.6%	5.1%	5.7%	5.4%	5.7%	5.4%
	Gotham City	7.5%	4.0%	4.6%	5.2%	6.2%	5.6%	5.4%

- From 2016 to 2019 the cost of the more staple dependent food basket for a single male and family of 4 increases by an average annual 5.9% in the Gotham City scenario and the Baseline.
- From 2016 to 2019 the cost of the more diverse food basket for a single male and family of 4 increases by an average annual 5.6% in the Gotham City scenario, compared to a 5.7% to 5.8% increase in the Baseline. Thus, the more diverse food basket is projected to have a slightly lower cost increase than the more staple dependent basket, which could be expected in the light of

projected maize meal and bread retail price increases.

4.5.3 Blood Diamond

Selected results for the white and yellow maize markets under the Blood diamond scenario are shown in Table 27 and Table 28.

TABLE 27 - WHITE MAIZE RESULTS – BLOOD DIAMONDS

White Maize		2015 (current)	2016	2017	2024
Price	**Actual**	**2634.6**	**2905.5**	**3211.8**	**5770.6**
	change from baseline		403.0	581.5	2229.7
	% change from baseline		16.1%	22.1%	63.0%
Production	**Actual**	**4621.8**	**7510.5**	**7506.0**	**7214.0**
	change from baseline		231.3	476.6	730.8
	% change from baseline		3.2%	6.8%	11.3%
Feed Use	**Actual**	**1024.0**	**628.9**	**640.8**	**611.8**
	change from baseline		-202.7	-210.8	-373.6
	% change from baseline		-24.4%	-24.8%	-37.9%
Human Consumption	**Actual**	**4446.8**	**4552.6**	**4547.3**	**4550.5**
	change from baseline		0.8	-19.0	-40.0
	% change from baseline		0.0%	-0.4%	-0.9%
Net Exports	**actual**	**-157.6**	**1673.3**	**1873.6**	**2036.7**
	change from baseline		319.7	575.9	1157.3
	% change from baseline		23.5%	43.6%	133.3%

TABLE 28 - YELLOW MAIZE RESULTS – BLOOD DIAMONDS

Yellow Maize		2015 (current)	2016	2017	2024
Price	**Actual**	**2535.9**	**2909.8**	**3263.2**	**5692.0**
	change from baseline		414.7	649.4	2199.9
	% change from baseline		16.6%	24.8%	63.0%
Production	**Actual**	**4758.3**	**7088.0**	**7162.3**	**9107.9**
	change from baseline		702.4	767.5	1572.3
	% change from baseline		11.0%	12.0%	20.9%
Feed Use	**Actual**	**4634.2**	**4598.5**	**4676.2**	**5631.5**
	change from baseline		237.8	128.5	-231.2
	% change from baseline		5.5%	2.8%	-3.9%
Human Consumption	**Actual**	**294.2**	**274.7**	**255.4**	**112.7**
	change from baseline		-24.9	-39.4	-139.0
	% change from baseline		-8.3%	-13.4%	-55.2%
Net Exports	**Actual**	**-323.2**	**1966.4**	**2010.8**	**3094.0**
	change from baseline		489.9	714.2	1961.2
	% change from baseline		37.9%	61.1%	213.5%

Under the Blood Diamond scenario, both white and yellow maize prices increase steadily over the outlook driven by high world prices as well as a weakening exchange rate. High maize prices offer lucrative opportunities for farmers and a massive 5 million tons of maize are exported by 2024. White maize net exports reach their peak in 2020 and decrease towards 2024 while yellow maize net exports are projected to increase over the outlook period (Figure 33).

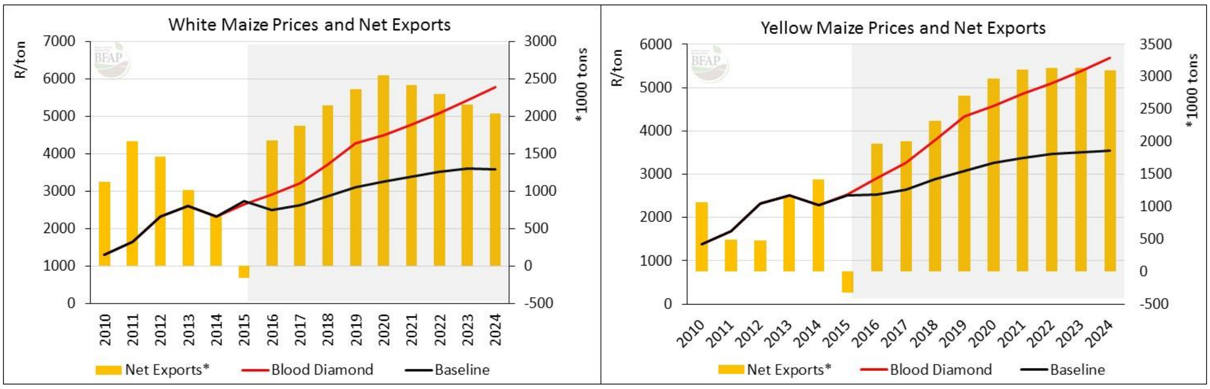

FIGURE 33- MAIZE PRICES – BLOOD DIAMOND

Source: BFAP

Area planted to maize decreases from 2.65 million hectares in 2015 to 2.33 million hectares in 2024 due to the reduction in total available cropland in the summer cash crop production region. Yellow maize area exceeds white maize area from the year 2023. The combination of the decrease in total available cropland and the decrease in yield growth for the various summer cash crops results in an annual average 470 and 700 thousand tons decrease of white and yellow maize production. The increase in soya bean hectares is dampened compared to the baseline while sunflower hectares decrease steadily over the outlook period (Figure 34). Yellow maize area increases steadily over the outlook at the expense of white maize area. Area planted to soyabeans increases over the outlook period. Meanwhile sunflower and wheat areas remain stable.

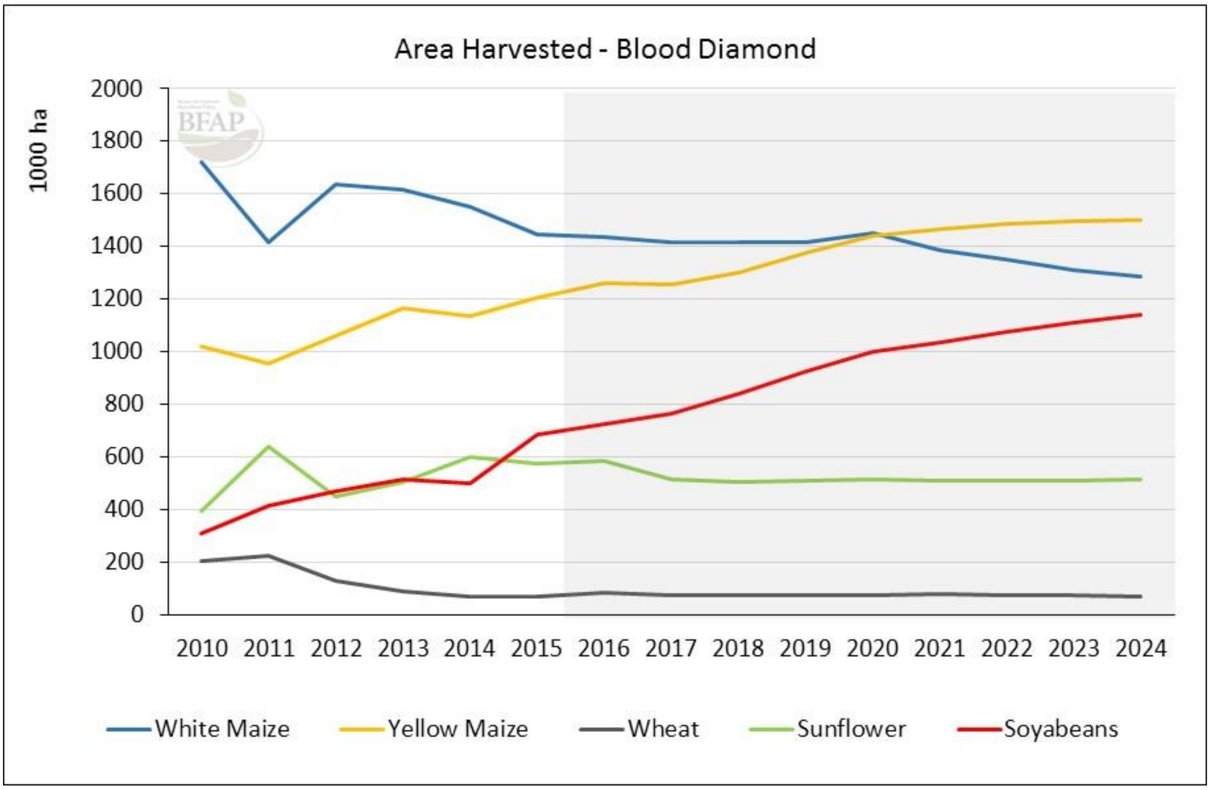

FIGURE 34-AREA HARVESTED – BLOOD DIAMONDS

Source: BFAP

Whilst maize production increases, human consumption of maize decreases by up to 3.6% in 2024. Overall human consumption of maize, wheat beef and chicken decrease due to higher prices across the board: consumer spending power is limited by the high price environment. The average per capita consumption of maize and wheat is 79.9kg/capita/annum and 62.2kg/capita/annum over the outlook period. A decrease in animal protein consumption with respect to the baseline is observed: the average annual per capita consumption of chicken and beef is 36kg and 14.5kg respectively.

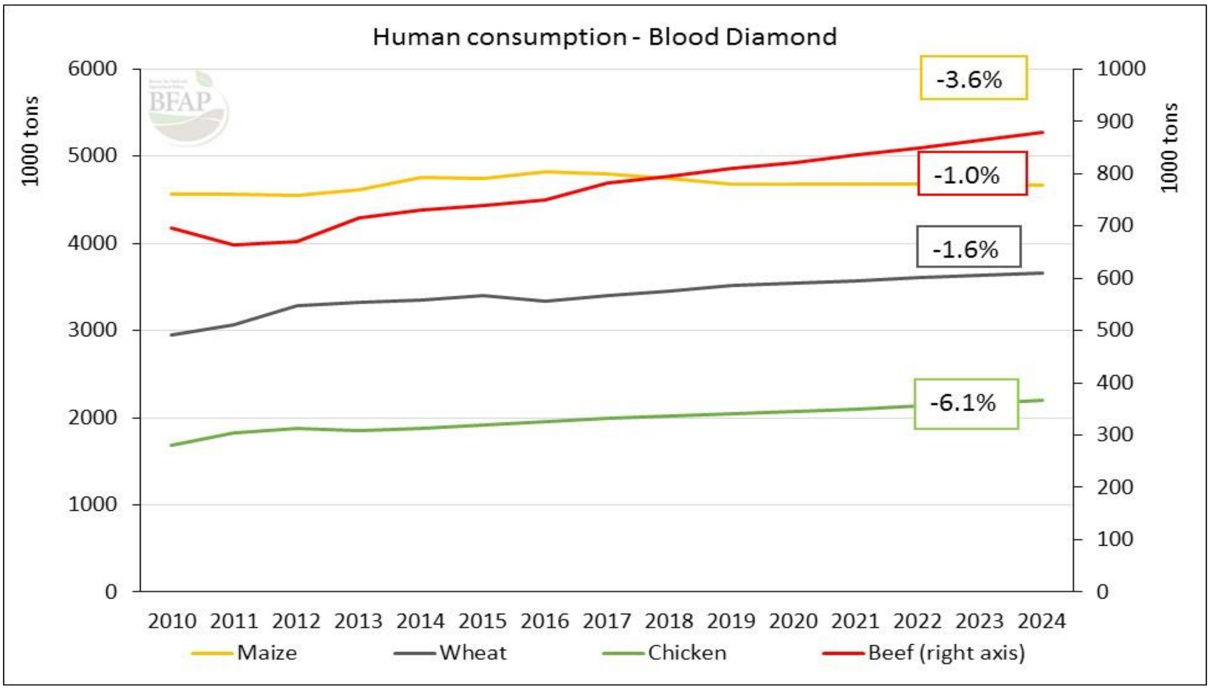

FIGURE 35- HUMAN CONSUMPTION (PERCENTAGE CHANGES FROM BASELINE IN 2024 INCLUDED)

Source: BFAP

The BFAP healthy food baskets were used to illustrate the potential impact of a Blood Diamond scenario on food affordability. The costs of the staple dependent and more diverse food baskets were calculated for a single male as well as for a family of 4. The base scenario assumes an average annual food inflation of 5.4% whereas the Blood Diamond scenario included the year-on-year changes in maize meal, white bread and chicken components of the baskets as shown in Table 29.

TABLE 29 - PERCENTAGE INCREASES IN RETAIL PRICES – BLOOD DIAMOND

	Year-on-year % change	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Maize Meal	Baseline	17.79%	-8.59%	4.89%	9.15%	8.17%
	Blood Diamond	17.79%	16.22%	11.43%	17.08%	6.22%
White Bread	Baseline	2.18%	8.62%	4.82%	5.42%	4.67%
	Blood Diamond	2.18%	15.25%	4.84%	6.16%	5.66%
Chicken: IQF pieces	Baseline	14.16%	5.67%	2.95%	6.53%	4.94%
	Blood Diamond	14.16%	14.31%	5.49%	9.57%	4.44%

From 2016 to 2019 the white maize meal and chicken retail prices are on average significantly higher in the Blood Diamond scenario compared to the baseline (+37.8% and +11.7% respectively), while the bread price is on average 6.8% higher.

These selected retail price changes together with an average projected CPI food inflation of the rest of the basket components were imposed to obtain the results shown in Table 30 and Table 31. In Table 30 the resultant costs of the various food baskets are shown when food prices increase at an average annual inflation in the baseline case and the maize meal, white bread and chicken components of the baskets increase by percentage changes given in Table 31 for both the baseline and Blood Diamond scenario.

TABLE 30 - COST OF DIFFERENT FOOD BASKETS - BLOOD DIAMOND

		Cost of basket - Rand / month					
		2014	**2015**	**2016**	**2017**	**2018**	**2019**
Staple dependent basket - Single male	Baseline	801	864	893	939	996	1052
	Blood Diamond	801	864	945	1007	1089	1149
Staple dependent basket - Family of four	Baseline	2839	3058	3170	3333	3531	3729
	Blood Diamond	2839	3058	3331	3545	3822	4029
Diverse basket- Single male	Baseline	999	1073	1121	1178	1246	1314
	Blood Diamond	999	1073	1162	1233	1321	1392
Diverse basket - Family of four	Baseline	3461	3719	3890	4087	4322	4557
	Blood Diamond	3461	3719	4022	4263	4563	4805

TABLE 31 – YEAR-ON-YEAR CHANGES IN THE COST OF DIFFERENT FOOD BASKETS - BLOOD DIAMOND

		Year-on-year % change in basket cost					Average year-on-year % change in basket cost 2016 to 2019	Average projected CPI food increase 2016 to 2019
		2014 to 2015	**2015 to 2016**	**2016 to 2017**	**2017 to 2018**	**2018 to 2019**		
Staple dependent basket - Single male	Baseline	7.9%	3.3%	5.1%	6.0%	5.7%	5.9%	5.4%
	Blood Diamond	7.8%	9.4%	6.6%	8.1%	5.5%	7.2%	5.4%
Staple dependent basket - Family of four	Baseline	7.7%	3.7%	5.1%	5.9%	5.6%	5.9%	5.4%
	Blood Diamond	7.7%	8.9%	6.4%	7.8%	5.4%	7.0%	5.4%
Diverse basket- Single male	Baseline	7.5%	4.4%	5.1%	5.8%	5.5%	5.8%	5.4%
	Blood Diamond	7.4%	8.3%	6.1%	7.1%	5.4%	6.6%	5.4%
Diverse basket - Family of four	Baseline	7.5%	4.6%	5.1%	5.7%	5.4%	5.7%	5.4%
	Blood Diamond	7.5%	8.1%	6.0%	7.0%	5.3%	6.5%	5.4%

- From 2016 to 2019 the cost of the more staple dependent food basket for a single male and family of 4 increases by an average annual 7.0% to 7.2% in the Blood Diamond scenario, compared to a significantly lower increase of 5.9% in the Baseline.
- From 2016 to 2019 the cost of the more diverse food basket for a single male and family of 4 increases by an average annual 6.5% to 6.6% in the Blood Diamond scenario, compared to a significantly lower 5.7% to 5.8% increase in the Baseline. Thus, the more diverse food basket is projected to have a lower cost increase than the more staple dependent basket, which could be expected in the light of projected maize meal and bread retail price increases.

4.5.4 The various scenarios' impact on food affordability

Considering the summary of results presented in Figure 36, the options resulting in the most affordable basket for a family of four up to 2019 are the more staple dependent basket under baseline, Sound of Music and Gotham City scenarios. The Blood Diamond scenario has a significant impact on the more staple dependent basket (42% increase from 2014 to 2019 compared to 33% for the baseline and other scenarios applied to the more staple dependent basket).

A similar trend is observed for the more diverse basket, resulting in the observation that the most expensive basket by 2019 could be the more diverse basket subject to the Blood Diamond scenario.

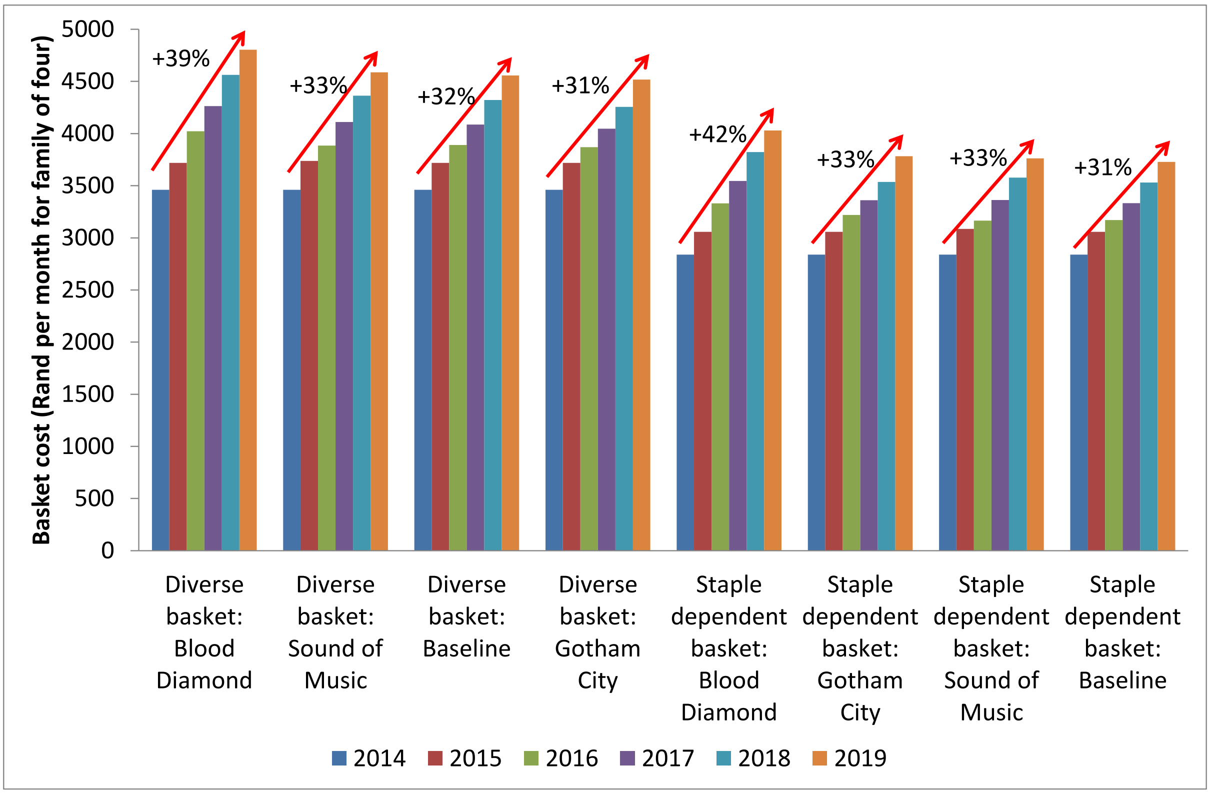

FIGURE 36- COST OF DIFFERENT FOOD BASKETS FOR THE VARIOUS SCENARIOS, AS WELL AS PERCENTAGE CHANGE IN COST OF BASKET FROM 2014 TO 2019

Table 32 provides a summary of the assumptions and the likely impacts of the baseline and the alternative scenarios on the agriculture sector over the period 2015-2024.

TABLE 32 - RESULTS SUMMARY

2015-2024	**Baseline**	**Sound of Music**	**Gotham City**	**Blood Diamond**
Macroeconomic environment	Slow but stable economic growth GDP growth rate: 2.5% per annum Depreciating Rand: R16.00 average	Stable environment from excellent governance High GDP growth rate: 4% per annum Strong and stable Rand: R13.00 average	Increased levels of uncertainty fuelled by bad governance Low and decreasing GDP growth rate: 1.2% per annum Rapid depreciation of Rand: R22.50 average	High levels of uncertainty and insecurity due to bad governance Low and decreasing GDP growth rate: 1.2% per annum Rapid depreciation of the exchange rate: R18.33 average.
Cropland Area	Shift out of white maize to soybeans. Yellow maize area stable. Total area under field crops remains relatively stable	375 000 additional hectares utilised by mining by 2024: High prices enable controlled, well governed expansion	187 500 additional hectares utilised by mining in 2024: low prices dampen mine expansion	375 00 additional hectares utilised by mining in 2024: High prices invigorate unregulated ad illegal mine expansion
Maize Prices	White and yellow maize trade close to export parity levels. Exports gradually decline as demand for feed in domestic market grows	Strong growth in demand for animal protein and therefore demand for yellow maize in the feed market. White and yellow maize prices trade above export parity prices.	Increasing premium for white maize over outlook Finer market balance: White and yellow maize prices ease away from export parity as local surpluses gradually increased demand and decreased production, leading to increased exposure to regional price and supply volatility	Maize prices increase significantly over the outlook fuelled by increased world prices and a weakening exchange rate.
Consumption	Steady move from basic starches to animal protein consumption as middle class expands	Basic starch consumption is further replaced by increased animal protein consumption	Increased dependence on basic starches at the cost of animal protein consumption.	Overall decrease in human consumption due to higher food prices.

4.6 Concluding remarks

In this section the implications of the macro-economic environment changes related to the Sound of Music, Gotham City and Blood Diamond scenarios and competing coexistence between agriculture and mining were quantified for the agricultural sector. While useful in quantifying the different scenarios, many factors remain uncertain and could therefore result in different outcomes. For instance, the question beckons: is competition between the two sectors and the loss of high potential agricultural land the only outcome, with only the extent to which this happens differing?

A future coexistence of mining and agriculture which reflects collaboration rather than competition is more difficult to quantify. Furthermore, collaboration is assumed only to be possible under a "good governance" scenario since under bad governance, social capital is depleted to such an extent that productive collaboration is no longer feasible. Some possibilities towards collaboration exist, which in the Sound of Music scenario, could be described as follows:

> *Hard and soft commodity prices are high, increasing the profitability of both the agricultural and mining sectors. High prices make mining expansion and deeper underground mining economically feasible and this has some surface operation implications – which would affect some agricultural land. However, miners recognize the value of collaborating with surrounding farmers to keep some of the mine-owned land agriculturally productive and included the farmer in the Environmental Management Plan in order to successfully restore reclaimed land, post-mining, to some agricultural potential. Water is too costly to use as irrigation as such, but in some cases mines treat AMD or harvested water which goes towards intensive, high value agricultural production near the mine or on the mine-owned land.*

Furthermore, the scenarios in this section only account for a "one-way" impact, and the linkages between agriculture and mining as well as developments in the mining sector are not accounted for. In this regard, the partial equilibrium model of the agricultural sector that was used for these simulations is by no means sufficient to capture the complex interactions between the two sectors. Therefore a general equilibrium model would be more suited to capture the full implications of some of these scenarios.

5 Conclusion

A summary of the journey to date, and the progress this study has made, is followed by recommendations and policy options toward ensuring national security and sustainable development in South Africa and finally, suggestions for future research in the area of intersection between mining and agriculture are listed.

5.1 The Journey Thus Far

The initial report by BFAP: *Evaluating the impact of coal mining on agriculture in the Delmas, Ogies and Leandra districts – With specific focus on maize production* provided an overview of possible economic, environmental and social effects of mining in a pilot study area in Mpumalanga. Short-run impacts on farm-level and medium-term impacts on maize markets were illustrated whereas long-run macroeconomic, environmental and social impacts were not looked at.

This report addressed the need for a national study with a wider scope in that it elevated the investigation of the interaction of the mining and agricultural sectors to a national level. A summary of the historical, economic, legislative and resource constrained context in which the two sectors operate in South Africa was given. In advancing the conversation between the two sectors, a scenario planning workshop was organised, hosting representatives from the various sectors, in which plausible futures for the two sectors and their impact on national security were formulated. The scenario planning workshop introduced the research to a wider, relevant audience and conversations between mining, agriculture and the environmental departments or sectors could be developed further using the established "common language".

The resultant scenarios or so-called futures were then articulated in an analytical framework addressing the 5 capitals necessary for sustainable development. This strategic approach emphasizes the greater national issue at hand, and attempts to illustrate the significant impact the primary sectors can have in South Africa, given the preceding unique context.

Consequently, the impacts of hypothetical futures could be determined for the agricultural sector, independent of the mining sector, using assumptions substantiated by the strategic analytical framework. Limitations with regards to existing modelling capacity were addressed in the future research agenda.

Even though this report ties up a variety of relevant considerations in the coexistence of mining and agriculture, a lot of gaps in the existing knowledge were identified and therefore the report emphasizes further key research questions that need to be answered in order to inform decisions by all relevant stakeholders in the allocation of resources, management of mine closure, and the value agriculture can add through collaboration with the mining sector.

5.2 Recommendations and Win-Win Solutions

An emerging theme in this report is the need for dialogue and holistic assessment regarding the prioritization of natural resource use. The South African context and the country's resource scarcity highlighted in this report are realities both agriculture and mining will face and must understand in order to make informed decisions. The 5 capitals as discussed in section 4.2 provide a framework within which sustainable development can take place. The state of the capitals can support sustainable development; however the management of these capitals, loosely referred to as "governance", which includes the quality and implementation of policies, is crucial in maintaining the desired state. The current state of some of the 5 capitals in South Africa is not desirable and suffice it to say that all 5 capitals should be wisely and carefully managed. Both sectors are vital to ensure national security but the mode of coexistence between the two has the potential to aid or undermine national security.

This report further highlights recommendations relevant to governance, legislation and sector-specific operations, as listed below (in no particular order):

Recommendations for Governance and Legislation:

- The DMR, DAFF, DEA, DWAF and the Department of Rural Development and Land Reform need to coordinate and strategically align in governing the allocation of resources such as water and land.
    - Clarity is needed regarding authority at various spheres of governance, resulting in long delays in project implementation and high cost of compliance for those operating in the primary sectors. Streamlined, coordinated governance structures which are 'compliance-friendly' are needed.
- Dedicated revenue sources, like the water pricing strategy and mine royalties, should be used appropriately and transparently within the local context to ensure the sustainability of natural resources.
- It is critically important to ensure that ample provisions are set aside in order to needed to rehabilitate land adequately, especially if post-mining land use is agriculture.
- Legislative requirements regarding the EIA of mines need to be structured in such a way, that the cumulative/regional impacts of mining in an area are accounted for.
- Clarity is needed in how the draft Bill on the Preservation and Development of Agricultural Land will factor into the SPLUMA framework.

Recommendations for Sector-Specific Operations:

- There is a need for an investigation of possible contractual arrangements which enable agricultural production on mine-owned land not destined to be mined.
- Where possible, agriculture should be prioritized as post-mining land use.
- Seeing that land rehabilitation is at its core a land-management activity, and therefore to some extent falls into the expertise of the agricultural sector, agronomic principles should form part of the mine's exit strategy to the benefit of both agriculture and mining.

5.3 Future Research Agenda

Some considerations for future research on the coexistence of mining and agriculture include:

- The development of a General Equilibrium Model containing economic, manufacturing, social, human and natural linkages between the two sectors in order to better understand and quantify the current and plausible future interactions between mining and agriculture and quantifying their contribution to the nation.
- Improved documentation and publishing of land reclamation research shedding light on the extent to which agriculture could assist in turning mining liabilities into assets; quantifying

and articulating the possibility of moving towards cross-sectoral partnerships instead of remaining competitors.

- Advancing research on re-using treated AMD water from mines unsuitable for domestic use, to irrigate selective, intensive crops.
- Methodology development and standardised measurement of environmental externality costs associated with mining and agriculture in order to better include these in impact assessments; including but not limited to the quantification of water use, pollution, noise and dust pollution, greenhouse gas emissions, impacts on biodiversity and land use, impacts on food production, social and household impacts.

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7 Appendices

A) Scenario Report (Tanja Hichert)

Write-up of a scenarios workshop to support a BUREAU FOR FOOD AND AGRICULTURAL POLICY (BFAP) project on possible futures for South Africa in terms of the interaction between the mining and the agricultural sectors.

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INTRODUCTION

Bureau for Food and Agricultural Planning (BFAP) commissioned a set of scenarios as part of a report proposed to the Maize Trust, which is a follow-up, nationally scoped report from the initial mining and agriculture pilot study (The impact of coal mining on agriculture – a Pilot study focus, based on maize production) published in 2012; in order to gain greater clarity about possible futures for South Africa when it comes to the interaction between mining and agriculture.

Scenarios are essentially stories with "plausible cause and effect links that connect a future condition with the present, while illustrating key decisions, events, and consequences [in] the narrative."[14].

As per the BFAP document circulated to all participants ahead of the 1 September workshop: "The aim of the scenario session [was] to provide a platform for experts in different sectors to discuss the possible futures of mining and agriculture in South Africa. The future of mining and agriculture have been called into question because the expansion of mining has the potential to outcompete the agricultural sector for land and other resources, thus impacting the basis for South Africa's food security."

"The scenario session forms the second phase in a three-phase study. Phase 1 will contain summaries of the contribution to the South African economy of each sector and unintended consequences or externalities of mining on the environment and will also introduce the trade-offs and opposing views from the two sectors."

"… the outcomes of the scenario session will be interpreted and used as scenarios for empirical analysis in the third and final phase of this study. The major deliverable of this study will be a report outlining the plausible futures between the agricultural and mining sectors (as defined in the scenario session), as well as the empirical results demonstrating the consequences of alternative futures for food security in South Africa."

The great strength of a scenario exercise is that it can be used to look at today's challenges from different perspectives. The process of identifying and examining how current factors and trends might play out in the future helps participants focus on the likely impact of those trends on their areas of responsibility. Quite often, participants find that the impacts are going to be bigger -- or happen sooner -- than they had previously realised.

Scenarios never predict the future. Rather they provide the means to consider today's policies, plans and decision-making processes in light of potential future developments.

HISTORY, CONTEXT AND KEY CHALLENGES

Before constructing scenarios it is important for all participants to have read the BFAP *Agriculture and mining scenario session Information Guide* and agree on the 'unit of analysis' (also known as the focal question) so that the stories can be as relevant and applicable as possible. This is because the scenarios need to be used as a decision-making tool – the so-called 'use' of the future to help take better decisions, and make better choices, in the present.

The conversation around the unit of analysis highlighted the following concepts and topics (all referring to South Africa and its history where applicable):

- Prosperity
- GDP

[14] Jerome Glenn

- Employment
- Export earnings
- Taxes
- Equality and equity
- Optimising degraded land and water and the sustainable use of resources.
- Food security
- Investment and how to finance growth and development of the mining and agriculture sectors.
- The coexistence of the mining and agriculture sectors in South Africa.
- Social stability and capacity building
- Energy supply (and demand) for the mining and agriculture sectors in the next 15 to 20 years.

Participants agreed on the unit of analysis as:

THE CONTRIBUTION AND CO-EXISTENCE OF MINING AND AGRICULTURE TOWARDS ENSURING NATIONAL SECURITY IN 2030-35.

Comments about the unit of analysis included:

- The downstream activities of the mining and agriculture sectors should be taken into account also.
- The broader context of the coexistence and contribution of the two sectors is important and must be taken into account (in this regard South Africa is very different from Brazil for example).
- The key difference in South Africa is its high unemployment rate.
- South Africa's National Development Plan (NDP) has a perspective and potential policy recommendations on all the important issues pertaining to the mining and agriculture sectors.
- South Africa is on an "American growth model".
- It is important to be a more export oriented economy.
- National security in its broadest sense means happy citizens, employment, no poverty, a transformed society and economy, food security and a sustainable natural resource base.

In addition to clarity about the unit of analysis, it is also imperative to lay the 'groundwork' for scenarios so that they are not just 'best guess' projections or extrapolations of the present. It is also in this way that each participant contributes to **building a shared context** within which a strategic conversation takes place.

In groups participants collectively analysed and engaged around mining and agriculture's history, key challenges, contextual environment and transactional environments (see appendices B – E). The aim is to include the following into the strategic conversation:

- learnings from history, as well as a sense of what legacy issues might impact the future,
- challenges, which could become obstacles to possible future options and choices,
- the trends and driving forces outside of mining and agriculture -- those factors that shape the future over which the sectors often have no control -- identify what they must survey and adapt to, and
- the stakeholders and actors that interact with the sectors.

Comments and insights in the plenary conversation around actors/stakeholders (refer to group work in appendix E) included:

- There are lots of independent stakeholders in both the mining and agriculture sectors.
- There is potential for cooperation given the stakeholders of both sectors -- there can be a natural affinity between miners and farmers.
- Land owners are critically important.
- Stakeholders are interacting with government about the same regulatory issues, such as land and

water, that affect both.
- Both sectors' stakeholders can influence infrastructure providers (i.e. Transnet, Eskom, Sanral).

Comments and insights in the plenary conversation around challenges (refer to group work in appendix C) included:
- The challenges for both mining and agriculture sectors are similar.
- The issue of skills and unskilled labour could be more challenging for agriculture.
- Automation/mechanisation and how it relates to employment and the type of employment is critical for both sectors going forward.
- Social acceptance and perceptions around social acceptance are big challenges.
- Arguably there is a lack of knowledge base that affects both sectors.
- With regard to policy making it is not clear who the political driver is.
- The natural resource base, cyclical economics, high start-up costs and climate change affect both sectors.

Comments and insights in the plenary conversation around the contextual environment (refer to group work in appendix D) included:
- Resource nationalism is a potential future issue.
- Living conditions, especially of unskilled labour, is an issue in both sectors.
- Competitiveness and issues around modernisation and mechanisation will impact both sectors.
- Water scarcity is very important.
- Mining and agriculture do not need to be mutually exclusive.
- Commodity prices affect competitiveness, and real prices are coming down.
- The role of China is a key issue.
- Mining and agriculture products in dollar-denominated economies -- given what South Africa exports versus what is in demand domestically.
- What is South Africa good at?

Comments and insights in the plenary conversation around the history of mining and agriculture (refer to group work in appendix B) included:
- The two sectors, mining and agriculture, are not unique -- there has been co-evolution and cohabitation.
- Both sectors supported the apartheid system.
- Historically there has been a commodity boom where South Africa anticipated 5% growth and based on that planned 20 power stations.
- It used to be about the 'yellow nexus' (gold and maize), now it is all about the food, water, energy nexus.
- Historically South Africa has squandered its resources.
- There have been key breaks in history -- this could happen in the future also.
- Energy and labour market instability were issues for both sectors 125 Years ago. This gave rise to new minerals laws and royalty tax.
- Mining has been ring-fenced.

KEY CERTAINTIES/"KNOWNS"

Key certainties, also called driving forces and 'rules of the game', are those underlying and impacting factors that set the pattern of events and determine outcomes for the interaction between the mining and the agricultural sectors -- the forces that make things happen. They can be the state the economy is in, regulatory decisions, competitive trends, the availability of natural resources, technological drivers, the political environment, etc. Ultimately they are the factors and 'shapers of the future' that participants agreed were 'knowns'.

Some of them were already mentioned in the breakout groups, but in collective conversation the following key certainties for the contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035, were agreed:

- Competitiveness is key: It is shaped by the regulatory environment, restitutional rents, the nature of the market and the investment environment (including its cyclicality, e.g. if the going is good there is likely to be reinvestment).
- Policy uncertainty is affecting investment; mining investment comes from overseas, agricultural investment is local.
- There is a limit on natural resources and their unsustainable use.
- Energy needs and resultant shortages will continue for the foreseeable future. Therefore energy will be supplied from coal for the foreseeable future.
- Coal mining is linked to agriculture and land use. Whether opencast or underground mining happens is a function of price and the depth and quality of coal reserves.
- 60% of exploitable coal reserves are underground where it is more expensive to mine.
- Price elasticity with regard to renewable energy is much higher for the agricultural sector than it is for mining, because of mining's size/large consumption.
- Coal is a reality, but it is also contested because of climate change commitments and the possibility that it might be kept in the ground depending on the profitability of mining.
- Rehabilitation of closed mines and the concomitant liability are so expensive that it is not feasible -- it is also largely unquantified.
- Mine closure is also not happening because of the disconnect between the rehabilitators and potential post-rehabilitation users (farmers)[15].
- There is extreme risk aversion when it comes to mine closure -- this is due to regulatory aspects as well as liability and taxes.
- Water (that has been used by mines) treatment is also a liability, however, opencast mines "harvest" water, which can be a source/input for agriculture.
- Overall there will be more uncertainty and a more risky environment, more people on the planet a more energised climate, more tipping points and higher instability. There are no short-term political or legislative solutions. Everyone will work in a highly contested environment and this means that the demand on R&D is higher whilst "money is a coward".
- Mining will be more expensive -- the easily reachable (low hanging fruit) resources are gone.
- Agriculture may not necessarily be more expensive -- maize production costs can come down, intensification is possible and land is available in Africa.
- R&D around new technologies and recycling is critical, but it is not enough given the intensified increase of resource use.
- Prices move in cycles. This means there must be cost control also in good times.
- Mining and agriculture will not solve the unemployment issue.
- Socio-economic problems will escalate if there is no good nutrition.

[15] Further useful comments, that can serve as a source for strategic options about post-rehabilitated land use, included that:

- Land use does not have to be, as in terms of legislation, "in its original state", to have agricultural potential.
- There is no prioritisation when it comes to rehabilitation as low value agricultural land is also rehabilitated.
- It is (should be) possible to return land for "agreed use".
- It is (should be) possible to identify fatal flaws in mining; "if you can't close it, don't open it".

- In both sectors the cost of capital is coming down and the cost of labour is going up, as a result mining and agriculture will become more capital intensive.
- Unemployment will rise.
- South Africa's mineral endowment (potential) is known and it has a comparative advantage given its wealth of different minerals. However, it is not competitive if all the costs and externalities are taken into account.
- South Africa does not have an agricultural endowment, whilst mining is taking away some of its potential land.
- Perceptions matter and are treated as reality (the comment was made with regard to transformation efforts).
- A lot of legislation governing the sectors is good, but implementation of the legislation is questionable.
- There is increasing social discontent in the mining areas because of local government failure. Farmers and miners are expected to supply services.
- The illegal use of natural resources, including water, will continue and may increase. (Mining uses 5% of South Africa's water and agriculture uses 65%).
- Water supply plans exist for mining.
- The current spotlight is on mining; it is a matter of time before it will be on agriculture and food security.
- South Africa will remain a price taker, as opposed to price maker, in all commodities.
- The lack of education, skills and training will limit some development in both sectors.

KEY UNCERTAINTIES/"UNKNOWNS"

Key uncertainties are the literally that – the driving forces and factors that shape the future that are uncertain. They can include the so-called 'known unknowns', risks, possible trend breaks and wild cards. It is their impact and lack of knowledge about them that are vital for developing a better understanding of how the future for the contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035 might unfold. The key uncertainties are:

1. Commodity prices (Rand denominated) of mining and agricultural products.
2. Climate change effects on
   a. Mining
   b. Agriculture
3. Can the (broader) consumption needs of a growing population be met?
4. ~~Quality of life~~? (*This uncertainty is contained in and was described more comprehensively in number 15.*)
5. The tenure rights system for agricultural land (as well as for mining -- who owns the land, and is this and its structure sufficient for political purposes and economic growth?)
6. The consequences of the current lack of investment in the mining and agricultural sectors.
7. Land use after restitution, i.e. is it used for housing?
8. The allocation of scarce resources such as water, including its quality, energy and land -- is it technocratic or political? (Which holds sway; politics or policy? Do political decision-makers 'walk the talk', can they implement and deliver equitably?)
9. What will we be eating? (Including to what extent will food be processed, how nutritious will it be, what will the inputs to the food system look like?)
10. The demand level for commodities, as well is the type of commodities in demand -- this determines prices, uncertainty number 1 above.

11. The state of infrastructure, including harbours, road, rail, water quality and power supply.
12. What happens to wilderness- and protected areas? (This uncertainty is linked to ecosystem services and opportunities around rehabilitation of mine closure areas for potential agricultural use.)
13. Game changing technology breakthrough (this uncertainty was treated as a wild card, see discussion below)
14. Will there ever be mine closures? (Or will there be more and other negative environmental legacies, and who will manage costs, liability, policy and enforcement?)
15. The type of society we have -- the extent of lawlessness and crime, the sort of value system, the level of corruption, and whether there is social cohesion. (Linked to uncertainty number 4, the quality of life.)
16. Will energy and water still be an issue? (The plans are there, but can they be implemented?)
17. Will there be trust-based relationships between business, government and society, and what will the capacity of the State be? (The outcome of this will directly shape uncertainty number 15.)
18. Which holds sway; ideology or pragmatism? (Will government, given its low levels of fixed capital stock and investment, trust the private sector to drive economic growth? Will Unions collaborate for growth?)
19. The role of China/India/BRICs with regard to trade, commodity pricing, in migration and food security.
20. The capacity of the private sector to truly transform -- this is cultural also, meaning the 'political will' to change fundamentally.
21. Regional integration with regard to trade, resources, energy, food production, markets and Labour. (It was deemed that this will not impact mining much.)

The following comments and insights arose in conversation around the key uncertainties and unknowns.

The outcomes of land restitution -- how it is fixed -- and manner in which it is done will shape farm structure, and perhaps food production patterns. This also has implications for investment. Restitution, however, is a subset of land use planning, which also governs what happens to wilderness- and protected areas (uncertainty number 12). If restitution fails it will mean there is no opportunity for proper land-use planning. Where restitution involves traditional communities, it is their decision how to use, or not use, the land -- it may be utilised for housing for example, and thereby contributing to neither mining nor agriculture.

Wilderness- and protected areas both provide ecosystem services, although there is a difference between a wilderness area which is a stock, and an ecosystem services provision area, which is a flow. The protection of pristine wilderness areas with their biodiversity also has a moral and aesthetic angle which touches on the human need for unspoiled nature.

A quick brainstorm on game changing technology breakthroughs with regard to mining and/or agriculture included the following:

- Green energy removing coal from the equation
- Changes in catalytic converters impacting platinum
- Drought resistant crops
- Alternative proteins
- Land rehabilitation practices
- Re-use and recycling
- New strategic rare earth metals

The point of listing these technologies is that they exist in the present, but it is unknown to what extent they will scale up, or 'tip' suddenly to fundamentally change the future of mining and/or agriculture, and in particular the interaction between the two.

Mine closures, and the concomitant collaboration with agriculture for the use of rehabilitated land, will work, as soon as the liabilities associated with it become an asset. There are some weak signals and experiments in this regard, such as CMR[16]. Successful mine closures, land rehabilitation and collaboration with agriculture is potentially one of the "sweet spots" where mining and agriculture can coexist and collaborate in a preferred future.

The type of society we have in future is directly linked, and a result of, current patterns of unemployment, including the history of the mining and agricultural sectors, as well as demographic patterns, such as the current youth bulge.

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All the key uncertainties were plotted on an 'Impact / Uncertainty chart' (diagram below) in order to prioritize those uncertainties about which least is known and have the highest impact when it comes to the contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035. It is important to remember that 'high' uncertainty does not mean 'high improbability'; high uncertainty means having little knowledge of how something may pan out -- it means 'a great lack of knowledge'.

The key uncertainties on the top left-hand side of the Impact/Uncertainty chart are those issues that are

high impact, but
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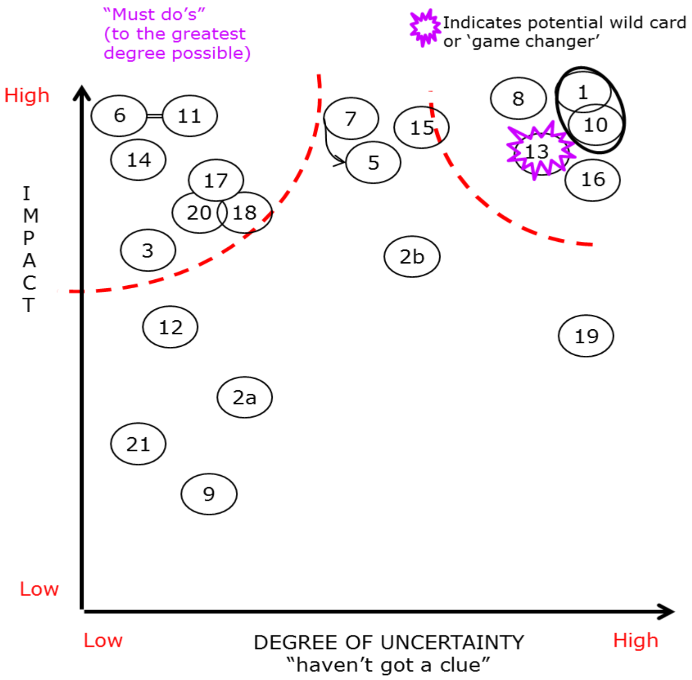

more certain. Issues
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uncertainties cannot
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manageable) as best

The 'must do' high impact factors for the contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035 are:

3. Meeting the (broader) consumption needs of a growing population.
6. Dealing with, and/or mitigating the consequences of the current lack of investment in the mining and agricultural sectors.

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[16] CMR² (Coal Mined Land Rehabilitation Research and Training Centre of Exellence) is an initiative that aims to create industry by evaluating and establishing sustainable land use systems or projects on mine rehabilitated land. CMR² will be launching projects in 3-4 months (www.cmr2.org)

11. Dealing with the state of infrastructure such as harbours, road, rail, water quality and power supply.
14. Finding a solution to mine closures and other negative environmental legacies and figuring out who will manage costs, liability, policy and enforcement.
17. Building trust-based relationships between business, government and society, and contribute to the capacity of the State as this will directly affect the type of society we have.
18. Fostering pragmatism on the side of the government and labour (possibly by building good relations, trust and social capital so that the private sector can have an opportunity to drive economic growth).
20. Delivering fundamentally meaningful (described as 'true) transformation in the private sector.

The Impact/Uncertainty Chart also acts as a radar screen on which key uncertainties for the contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035 can be monitored over time in order to get a better idea of the unfolding future. This can enable a more strategic and proactive response to uncertainties.

The drivers in the top right-hand side of the chart are those with the highest levels of uncertainty and impact, which are typically used to create scenarios.

SCENARIOS AND THE SCENARIO GAMEBOARD

In the case of the contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035, the highest impact, most uncertain uncertainties are:

No's 1 and 10 that relate to commodity prices and the demand level for commodities, as well is the type of commodities in demand

and

No's 8 and 16 that relate to the allocation of scarce resources such as water, including its quality, energy and land, and whether that allocation, and the governance of these resources, is political or policy-driven.

No. 13 is a technology wildcard – a so-called 'unknown unknown' – and therefore unsuitable for use as a scenario gameboard axis. (The best one can do with regard to a wildcard is to build foresight capability through horizon scanning for weak signals -- like the preliminary list above -- and/or develop breakthrough technology self.)

Using No's 1 and 10 as an axis, participants identified opposite extremes of the 'allocation of scarce resources' uncertainty and related it to the nature of governance in general. This included the critical aspect of state capability and in particular its ability to implement. This uncertainty is something that can, albeit with great difficulty, be influenced: The axis extremes were labelled as:

Excellent governance,

vs.

Terrible governance

A more generic critical factor with maximum uncertainty – that of commodity prices, with its polar opposites being

High prices

vs.

Low prices

was used as the other scenario gameboard axis. It is worthwhile to note that both sectors have virtually no control or influence of this uncertainty. The two axes provide a framework for four plausible futures and their descriptive titles, as follows:

SOUND OF MUSIC

The contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035 is characterised by high commodity prices and excellent governance.

BEAUTY AND THE BEAST

The contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035 is characterised by excellent governance but in the presence of low commodity prices.

GOTHAM CITY

The contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035 is characterised by low commodity prices and terrible governance.

BLOOD DIAMOND

The contribution and co-existence of mining and agriculture towards ensuring national security in 2030-2035 is characterised by terrible governance in the presence of high commodity prices.

The four scenarios showing where mining and agriculture can plausibly find itself in the future (as well as the past and present) are shown with images below, and short narratives thereafter.

HIGH COMMODITY PRICES

	BLOOD DIAMOND	THE SOUND OF MUSIC	
TERRIBLE GOVERNANCE	**BLOOD DIAMOND** It's a dog-eat-dog world out there with cutthroat tactics when it comes to producing the 'yellow gold', be it maize or mineral. For a while the farmers had the upper hand because of food security concerns, but corruption and mining are a match made in heaven. Mind you, the panga swings… any more food price hikes, and riots will lead to a rethink. Pity the roads are unusable, never mind the water….	**THE SOUND OF MUSIC** The hills truly are alive with the sound of music as all stakeholders 'sing from the same hymn sheet'. There is fierce competition for land and mega-bucks to be made, but miners, farmers, government and investors all play by the rulebook; plus play nice with one another. Best of all is the brilliant management of scarce water, combined with the solid shift to renewable energy. It's time to yodel… wait, let's make that ululate!	EXCELLENT GOVERNANCE
	GOTHAM CITY You don't need to be a Batman fan to recognise this dark and dysfunctional setting. The mining and agriculture sectors are bleeding profits, people and principles. Not that this makes the headlines, though. The crisis is all about out-of-control corruption, service delivery protests on steroids and 'water-shedding' in full swing. Some land lies fallow, some land degrades and some land is up for grabs, just because it is…	**BEAUTY & THE BEAST** The transformation and NDP pay-off has properly kicked in, and as expected, some old (fashioned) mining and agriculture stalwarts (aka the beasts) haven't survived into the new, albeit tough, era. If only the commodity cycle would tick up. It is punishing to make a profit, especially when policy, and even monetary, support goes only to those who work together *and* deliver the true triple bottom-line. Wilderness areas are a beauty to behold, though.	

LOW COMMODITY PRICES

The expanded stories of plausible futures in these four quadrants are as follows:

SOUND OF MUSIC

Consistently strong demand from China and India, not to mention the burgeoning African economies, has caused commodity prices to surge in both the mining and agricultural sectors. Whilst this is fantastic for farmers and mining exporters, vigilance is needed so that high food prices and consumer inflation don't spin out of control. Luckily South Africa's well-designed and -managed basic income protection system keeps a lid on things and food (in)security is more of a historic concept than anything else.

Unfortunately there is no such structured system in place to manage competition between the mining and agriculture sectors when it comes to competition for land – especially now that investment and expansion is rife and on everybody's radar. It is interesting (and for some amusing) that South Africa's excellent governance framework for scarce resources, energy and water in particular, as well as a solid track record of cooperation and collaboration, saves the day. From mid-2017, when water-shedding really kicked in, farmers and miners have been exploring and innovating together around re-use, recycling and win-win solutions. It all started by transforming rehabilitated mining land and treated water into super-productive farms. Liabilities were converted to assets.

The fact that key players in both sectors drove transformation hard, and that there were and still are excellent relations in place with effective technocrats, made the seemingly impossible actually happen. Of course it was all helped along by the strategic role both industries played in the PPP infrastructure rollout.

So now that there might be a 'access to land' bunfight between the two, it helps greatly that;

a) they have a track record of working together for mutual benefit as well as the greater good,
b) there is a stable and predictable policy environment for them to operate in, and
c) renewable energy has taken a lot of coal-earmarked land out of the equation anyway.

Let's hope for the best…

BEAUTY AND THE BEAST

Times are difficult, there's no denying it. Ever since the 2016 crash, the 'new normal' has meant low demand, even lower prices and stagnation for virtually all commodities. The one upside of this sorry state of affairs is at least a rational and mature divvying up of land use for the respective mining and agriculture players. Due to the innovative and collaborative working relationships they've built up over the last 5 years' worth of horse-trading and working with the reformed government, the 'right' farmers can access good land previously set aside for opencast coal mining. Some of this land has also now been proclaimed as protected Wilderness areas for the use of future generations, bio-diversity safeguarding and eco-system services valuing.

Now that renewable energy is in full swing, though, and the miners' investment money has dried up, it has become critical for agriculture – especially if it gets government support – to be as productive as possible given its own margin squeeze. These days it's more of a problem managing farm closures than mine closures and it seems it is only the progressive, commercial, 'transformed' players that survive, never mind thrive. This is because some pretty stringent, but usefully clear and fair, transformation policies created an equitable crop of productive farmers. The fall-out from mining and farm job losses has also been adequately managed thanks to some forward planning and alternative economic activity sector stimulation. Unfortunately, though, it has not been as easy to manage the 'old school' farmers that have lost their land – some trade-offs are inevitable.

Consumers are better off, not only because food is affordable, but because infrastructure investments (some due to beneficiation of raw materials that were better utilised locally as opposed to exporting) have unleashed new economic activity and opportunities. Now it's just a matter of time…

GOTHAM CITY

These are intensely turbulent times. Ever since the concentration of 'capitalist interests' conspired to try and keep the quality mining and agricultural assets in the hands of the privileged plutocrat few, and this blew up in their faces, plus the near total breakdown in service delivery, it has been difficult to find a ray of hope anywhere. And it seems hope is about the only thing left to do. Any opportunities for working together for the greater good were wiped out when the Transformation Whitewash scandal came to light. What seemed to be a good idea way back in 2018, especially given the policy uncertainty, has with hindsight turned out to be a very short-sighted stupid endeavour indeed. Of course it was all motivated by greed and hubris, and of course these clever creatures were the first to jump the sinking ship.

Now nobody seems to be in charge of anything anywhere, it's inconceivable to make a return on any kind of investment, and chaos rules. People are still managing to afford the most basic types of food, but only just. The daily CBD protests seem, for now, to be more about the lack of water, the breakdown of the transport system, not to mention the corruption.

For those still hanging onto a semblance of normality the saddest thing is what is happening to the land and tiny fragments of surviving nature. Extreme air pollution and coal dust smog seem to have permeated everything and an acid river runs through it. It's impossible to grow maize now in areas that used to yield abundance and the resilience of the veld has finally given in. No one bothers to try farming, whilst mining is left to the desperados and zama-zama's. It's only the food importers left hanging in there, but who knows for how long… ?

BLOOD DIAMOND

In these eye-wateringly expensive times the few well-connected crooks are coining it, in dollar terms no less. The Chinese environmental disaster and near continuous El Niño has caused prices and profits to skyrocket, but because of all the underhand deal-making and breakdown in the legal system, nobody knows who owns the land, how it is treated and where the products end up. All that seems certain is that the rich (read the rich and unscrupulous) are getting richer and the poor are getting poorer. Speak of 'elite capture', these guys have perfected the art.

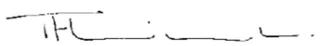
These usual suspects don't always have the upper hand, though. A good number of their farms have been 're-purposed' for the mine magnates. The argument is always that South Africa desperately needs the coal for energy, but with nowadays' heady prices, it seems more likely that anything that can be strip-mined, is. The other booming industry is of course high-end security with both farms and mines no-go areas with some serious asset protection going on. These sectors are awash in investment money seemingly all from shell companies with headquarters in the Cayman Islands. Politicians, needless to say, get their requisite cuts, otherwise the system won't work.

As for the state of water, soil, air and not to mention biodiversity, it's 'cry the beloved country'. Not that any of these issues make the headlines. On a daily basis all we hear about is the rioting – not the least due to high food prices – arrests, and breakdown of anything and everything that used to work fairly well. If only we could return to the stability (never appreciated) we had in the mid 2010's…

OPTIONS FOR GETTING TO A PREFERRED FUTURE

Insert green bullet point list

The workshop closed at 16:00 on 1 September 2015. This serves as a working document that can be used by BFAP and/or it can be expanded by sector organisation into other relevant formats.

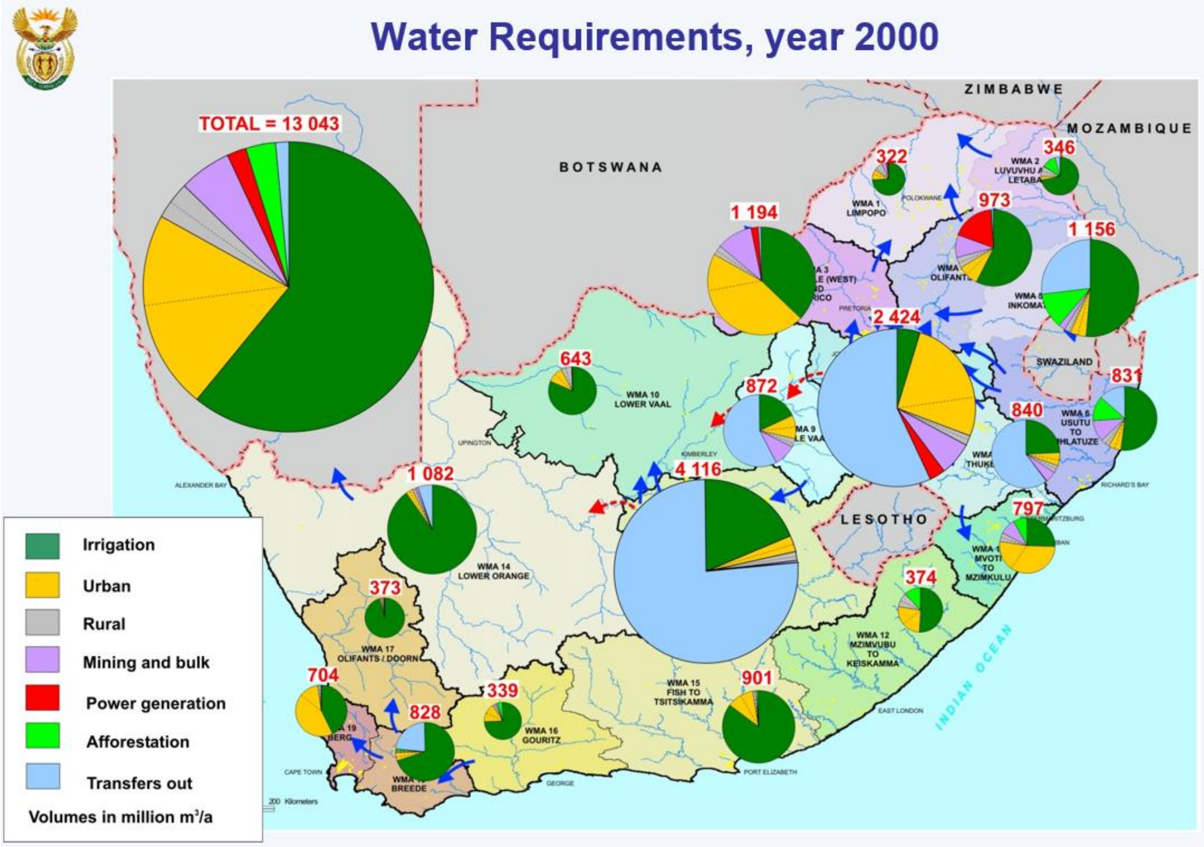


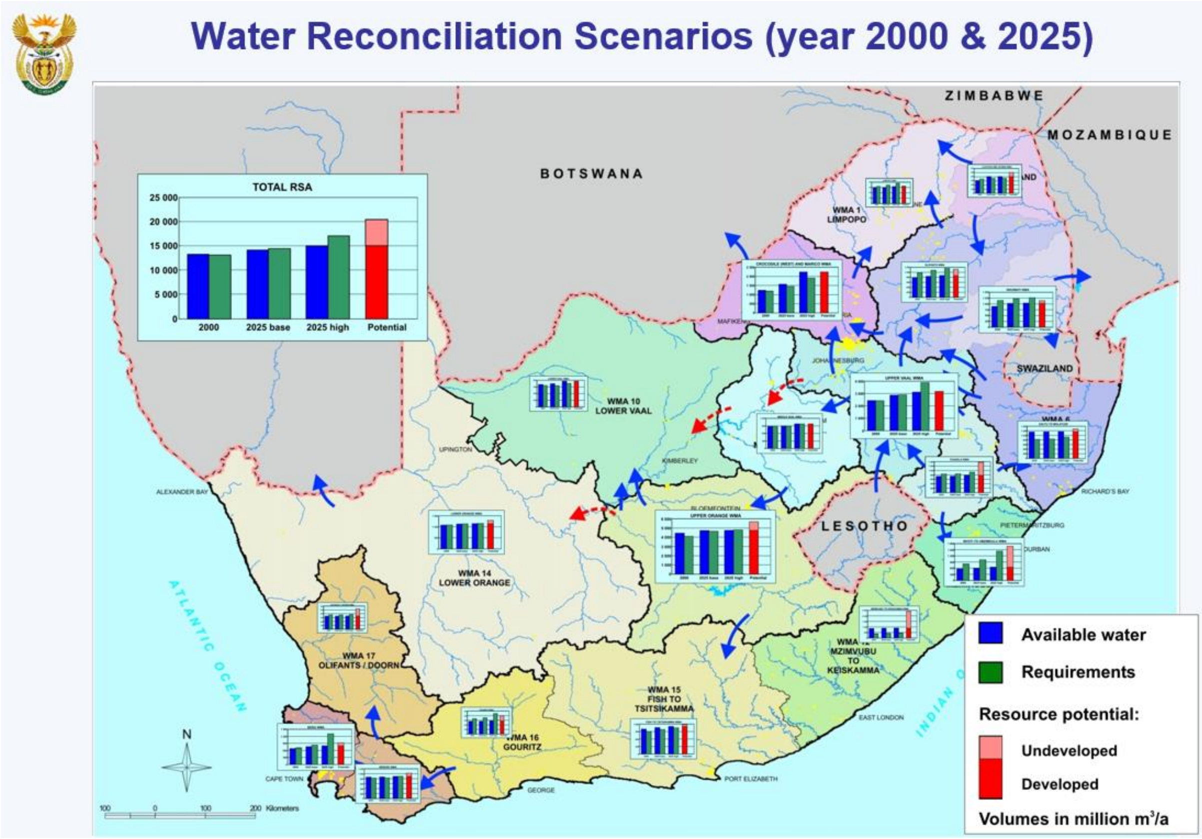
TANJA HICHERT

19 SEPTEMBER 2015

B) Water Resources National Footprint (NWRS1 & 2)

The water footprint is summarized in the following 3 figures showing the available water resource, the existing water requirements and the resulting water balance per water management area.

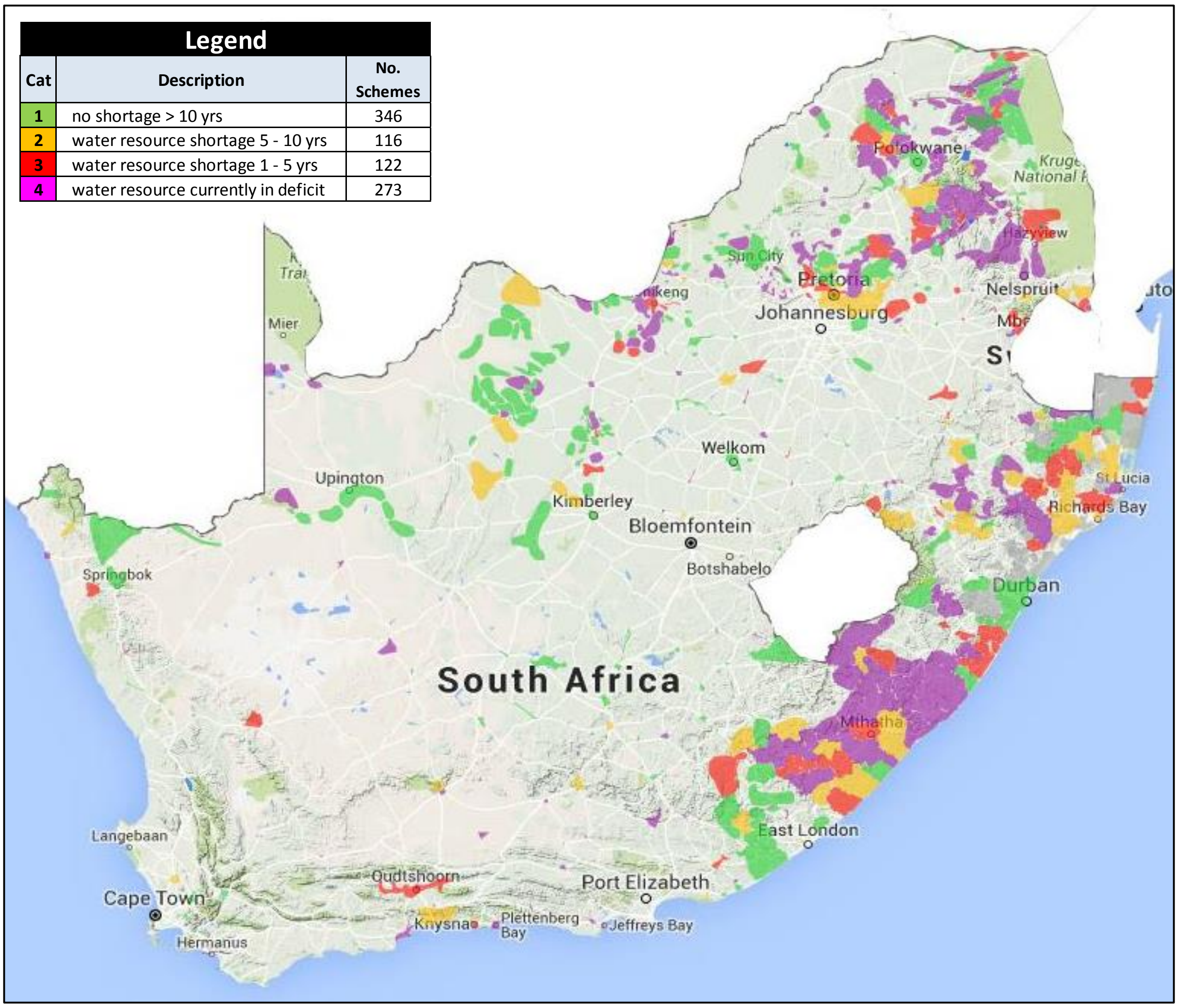




Above figures highlight that water resources are unevenly spread across the country and that economic water uses are often spatially removed from water resources, requiring costly water storage, abstraction and distribution infrastructure to serve the growing water requirements.

The total water available and water requirements per water management area, show that water for mining is only exceeding that of agriculture in the Upper-Vaal water management area. Irrigation, dominates the most in down-stream river reaches where there is no or little competition from domestic, mining or industrial uses (e.g. Lower Orange River WMA).

The real competition for scarce water resources is at a local level, depicted in the following figure of water supply reconciliations at local water supply schemes (DWS All Town Reconciliation Studies, 2014).



Source: PULA (2015)

The competition between mining and agriculture for scarce water resources, must take cognisance of the domestic water requirements in their vicinity as this will receive priority over their water demands.

The following figure shows the quaternary river catchments, where agriculture competes with mining for scarce water resources. The following is depicted:

1. Areas where there is no domestic water shortage in the next 10 years and where agriculture and mining water demands can co-exist and co-expand with limited competition
2. Areas where there is limited water and where high value minerals will most likely increase their water share against agriculture
3. Areas where there is limited water and where high-value strategic agricultural produce will counter the competition from lower value mining
4. Areas where domestic water resources will run into deficits within 5 years or where competition for water resources could be restricted due to secondary impacts on water quality and the environment