2012

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Evaluating the impact of coal mining on agriculture in the Delmas, Ogies and Leandra districts – With a spesific focus on maize production

Bureau for Food and Agricultural Policy

BFAP

Evaluating the impact of coal mining on agriculture in the Delmas, Ogies and Leandra districts

A focus on maize production

A report by BFAP

Compiled for the Maize Trust

May 2012

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Abbreviations and Acronyms

BFAP	Bureau for Food and Agricultural Policy
DALA	Department Agriculture & Land Administration
EIA	Environmental Impact Assessment
LSU	Livestock Unit
WWF	World Wildlife Fund
AMD	Acid Mine Drainage

List of Standard Units

ha	hectare
t/ha	tons per hectare
pa	per annum

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Executive summary

South Africa has only 1.5 % high potential arable soils (soils best suited for cash crop production),[1] and 46.4 % of this total area is in Mpumalanga. At the current rate of coal mining in Mpumalanga, it was calculated that approximately 12 % of South Africa's total high potential arable land will be transformed, while a further 13.6 % are under prospecting by the mines in Mpumalanga. Current mining and new prospects for mining could soon have meaningful effects on agricultural production as well as long-term implications for food prices, for the entire country. Some of these effects within the pilot study area are summarised in the following paragraphs.

The impacts of mining on agricultural production

The pilot area has approximately 5.3 % of South Africa's total high potential arable land, making it one of the most productive regions in South Africa with respect to grain and oilseed production. The potential loss of maize production from current mining activities and activities in the near future, amounts to 284 844 tons per annum. A further 162 736 tons of maize could be lost from the prospecting areas that in future could also be transformed. Over the long-run the reduction of 447 581 tons of maize per year, removed from the market, would result in an average annual price increase of R300/ton, over and above a long-run projected average maize price of R2 090/ton. In other words, average maize prices are projected to increase by approximately 14 %, which in turn would cause maize meal prices to rise by approximately 5 %.

Natural resources – Environmental impacts

Due to the adverse effects of coal mining on agriculture's sustainability, one has to evaluate the effects on agriculture if restrictions are not put in place to protect resources such as rivers, groundwater and high potential arable soils. The following lists the environmental effects of coal mining on agricultures natural resources. BFAP has not undertaken any environmental impact analysis and, therefore, section of the report only provides an overview of studies that have already been conducted with respect to the environment and natural resources:

- **Soil degradation**

Based on previous published studies, we could argue that high potential soils which are mined will never be rehabilitated back to the state/potential which it previously had. This, in effect, means that Mpumalanga has potentially lost approximately 26 % (**225 217 ha)** of its high potential arable soils to current mining activities.

The replacement of thick layers of topsoil in the post mining rehabilitation processes is not necessarily a recipe for crop success as was commonly thought. The compaction caused by machinery during the rehabilitation process is a major destructive factor, as is the possible

[1] High potential soils have some limitations that reduce the choice of plants or require moderate conservation practices; they may be used for cultivated crops, but with less latitude in the choice of crops or management practices than Class I (very high potential soils); the limitations are few and the practices are easy to apply.

hard setting nature of soils when moved wet. The inability of the roots to penetrate deeply into these hard soils, results in the stored water being unavailable for plant growth. These issues arise in soils that are stored too long (typical in opencast strip mining), due to a lack of aeration, thus reducing the likelihood of crop re-establishment on previously mined land.[2] Besides these factors, we also found that the costs involved in the replenishing process to get soils back to possible cash crop potential, outweigh the long-term feasibility of the land.

Another truism faced by all underground mining excavations, is the fact that they will collapse over time and pillars will spall. Many board and pillar sections are between 50 and 60 years old and experience indicates that serious subsidence will only occur after 100 to 120 years.[3] Thus the topsoil is ultimately left disturbed, with the additional effects of Acid Mine Drainage (AMD) and intoxicated landscapes.

- **Water quality effects**

Besides the environmental impact of coal mining causing effective sterilisation of the land due to collapsing and acidification of soils, one of the most severe problems seems to be water pollution.[4] Findings from McCarthy *et al*. (2009:1) show that pollution in the Middelburg Dam exceeds the quality limits for water for human consumption, and Witbank Dam is heading in the same direction. Moreover, these pollution levels are still on the rise.

Coal mine drainage can be detrimental to the aesthetic appearance of streams and rivers and destroy the living organisms that inhabit them. This in turn reduces their self-purification power and makes streams unfit for domestic, industrial or agricultural use, requiring surface waters to be extensively treated (at very high costs) before they are suitable for such uses.[5]

- **Health risks associated with mining**

Human exposure to AMD pollutants can occur through ingestion of contaminated water, food or through dermal absorption via water or air.[6] Studies have looked at the health effects in coal mining communities and found that community members have a 70 % greater risk of developing kidney disease and a 64 % greater risk of developing chronic obstructive pulmonary disease (COPD) such as emphysema. They are also 30 % more likely to report high blood pressure (hypertension).[7]

[2] Aken *et al*. (2005:5)
[3] Aken *et al.* (2005:6)
[4] McCarthy *et al*. (2009:1)
[5] Kemp (1967)
[6] WWF-SA (2011:57)
[7] WWF-SA (2011:58)

Introduction

Agriculture and mining have been the key driving force behind the South African economy for a number of centuries. Although their contribution to GDP has shrunk significantly as the economy has developed over time, these two industries remain at the heart of economic growth and the creation of unskilled job opportunities. 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 10 to 15 years has been phenomenal. The areas where the expansion in mining activities has and is taking place, ranges from desolate areas with limited agricultural potential, to areas where high potential agricultural land is taken over by mining activities.

The Bureau for Food and Agricultural Policy (BFAP) was approached by the Maize Trust to compile a report which covers relevant issues regarding the impact of mining, specifically opencast mining, on the agricultural sector in the Ogies, Delmas and Leandra districts. Since the specific area that was identified by the Maize Trust is relatively small compared to the impact of mining on agriculture in SA at large, this study can be regarded as a **pilot project** to assess the impact of mining in the specified region.

The first phase of this report focuses on literature that is already available and provides a summary of the personal surveying work that was undertaken by BFAP in the region. An EIA (Environmental Impact Assessment) report that was compiled for mining activities in this region in October 2011 for the Springboklaagte mining group was used as a point of reference for this study, due to its relevance in the study area. This is a typical EIA report that was undertaken subject to the latest mining act and addresses issues like traffic, soil and land use, noise, air quality and surface water quality.

The report focuses on the following topics:

- **The economic impact on the area with reference to:**
    - *Loss in maize production*
    - *Total summer cash crop losses*
    - *Grazing capacity reduction and economic impact*
    - *Traffic on roads and transport costs*
- **Rehabilitation and sustainability**
- **Health risks**
- **Environmental impact on the designated areas relating to:**
    - *Soil degradation*
    - *Water pollution*
    - *Biodiversity impacts as well as wetlands*
    - *Air pollution*
    - *Effects of coal dust*
- **The social issues within mining and the effects on agriculture**

An overview of agriculture in Mpumalanga

Cash crop production

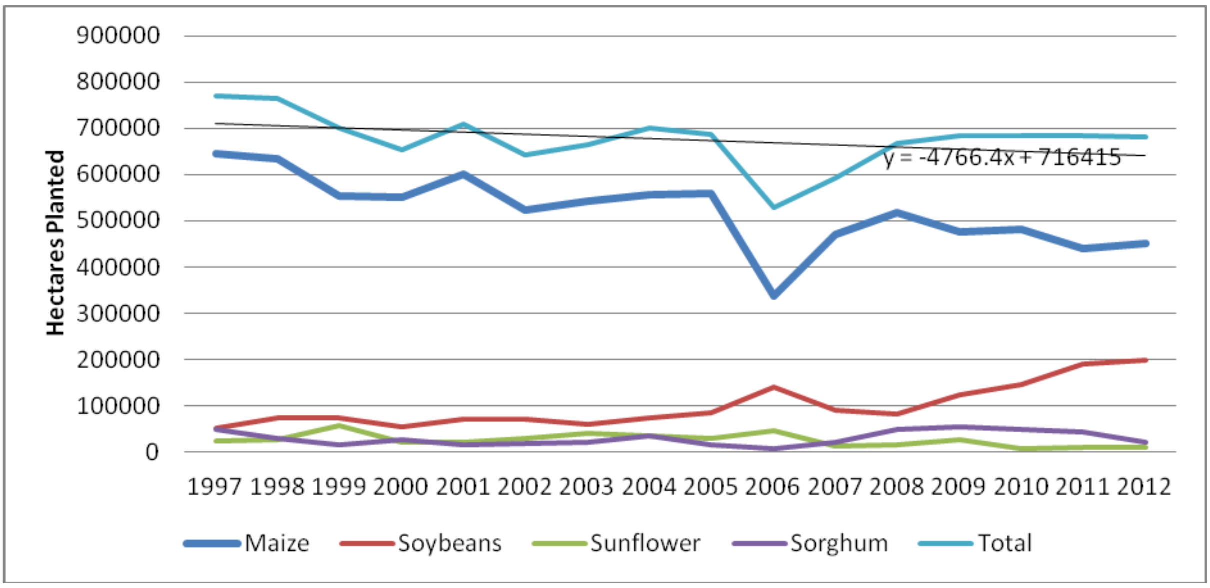
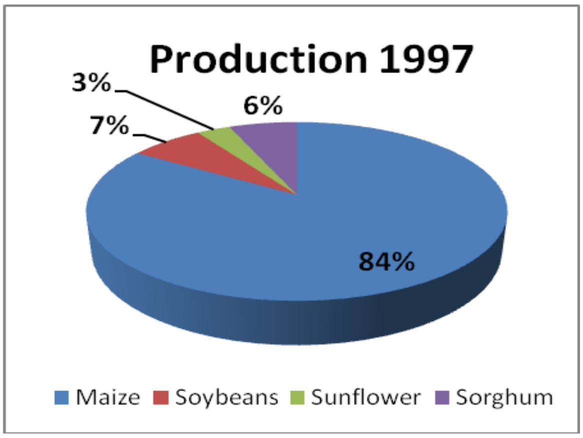


Figure 1: Mpumalanga – selected summer cash crop production per crop
Source: SAGIS 2012 & CEC 2012

Figure 1 shows a reduction of 196 000 ha in the area planted to maize, while the area of soybeans increased by 148 000 ha in the same period (1997–2012). The reduction in maize plantings can be assigned to the rotational cropping with soybeans, as Figure 2 shows the percentage change from 1997 to 2012. But in view of the total area planted to maize, soybeans, sunflower and sorghum, it should be noted that the area decreased from 770 000 hectares to 680 000 hectares in 15 years, totalling a 90 000 hectare reduction.



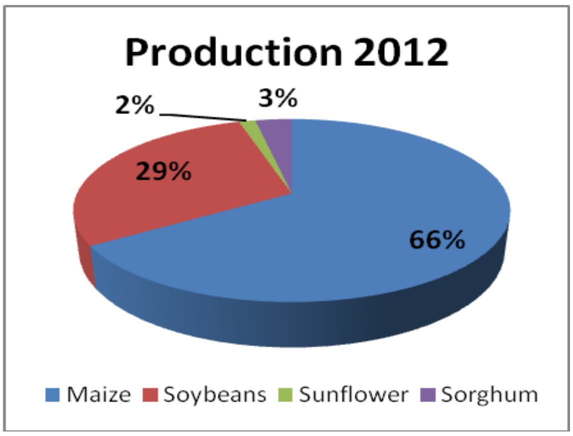
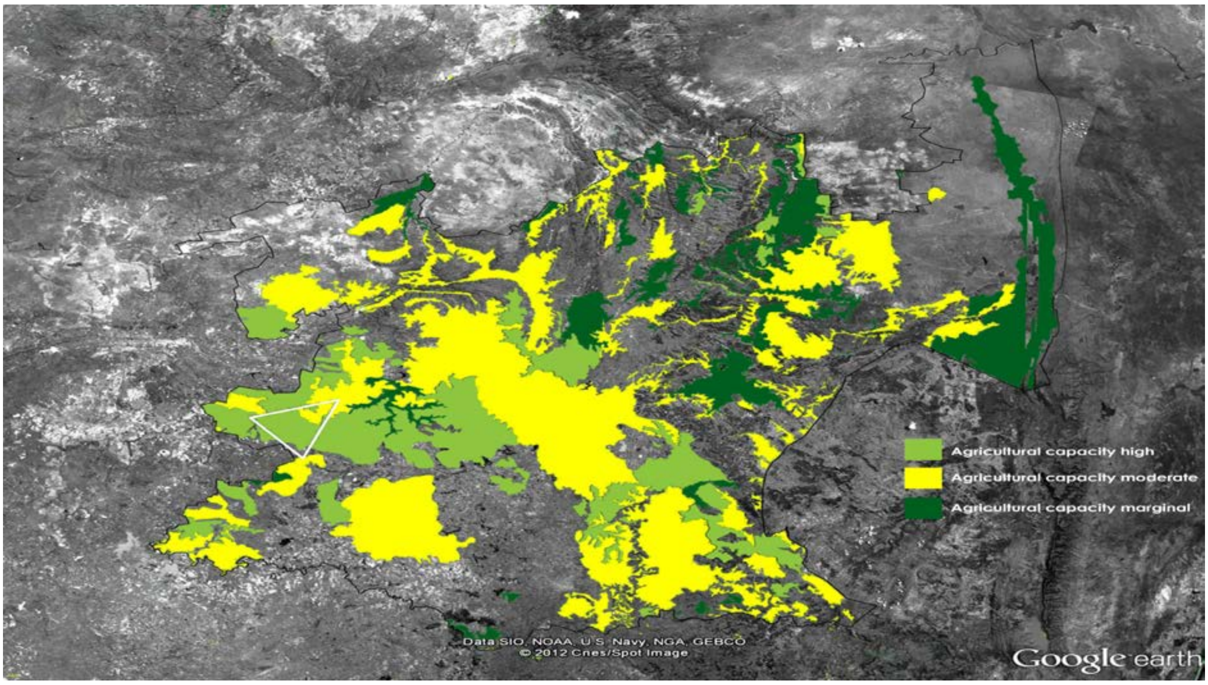


Figure 2: Mpumalanga – percentage production reduction 1997–2012 in maize area planted
Source: SAGIS sourced from the crop estimates committee

Arable land potentials for Mpumalanga



Map 1: Mpumalanga high to marginal potential arable land
Source: Map overlaid with CPlan (Conservation Plan) data, and compiled by MENCO consulting 2012

Based on the findings from Schoeman *et al*. (2002), the entire Mpumalanga province has 12.1 % high potential arable land and 26.9 % moderate potential arable land (Table 1). In total, South Africa has only 1 878 750.13 ha (1.5 %) of high potential arable land (AGIS, 2011) and of this, Mpumalanga has 46.4 % or 872 007.6 ha of high potential arable land (BFAP, 2011).

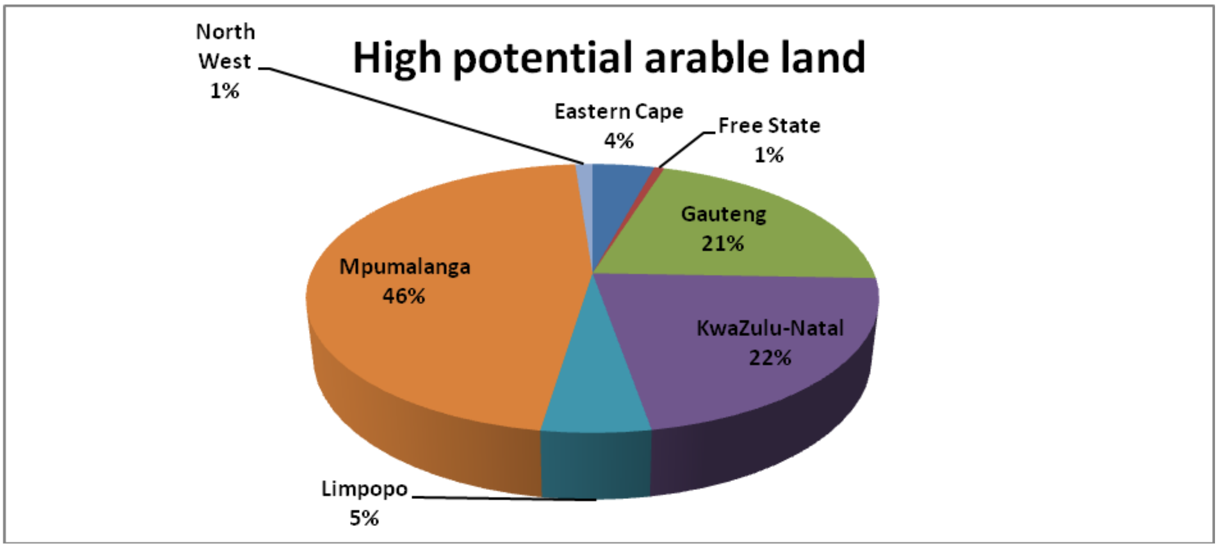


Figure 3: High potential arable land in South Africa
Source: Own calculations

Table 1: Percentage arable land per province in capability classes

Percentage of province occupied by various arable potential classes				
	Very high (I)	**High (II)**	**Moderate (III)**	**IV**
Eastern Cape	0.001	0.9	6.7	9.9
Free State		0.3	17.3	28.7
Gauteng		20.4	35.3	5.6
KwaZulu-Natal	0.001	5.7	24.9	11.1
Limpopo		0.7	16.8	20.2
Mpumalanga		**12.1**	**26.9**	12.2
North West		0.2	14	21.7
Western Cape		0.2	6.9	6.8

Source: Schoeman *et al*. 2002

Based on statistics from AGIS (2011) it was calculated that in the year 2007, Mpumalanga's cultivation equalled a total of 993 301 hectares. If the current mining areas are overlaid with the latest field crop boundaries, a total of 326 022 ha of farmland will be lost to mining and a further 439 577 ha are at risk if the prospecting area is also transferred, totalling 765 599 hectares of cultivated land potentially transferred if all the mining activities take place as indicated by McCarthy *et al*. (2009).

Table 2: Total cultivation per province

	Year when data was captured & Province						
	2008	**2009**	**2007**	**2007**	**2007**	**2007**	**2009**
	FS	**GP**	**KZN**	**LP**	**MP**	**NC**	**NW**
Cultivation Type							
High cultivation	1064183	26995	0	141252	159773	27274	936800
Medium cultivation	1738863	165619	159133	199424	579197	2996	641205
Low cultivation	652712	81953	131414	255540	204736	156722	384404
Old Fields	170744	1934	3291	21369	0	2180	69218
Pivot Irrigation	121540	18650	40110	125183	33298	72546	67865
Small scale farming	23919	1940	255963	524540	16297	282	184244
Smallholding	0	3913	0	0	0	0	0
Smallholding < 5ha	0	13932	0	0	0	0	0
Total	3771961	314936	589911	1267308	**993301**	262000	2283736

Source: AGIS (2011)

Current mining and prospecting

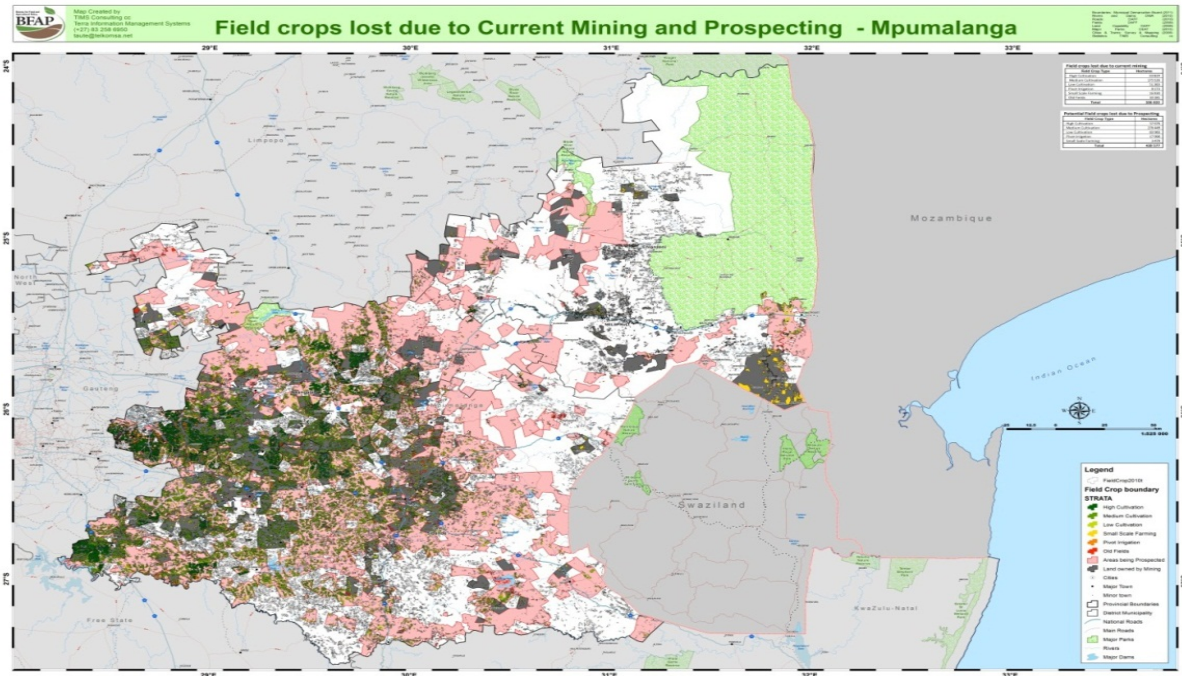
According to the maps made available, mining and prospecting areas cover an extensive part of the Mpumalanga Province. According to Venter (2012), the maps and GIS data layers should be interpreted with caution. The following interpretation is proposed:

- ***Mining or current mining*** *includes all areas on which some form of mining operations exist or where there are mining rights. Some of these mines are operational and some are not.*

- ***New mining applications or prospecting** areas include all areas for which applications for prospecting permits have been received by the relevant departments and which have either been approved or are still being processed*

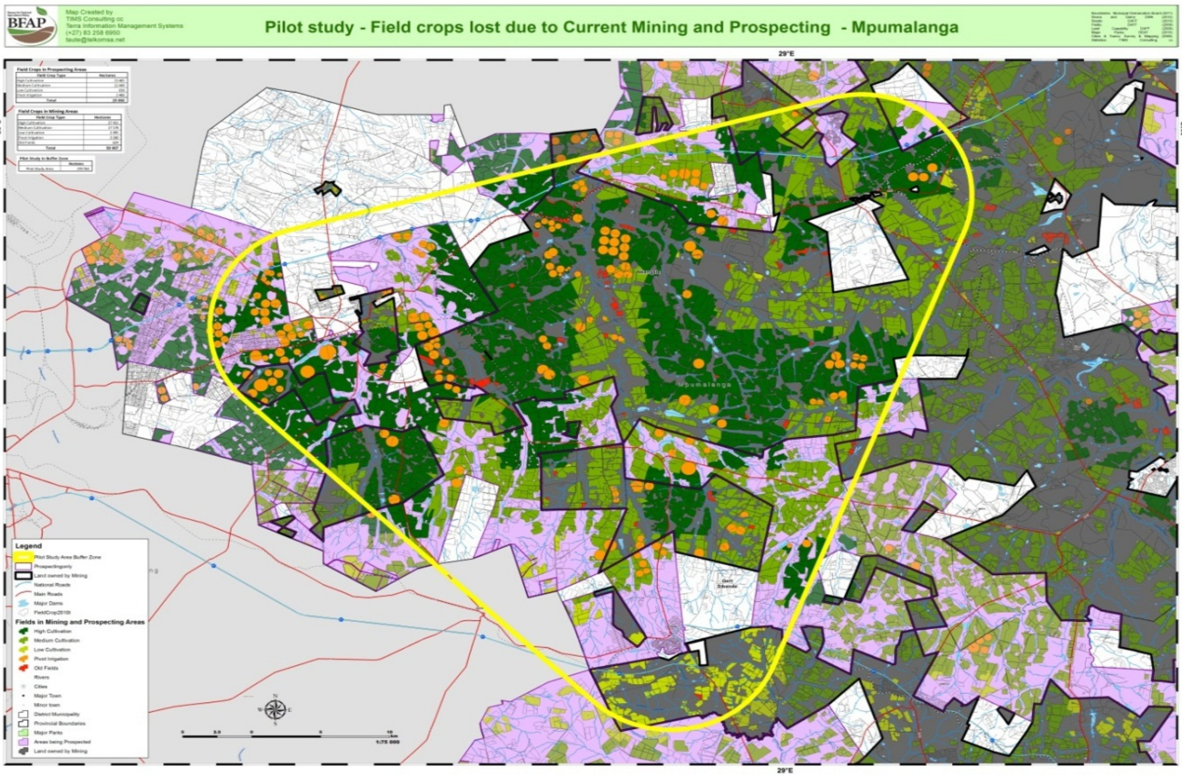
It should be noted that although large farm portions are shown to be covered by mining operations or prospecting areas, only small areas of these farms will be subjected to mining and or prospecting. Applications for prospecting and mining rights are done over large areas in order to obtain a permit usually applicable only to a smaller portion or area within the larger area. In this sense it might seem as if the maps displayed are an over-exaggerated picture of the actual reality, but there is still room for concern given that the mines will have to buy the entire piece of land. Furthermore, the social and environmental impacts of mining activities on a region (e.g. air pollution, water pollution, crime, etc.) are in many instances so severe, that farming activities cannot be sustained on the land that is left between all the mining activities.

Awareness of the current situation that potentially threatens the agricultural industry in Mpumalanga and ultimately South Africa is necessary to enable all the relevant stakeholders to act and ensure that land that has previously been set aside for agricultural use is protected.



Map 2: Field crop boundaries overlaid with current & prospecting mining activities
Source: DALA 2009, AGIS 2011, compiled by TIMS consulting for BFAP

Pilot study area

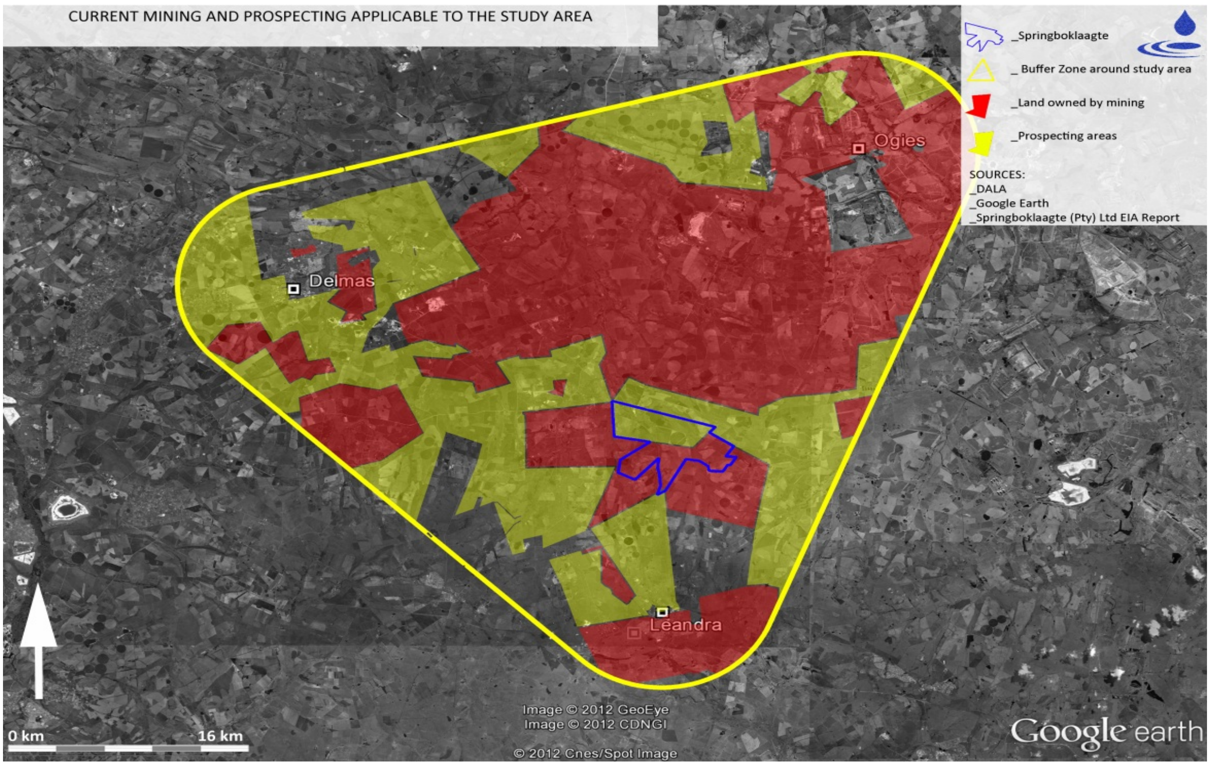


Map 3: Pilot study area containing the field crop boundaries, with current & prospected mining areas. Delmas, Ogies and Leandra
Source: From Map 2, Compiled by TIMS for BFAP 2012

Map 3 illustrates that the pilot area has an approximated total area of 170 763 ha, of which 99 518 ha is made up of high potential arable land and 38 020 ha is classified as moderate potential arable land. Of the 170 763 hectares of land, 84 428 hectares are considered to have high to low cultivation taking place on them and a further 5 956 hectares can be regarded as pivot irrigated land.

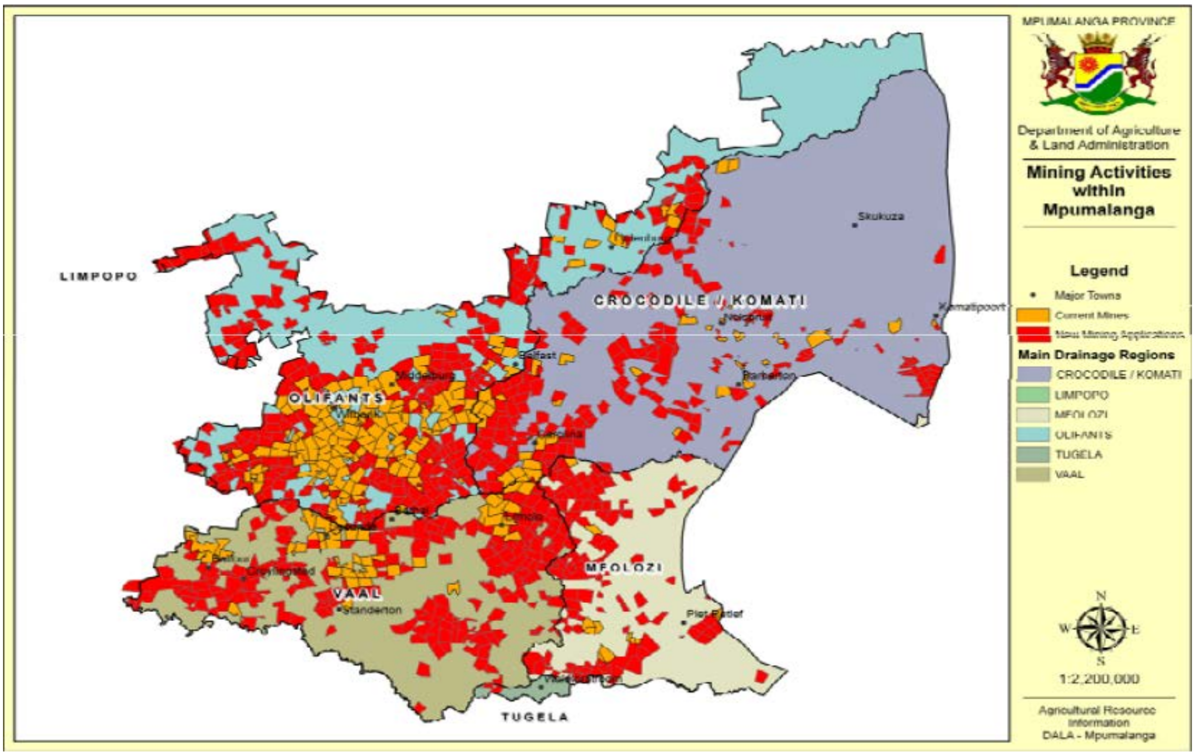
The total high, medium and low cultivation hectares influenced by current mining are 27 431, 17 178 and 2 495 ha respectively, as well as 3 180 ha for pivot irrigation. Then from the proposed prospecting areas another 13 485, 12 448 and 638 ha, within the same field crop boundaries as mentioned, and 2 488 for irrigation. This was calculated by TIMS Consulting, using ARC GIS mapping, with the field crop boundaries data provided by AGIS, 2011. For the purpose of this study, it was calculated that an approximated total of 79 967 ha (Map 3) of the current cultivated land in the Delmas, Ogies and Leandra district will potentially be taken over by the mines. The time frame for this is uncertain, but the most likely scenario is that this area will be taken up by mining activities over the next ten to twenty years.

Map 4 (with a spot image background) displays the amount of mining and prospecting taking place in the area.



Map 4: Spot view of pilot area showing current and prospecting areas as well as the proposed Springboklaagte colliery inclusion.

Source: DALA 2009 (By: Lotter M), compiled using Google earth by MENCO for BFAP 2012



Map 5: Map from the Department of Agriculture and Land Administration (DALA), Mpumalanga province, showing the potential future of mining.

Source: (McCarthy T.S. and Pretorius K, 2011) sourced from DALA (Lotter M.)

Economic impact of mining on agriculture

Based on the findings from the above maps, further calculations can be made. It is important to note that the data from the maps provide an indication of potential hectares to be lost since the actual hectares cannot yet be verified by any of the governmental departments. Evaluating the true economic impact of mining will have to go further than the pilot area, as externalities such as the pollution of the countries scarce water sources and air pollution cannot be left out of consideration.

The pilot area will provide an estimate of the potential impact, based on production potential averages for the area, and certain losses that in future will have to be considered by the 'reclamation farmers'. A 'reclamation farmer' is a term created for the future farmers in the area, as the current arable agricultural land will potentially be transformed by mining activities.

After the mines have left, one should find rehabilitated land. According to Section 40 of the Minerals Act this land 'should be in the same state as what it was before mining took place' and 'failure to do so is enforced through criminal sanctions (Sections 5(2), 8(1), 38, 39(1), 40 and 60(a) of the Minerals Act and draft reg. 5.7.8 GN 275 read with section 63(5) of the Act)' (Fuggle & Rabie, 2000).

The Minerals Act further provides for the expropriation of land where the use of land for mining purposes prevents or hinders the proper use of such land for farming purposes. (Sections 42(1)(a) and 42(2)) (Fuggle and Rabie, 2000). In other words, these farmers will farm on mining land and technically not on agricultural land, hence the phrase reclamation farmers and great confusion of ownership.

The sections below will focus not only on the impact on agricultural production, but also highlight selected environmental economic aspects.

Potential loss in maize production

In order to calculate the loss in maize production, two scenarios have to be taken into consideration. The first table illustrates the loss in production, only due to the current mining activities and the second table shows the effect if the area under prospecting is also taken into consideration. The tables were compiled based on the average of 75 % (Figure 3) maize cropping for the Mpumalanga, and further 25 % soybeans.

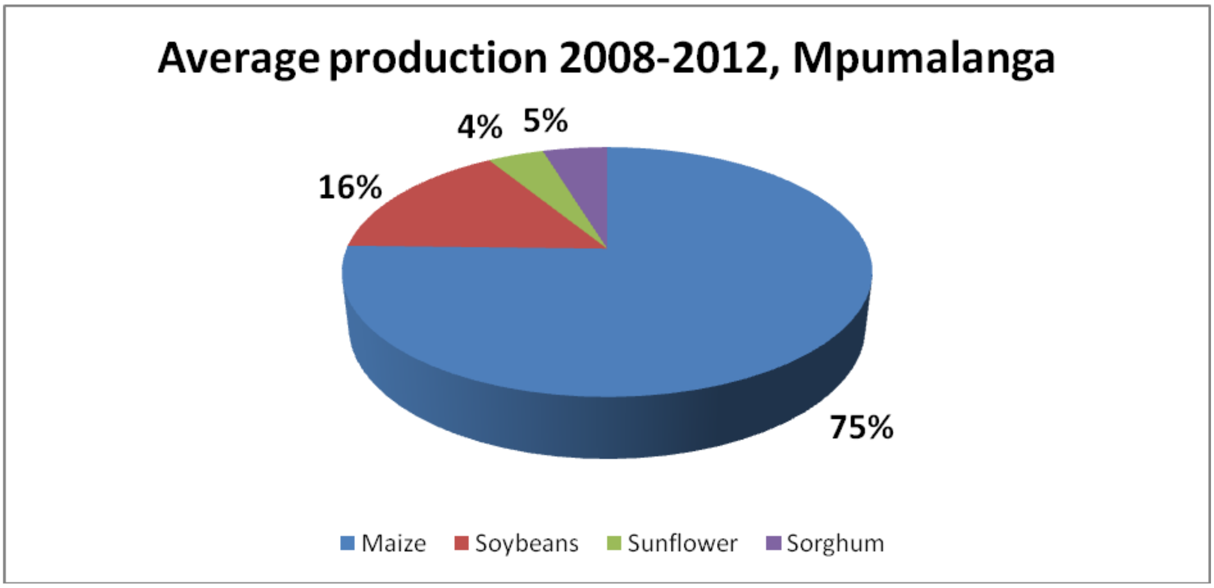


Figure 4: Average share in production for Mpumalanga from the four summer crops
Source: SAGIS 2012, compiled by BFAP 2012

Table 3: Soil potential and crops cultivated on the area based on Springboklaagte results

According to Springboklaagte EIA Soil assessment		
Product	**Arable potential**	**Potential yield**
Maize dry land	high	7-9t/ha
Maize irrigated	high	11-15t/ha
Maize dry land	moderate	6-8t/ha
Soybeans dry land	high	2-2.5t/ha
Soybeans dry land	moderate	1.5-2t/ha

Source: Steenekamp 2011.

Based on personal correspondence with farmers in the area, it was also confirmed that these yields are the norms in the area, due to high potential fertile soils, and enough heat units, allowing for optimum growth. It was also taken that the area receives an average of 650–700 mm of rain pa (Steenekamp, 2011: 54).

Table 4: Maize tonnage losses due to current mining activities

Loss in maize production if current mining takes place				
	Hectares	**Potential t/ha**	**ha if 75 % is maize (fig 1)**	**Tonnage**
High cultivation	27 431.0	8.5	20 573.3	174 872.6
Medium cultivation	17 178.0	6.5	12 883.5	83 742.8
Low cultivation	2 495.0	4.5	1 871.3	8 420.6
Pivot irrigation (assuming 40 % maize)	3 180.0	14.0	1 272.0	17 808.0
Total	**50 284.0**		**36 600.0**	**284 844.0**

Table 4: Maize tonnage losses if prospecting area is also transferred

Loss in maize production if prospecting also takes place				
	Hectares	**Potential t/ha**	**ha if 75 % is maize (Fig 1)**	**Tonnage**
High cultivation	13 485	8.5	10 113	85 966
Medium cultivation	12 448	6.5	9 336	60 684
Low cultivation	638	4.5	478	2 153
Pivot irrigation(assuming 40 % maize)	2 488	14.0	995	13 932
Total	**29 059**		**20 923**	**162 736**

Source: Computed from map 3 and Table 3 - own calculations

Without taking expected yield improvements into consideration, it is estimated that approximately 447 581 tonnes of maize could be taken out of production from this area over the next 20 years, if all the current & proposed future mining (on prospected areas) takes place as displayed on map 3.

Potential loss in soybean production

Although there has been a significant shift to expand soybean production in recent rotational cropping practises, a 25 % rotation of maize with soybeans was taken as an average for the purpose of illustrating the impacts. Based on this assumption, approximately 49 889 tons of soybeans would also be removed due to the same activities as calculated for the maize reductions. Again, for the purposes of this exercise, current yield potentials are taken into consideration, and given the fact that soybean production has been replacing maize production in recent years the projected impact on soybean production presented in table 5 is probably a conservative estimate.

Table 5: Potential soybean tonnage reduction

Loss in Soybean production due to current mining				
	Hectares	**Potential t/ha**	**ha if 25 % soy**	**Tonnage produced**
High Cultivation	27 431.0	2.5	6 857.8	17 144.4
Medium Cultivation	17 178.0	1.9	4 294.5	8 159.6
Low Cultivation	2 495.0	1.5	623.8	935.6
Pivot Irrigation (40 % Soybeans)	3 180.0	4.0	1 272.0	5 088.0
Total	**50 284.0**		**13 048**	**31 327.6**
Loss in Soybean production if prospecting also takes place				
	Hectares	**Potential t/ha**	**ha if 25 % soy**	**Tonnage produced**
High Cultivation	13 485.0	2.5	3 371.3	8 428.1
Medium Cultivation	12 448.0	1.9	3 112.0	5 912.8
Low Cultivation	638.0	1.5	159.5	239.3
Pivot Irrigation(40 % Soybeans)	2 488.0	4.0	995.2	3 980.8
Total	**29 059.0**		**7 638**	**18 561.0**

Source: Computed from Map 3 and further own calculations

The BFAP sector model was used to provide an indication of the projected long-run impacts on maize markets if 447 581 tonnes of maize are taken out of the market. It is important to note that this shock was analysed under the assumption that the full potential loss in maize production would occur by 2020, which is not necessarily the case. The shock was simulated in the model by gradually introducing a decline in the area under maize production. The total decline in the area under production towards 2020 amounted to 79 343 ha as calculated in Table 5.

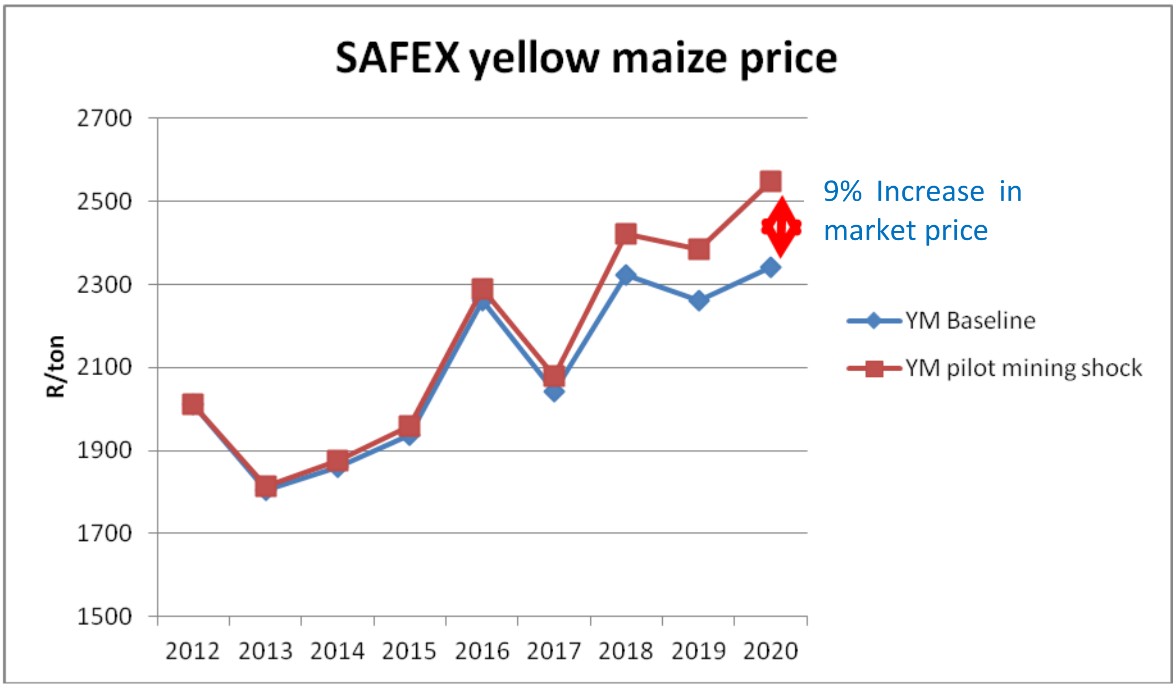


Figure 5: **Impact of mining in the pilot area on national yellow maize market**
Source: BFAP sector model, June 2012

It is important to note that this is only the impact of the pilot area on the national market price, in other words, the loss of 79 343 ha of crop land. In a proposed second phase of the research the magnitude of the impact on national maize markets will be significantly larger as preliminary indications are that approximately 400 000 ha of high potential land can be lost in total in Mpumalanga. If the anticipated rotational cropping practices brings soybean up to 40 % of the total maize area over the long run, it implies that approximately 240 000 ha of high potential land will be lost to maize alone. At a conservative average yield estimate of 5t/ha, this implies that 1.2 million tons of maize will be taken out of the market.

Comprehensive modelling work will be conducted in the proposed second phase, but it is relatively obvious that with this amount of maize out of the market, local prices will tend to trade closer to import parity levels. Naturally, other areas in the country that are currently underutilised will potentially be brought back into production as market prices rise significantly to absorb some of the crop losses, however since the potential of the land is lower than the potential that is lost, the average costs of producing 1 ton of maize in SA will increase, which will in the end affect food prices.

A number of calculations were undertaken to illustrate the impact of mining on the pilot study area. For example, the potential financial loss for in agriculture the pilot area over the long run is estimated at approximately R3.4 billion. There were figures estimated to determine the current value of land in the area and these figures can be made available if required.

Since not all the land will be used for mining, the argument for farming on the residual plots of land also has to be considered, and apart from all the health and social impacts of living in the area that will be discussed at a later stage, here the economies of scale really matter. For example, if a total farming unit covers an area of 1 000 ha, and the mine acquisition comprises only 400 ha, will the remaining land still justify the farmer's machinery costs, and in turn, what effect will this have on his farm as an economic unit? The capital investment has already been made to produce on a much larger farm. In this specific example, the loss in direct investment in machinery will amount to R1 316/ha.

This was only an example drawn on direct machinery costs and factors such as overheads, family living expenses and the decrease in total net farm income have not yet been calculated for the area. The potential exists to take a specific farm, relating to the study area, and build it into a farm benchmarking model, which will show the net effect on total farm income, as the farmer's hectares decrease. Due to this being a pilot study for the entire area of 170 000 ha, based on maize production primarily, this was not calculated.

Economic impact on livestock production

For the purpose of this study, the impact on livestock production was not the core focus. However, due to the high value of the grazing capacities in the Highveld, a quick summary was given to provide an overview of the grazing potential of these fields in relation to other grazing areas in the country. Furthermore, in many instances livestock production is combined with crop production where natural and cultivated pastures provide grazing in summer time and combined maize fields provide grazing in winter time. The purpose of this overview is to provide an indication of plausible costs on a per hectare basis to relocate the livestock component of a typical farming unit to other typical livestock production areas in the country. Again, these calculations have been simplified for the purpose of the pilot study.

Table 6: Cost for 1:2 LSU carrying capacity

	ha needed for 1 LSU	Head of cattle on 500 hectares	Added ha needed to = Highveld capacity	Est cost per ha in province	At what cost	Value per ha to equal Highveld
Highveld	2	250	none			
S Free State	7	71.42	1250	6800	850 0000	**17 000**
E Free State	5	100	750	13000	975 0000	**19 500**
North West	7	71.42	1250	7500	937 5000	**18 750**

Source: compiled by BFAP

An average stocking rate of 2 hectares per livestock unit (LSU) is applied where natural pastures provide the grazing in summer time and combined maize fields provide grazing in winter time. In order to relocate a typical livestock enterprise with 500 livestock units of a farm to an alternative part of the country ranges between R17 000 and R19 500 per hectare in the pilot area.

Environmental impact on the designated area, and further downstream

This section will focus on the environmental impacts of mining in the Highveld region. The true economic impact in the designated area will have to focus on these external environmental economic issues, as their repercussions are far-reaching, and could possibly affect the greatest part of agricultural activities in Mpumalanga as well as Limpopo Province.

These issues could not be confined to the study area, as very little research has been done in this specific region. But literature from similar regions was drawn on, and used to illustrate the potential overall impacts of mining on agricultural land.

Soil degradation

> *Soil formation takes thousands of years and, by only restoring a fraction of the original land capability, future generations are deprived of the choices that are available to this generation*. (Aken, Limpitlaw, Lodewijks and Viljoen, 2005:4)

As mentioned at the beginning of this document, Mpumalanga has the highest percentage of high potential arable land in the country, and the pilot study area lies exactly in this area. An assessment the economic impact of soil degradation is a project on its own, but making use of the literature currently available on this topic provides a general indication of the potential impacts that coal mining could have on arable land in the study area.

Open-cast mining

The EIA report from the proposed Springboklaagte Colliery was used as a point of departure. The findings from this soil assessments reports indicate that most of the soils in the pilot study area (58.3 %) are classified as high potential arable land and 22.3 % as moderate (sourced from Map 3). To understand the effects of open-cast mining on arable land, we include certain literature from the EIA report. First the arable agricultural value of the soils are described, then the stripping process which takes place prior to the physical mining. According to Steenekamp (2011:55):

> *It is important to bear in mind that the natural soil horizons developed over thousands of years in a specific sequence and [this] is the result of soil genesis (weathering) of the parent rock driven by climatic conditions (temperature and moist) within a specific topography.*
>
> *Stripping and replacing of soil will always result in a moderate to severe disturbance of the natural balances in the soil's physical and chemical properties. This implies that even with precise execution of well-defined rehabilitation procedures, a degradation from pre-mining to post-mining land capability is unavoidable.*

Most rehabilitation specialists argue that they can rehabilitate the soil potential back to 70 % of its pre-mining potential as described by Steenekamp (2011:55): 'The stripping procedures aim, with consideration of practical limitations, to reconstruct the original horizons sequences. That will be the only way to re-establish 70 % or more of the pre-mining land capability'. They reckon that most of this '70 %' could be achieved by separate stockpiling and following exact rehabilitation procedures. Stockpiling is a process in which the different layers of topsoil (A-G) are removed separately and dumped on separate sites, to in future replace them back as the final topsoil (Steenekamp, 2011:56,57). Parts of the process as described by the report include the following:

- *The A and B-horizon should be stripped and stockpiled separately as specified by the Chamber of Mines (Guidelines for the rehabilitation of mined land, Section 3.2). Each stockpile should therefore consist of a section for both the A and B-horizons. The A and B-horizon sections should be marked with a signboard.*
- *The A and B-horizons should be replaced in the same sequence on top of the soft overburden material. The fairly higher organic carbon content of the A horizons provides a buffer against compaction and hard setting. The A-horizons also serves as a seed source which will enhance the re-establishing of natural species. When B-horizons are replaced on the surface they tend to seal and compact severely, which increases runoff and triggers erosion.*
- *The soil fertility status should be determined by soil chemical analysis after levelling (before seeding/re-vegetation) and soil amelioration should be done accordingly as recommended by a soil specialist in order to correct the pH and nutrition status once off.*

It was mentioned that if no proper guidance and enforcement of these rehabilitation measures are applied, 70–90 % of the pre-mining soil potential will be lost, even if the correct depth is allowed for (Steenekamp, 2011:68,69).

Real effects of open-cast mining and soil degradation

The question then remains, how much do the mines really rehabilitate in this manner? Besides the rehabilitation, there is no evidence to prove that you can get these soils back to their pre-mining potential; in fact, the **contrary is shown**. According to Aken *et al*. (2005:4):

> *Pre-mining environment consists of bio diverse grassland of varying agricultural potential. Through the rehabilitation process, land is returned to* ***low levels of biodiversity*** *as rehabilitation programmes preferentially use commercially available seed,* ***with high nutrient and water requirements****.*
>
> *Through over-fertilisation, grass monocultures are promoted, preventing the re-establishment of bio diverse pastures. For example, a commonly used rehabilitation grass,* Eragrostis *sp., secretes a hormone from its roots prohibiting the germination of other seeds. This problem has been detected by environmental audits in many rehabilitated colliery landscapes.*
>
> *Once the high input regime, established during the* ***rehabilitation programme ceases, after five years*** *or so, the* ***grass cover often deteriorates****.*

This does not even mention maize production or feasible cash crop production. Mono-specific grasslands and pastures (such as *Eragrostis*) are, according to Aken *et al*. (2005:4), not able to sustain economic grazing systems, due to their high input costs.

Future cash crop production

The effects of soil losses on rehabilitated lands are at the moment not fully appreciated, as these effects may be delayed for several years once rehabilitation is completed, and some only become evident 15 years later. Due to the erosion, salt migrates upwards through rehabilitated surfaces, and has a negative effect on re-established vegetation (Aken *et al*., 2005:5).

The question that everyone then asks: 'Will rehabilitated land come back into maize production?' seems self-explanatory if you look at the findings of Aken *et al*. (2005:5). They report as follows:

> *Replacement of thick layers of topsoil is not necessarily a recipe for crop success, as was previously thought. Compaction caused by machinery during the rehabilitation process is a factor, as is the possible* ***hard setting*** *nature of soils when moved wet. Rehabilitation may be more prone to failure on compacted deep soils than on compacted shallow soils as, in the latter; plants are able to extract water from the underlying spoils which do not compact readily. Red soils, with a clay content of less than 28 %, are common on the Highveld and are highly compactable when replaced during the rehabilitation process. This is especially true if the soils are moved when they have a soil moisture content in excess of 10 %. The rehabilitation process often, unwisely, uses graders to smooth off rehabilitated surfaces to achieve a pleasing aesthetic landscape. The high bearing load on the wheels of this machinery promotes soil densification. Plant roots cannot penetrate such dense soils and water in underlying spoils cannot be extracted.*
>
> *Although a compacted soil profile may contain soil water at field capacity, the inability of the roots to penetrate deeply into these soils means that the stored water is unavailable for plant growth. Under such conditions, one metre of soil is replaced, but only half a metre is available for growth.* ***Even deep-ripping of re-emplaced soils has proved ineffective. Hard setting follows the first rains after deep ripping due to the lack of organic materials and microbes in the soils.***
>
> ***This arises in soils stored too long, due to a lack of aeration, reducing the likelihood of crop re-establishment on previously mined land.***

Direct effects on farms next to mines

Farmers in the Middelburg district who make use of precision equipment such as combine monitors have reported crop losses on fields close to mining operations, especially from roads that generate a lot of dust. Typical reductions in yields amount to 1.5–2t/ha. (BFAP survey, April 2012). The yield charts from the combines could be made available towards the end of the harvest season in June 2012. Figure 6 shows similar effects from the mine dust. This figure was obtained from the WWF (World Wildlife Fund – SA). The black coal dust is clearly visible next to the road. When it rained and the mine dust washed in, part of the maize crop was 'burned' or turned yellow as a sign of crop stress and death.

Figure 6: Effects of coal dust or transport next to maize fields.
Source: J. Brown (February 2011) in WWF (2011:81)

Underground mining and related effects

The effects of underground mining in relation to open-cast mining, is also relevant for the pilot area. Very little was reported in the soil assessment study of the Springboklaagte EIA about the underground mining areas and their 'cultivated land losses'. According to Steenekamp (2011:7), the proposed Springboklaagte mining project will consist of 6 open pits with a total of 261.58 ha and the underground mining of the '2-seam, 4-upper, 4-lower and 5-seam' has a **total of 1 492.22 ha**.

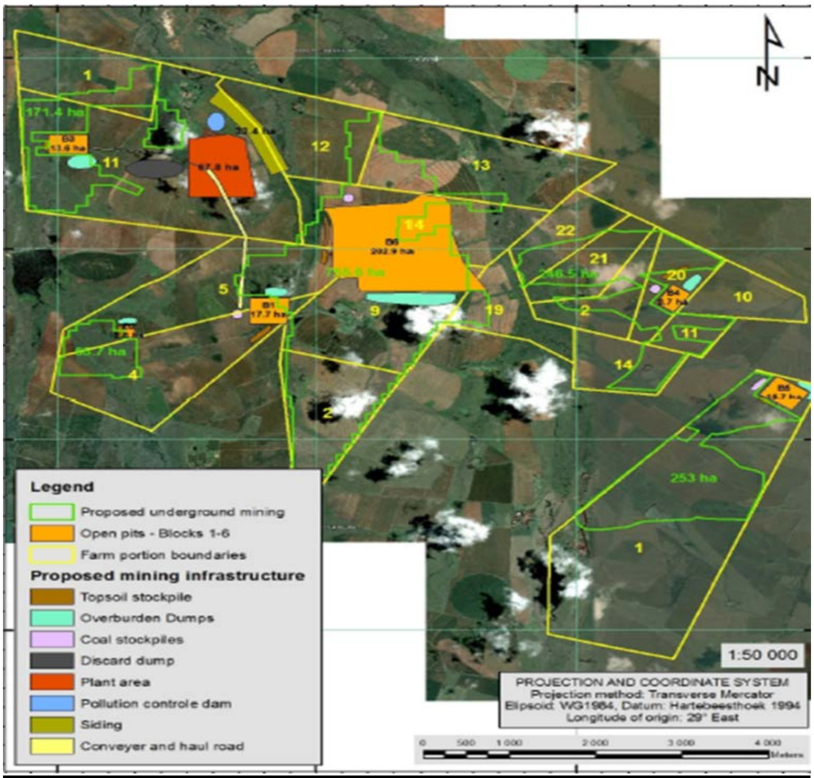
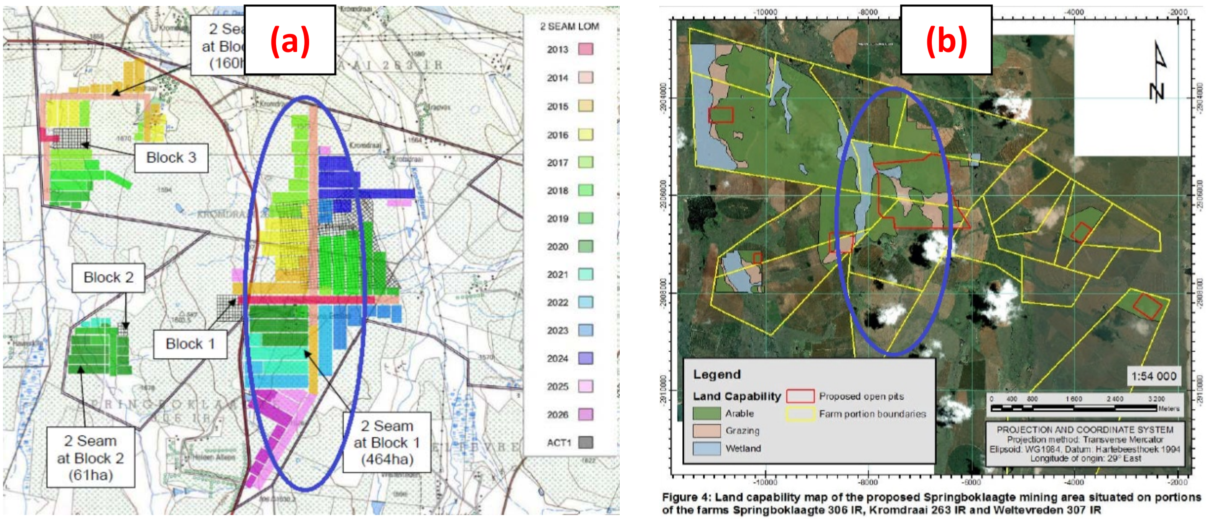


Figure 7: Proposed Springboklaagte colliery – boundaries of open-pits and underground mines (light green lines).
Source: Steenekamp (2011:8)

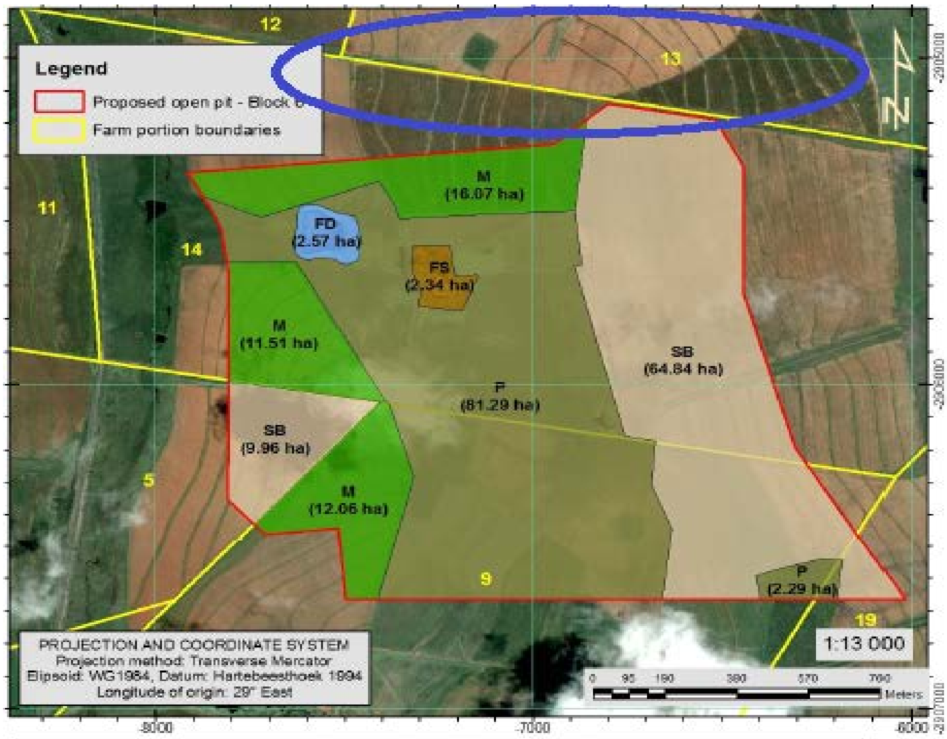
At the top of Figure 7, within block 13, a light green border represents the boundary of the proposed underground mining section.

Arable land is shown on the maps (e.g. Figure 8b), but the area of cultivated land potentially transformed by underground mining (Figure 8a) is not shown as a reduction in crop losses, compared with the open-pit mining calculations. Figure 9 shows how the open-pit mines are displayed with their crop type and hectares, but as the blue circle shows on the same figure, no calculations are made that will show to what extent the proposed underground mine might affect the topsoil.



Figures 8a & b: (a) Underground mining 'shaft' developments, (b) Arable potential for the proposed areas.

Source: (a) Oosthuizen (2011:13) and (b) Steenekamp (2011:8)



LEGEND – PRE-MINING LAND USE				
Land Use Code	Pre-mining Land Use	Unit Count	Area (ha)	Area (%)
M	Maize – Dry land	3	39.64	19.53
SB	Soybeans	2	74.80	36.86
P	Pasture	2	83.58	41.19
FS	Farmstead and related structures	1	2.34	1.15
FD	Farm Dam	1	2.57	1.27
	TOTAL	9	202.93	100.0

Figure 5f: Pre-mining land use map of the proposed Block 6 open pit situated on portion 14 of the Farm Kromdraai 263 IR and on portions 5 and 9 of the Farm Springboklaagte 306 IR

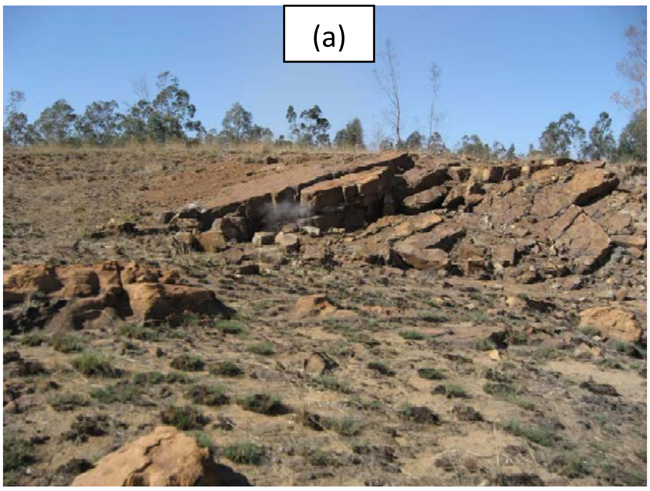
Figure 9: Illustration of open-pit mining area (block 6, outlined in red) – cultivation potential vs. Underground mining area (drawn in blue border) – with cultivated fields, but not included as 'pre-mining land use'.
Source: Steenekamp (2011:53)

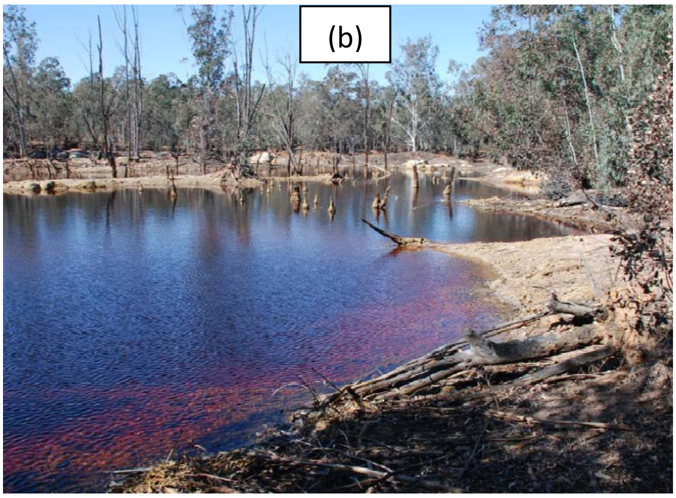
The effect of underground mining is an aspect that receives very little attention in the EIAs, as very little arable topsoil will be disturbed during the direct mining process. But the true effects are only seen some years later when these underground structures give way. Aken *et al*. (2005:6) argue that underground mining could contribute to the destruction of high potential arable land.

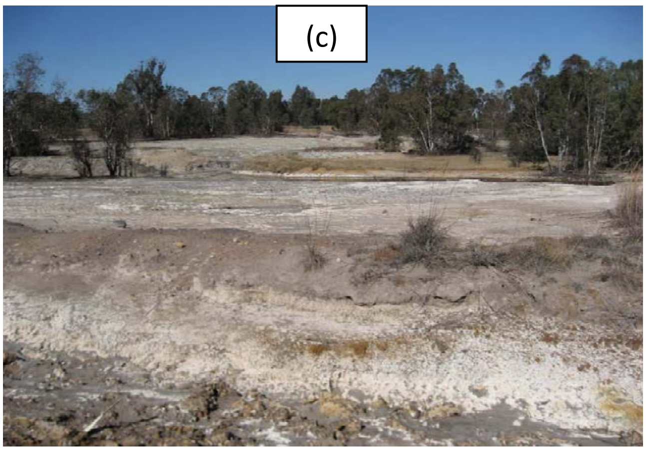
According to Aken *et al*., (2005:6):

> *Subsidence* (sinking or subsiding) *is a problem that has not received adequate attention. The impacts of land subsidence have not been felt as originally predicted by models. Many board and pillar sections are between 50 and 60 years old and experience indicates that serious subsidence will only occur after between 100 and 120 years. As the old, closed sections age, mass subsidence may occur due to pillar runs and the collapse of whole areas.*

A truism is that all underground excavations will collapse over time and pillars will spall. Where these excavations are near surface, rat-holing and subsidence will follow. Even where such excavations are not very shallow, as in Springs on the East Rand, sinkholes have propagated 65 m up to surface (Stacey & Page, 1983).







From figures a-c, it appears that the effects of underground mining could be just as detrimental in extreme cases as the attempts to rehabilitate open-cast mines.

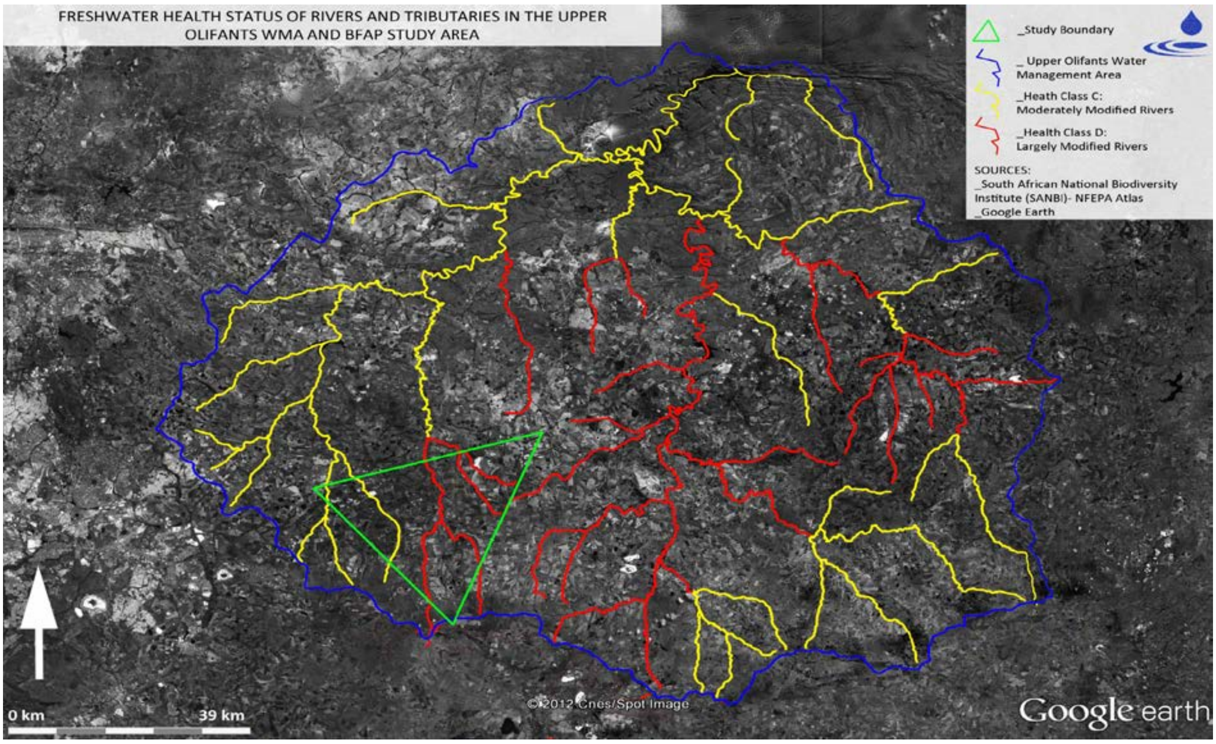
Figure 10: (a)(b)(c): (a) A collapsed, burning coal mine, (b) Acidic, iron-rich water filling a collapsed coal mine, (c) Barren, sulphate-encrusted soil caused by seepage of acidic water from a flooded coal mine.
Source: McCarthy and Pretorius (2009:58-59)

It is not possible to provide a comprehensive estimate of the environmental impact of mining, since many of these effects will only play out over the long run. However, taking the existing literature into consideration, it seems to be fair to conclude that it is unlikely that the original agricultural potential of the soil will be achieved. In fact, according to personal interviews with soil science specialists (Dr van Vuuren and Prof Claasens) it seems plausible that rehabilitated soils will only be suitable for very limited agricultural practices and not nearly at the same level of intensity as is currently the case.

Water pollution, biodiversity impacts as well as wetlands disruption

Effects of mining on water quality

Mining activities exert their effects on water quality during construction and operational phases and in many cases, also at abandoned, post-operational mines. This is mainly due to extremely poor infrastructure, management and legislative control. The negative impacts of coal mining have been documented over years and described: ‘Coal mine drainage adversely affects the aesthetic appearance of streams and rivers, destroys the living organisms that inhabit them and hence reduces their self-purification power, and makes streams unfit for domestic, industrial and agricultural use, requiring surface waters to be extensively treated before they are suitable for such uses’ (Kemp, 1967). The effects of mining impacts can be as far-reaching as 18 km downstream from the impacted site and if no mitigated measures are put in place, can have long-lasting effects (Dallas & Day, 2004).



Map 6: Upper Olifants catchment and pilot study area

Source: South African National Bio-diversity Institute and NFEPA, 2011. Compiled on Google earth by MENCO Consulting, 2012.

As data was a limiting factor, with very few comprehensive monitoring data sets available for the past 20 years in the specific area of the pilot study, no comparisons and conclusions could be drawn with respect to water quality. A more comprehensive overview of the entire Olifants catchment provides more substantial data, but was outside the scope of this study. Therefore **Appendix A** provides an overview of the catchment and pollution-related effects on the entire catchment, with some effects mentioned in the pilot area.

Coal mining-related pollution in the Highveld

According to McCarthy *et al*. (2009:1), the Witbank area provides an opportunity to examine the longer-term impacts of coal mining, as mining has been in operation there for over a 100 years. A summary of their findings include:

> *The impacts include* ***sterilization of land*** *due to* ***collapse and acidification of soils****, but the* ***most severe*** *problem is* ***water pollution****, which is high and rising. Water in the Middelburg Dam exceeds the quality limits for water for human consumption, and Witbank dam is trending in the same direction. The pollution levels are still rising, notwithstanding mitigation measures that have been taken.*

Detailed findings from McCarthy *et al.* (2009) show the severity of the situation. The main sources of water pollution seem to be mining, the inactive sewerage works and agriculture, which also contributes to chemical pollution. Inclusions from their findings are also shown in **Appendix A**.

One of the most severe impacts – AMD (Acid Mine Drainage)

The impacts that acid mine drainage exerts on a receiving stream are dependent on the nature of the receiving water body and are related to the buffering capacity of the receiving stream (Ward, Canton, & Gray, 1978; Dallas & Day, 2004). Larger and faster flowing streams are less prone to impacts by the effects of acid mine drainage. The rocks and soil of the surface over which the acid drainage occurs, as well as the receiving stream, further determine whether there will be an impact as well as the severity of the impact (Oliff, 1963) (Dallas & Day, 2004).

Figure 11: A coal mine-related pollution event (June 2007), in the Wilger River
Source: McCarthy and Pretorius (2009)

According to McCarthy *et al*. (2009), it is believed that the blue colour (Figure 11) is due to the precipitation of aluminium compounds in the river.

McCarty *et al*. (2011:6) further mention that AMD is one of the most serious environmental problems arising from coal mining, due to the generation of sulphuric acid as a result of a chemical reaction between an iron sulphide mineral (pyrite) present in the coal and its host rocks and oxygen-bearing water (infiltrated rain water). According to McCarthy *et al*. (2009):

> *Under **natural conditions**, the process is extremely slow and other equally slow reactions **completely neutralize the acid**. However, **mining breaks up the rock mass** allowing **free access of water** and the **acid-producing chemical reactions proceed faster** than the acid can be neutralized. The **acid water dissolves aluminium and heavy metals** (iron, manganese and others) and is toxic to animal and most plant life.*

Figures 10 (a-c) all form part of McCarthy and Pretorius's study, showing the effects of AMD on the environment as well as collapsing of mines and the result of decanting. Figure 11 explains the effect due to the precipitation of aluminium compounds found in the Wilger River during June 2007, which relates to the AMD.

Effects and mitigation of AMD

(Rout, Samantaray and Das, 2000, in WWF-SA, 2012) describe Aluminium (Al) as an important metal associated with AMD and acidification. Below a pH of 5, Al is toxic to plants and acts as an important ***growth-limiting factor for crops***, causing cell damage and limited nutrient uptake (Zheng, 2010, in WWF-SA, 2012). Hence, acidification and consequent release of Al in AMD-affected areas can lead to ***significant losses*** in plant biomass and ***crop yields*** (Baligar. Pitta, Gama, Schaffert, Bahia Filho, and Clark, 1997, in WWF-SA, 2012).

The effects of AMD cannot easily be overcome, if at all. According to Oberholster and Ashton (2008, as cited in WWF-SA, 2012:58), the following was observed:

> *Aluminium toxicity in shallow soils can be countered by increasing the pH of the soil with lime treatment, and nutrient deficiencies can be addressed by applying more phosphates. Ammonium-based inorganic nitrogen fertilizers on the other hand would add to the acidification problem. However, liming and phosphate additions are only feasible for shallow-rooted crops and their expense creates a financial burden to farmers. In turn, the use of phosphates adds to the eutrophication crisis in South Africa, where currently data from 88 % of the national water quality monitoring sites indicate that the waters already exceed the Resource Water Quality Objectives.*

Mining and ground water

The impacts of mining on ground water are still poorly understood. In most cases, the effects of the act of mining on groundwater are localised to the mining area (Younger & Wolkerdorfer, 2004).

This is dependent on the rehabilitation procedure of the mine (operational and closure phases), the extent to which blasting takes place, depth below the surface, geology, topography and the size of the catchment in which the mine is located. The effects of mining on groundwater adjacent to or close to a mining area are only possible if the area in question is situated downstream and in the same drainage/sub-catchment region of the mine.

Groundwater usually decants into tributaries and streams in the vicinity or area of the mine and this is determined by the geo-hydrological study. Pollution can occur both directly and indirectly. The direct effects manifest if groundwater is located down gradient from a surface mine, which drains into surface pits and ponds, or water that filters through to groundwater during rainfall, contaminated by surface pollutants on the mine property. Blasting may sometimes cause rock fractures to develop between two naturally divided areas, creating connections between underground seams through which polluted water can drain into adjacent unpolluted underground areas. This is an indirect manner (Rauch). Careful evaluations of the geo-hydrological study will provide a clearer understanding of the potential risks involved in groundwater contamination of areas in the close vicinity of the mine. Mine closure applications and EMPRs should indicate the degree to which a mine is rehabilitated and the extent to which the contaminated groundwater is localised.

The main impacts on aquatic ecosystems (mainly from Gold, Uranium and Coal mining) are therefore related to the following (Dallas & Day, 2004):

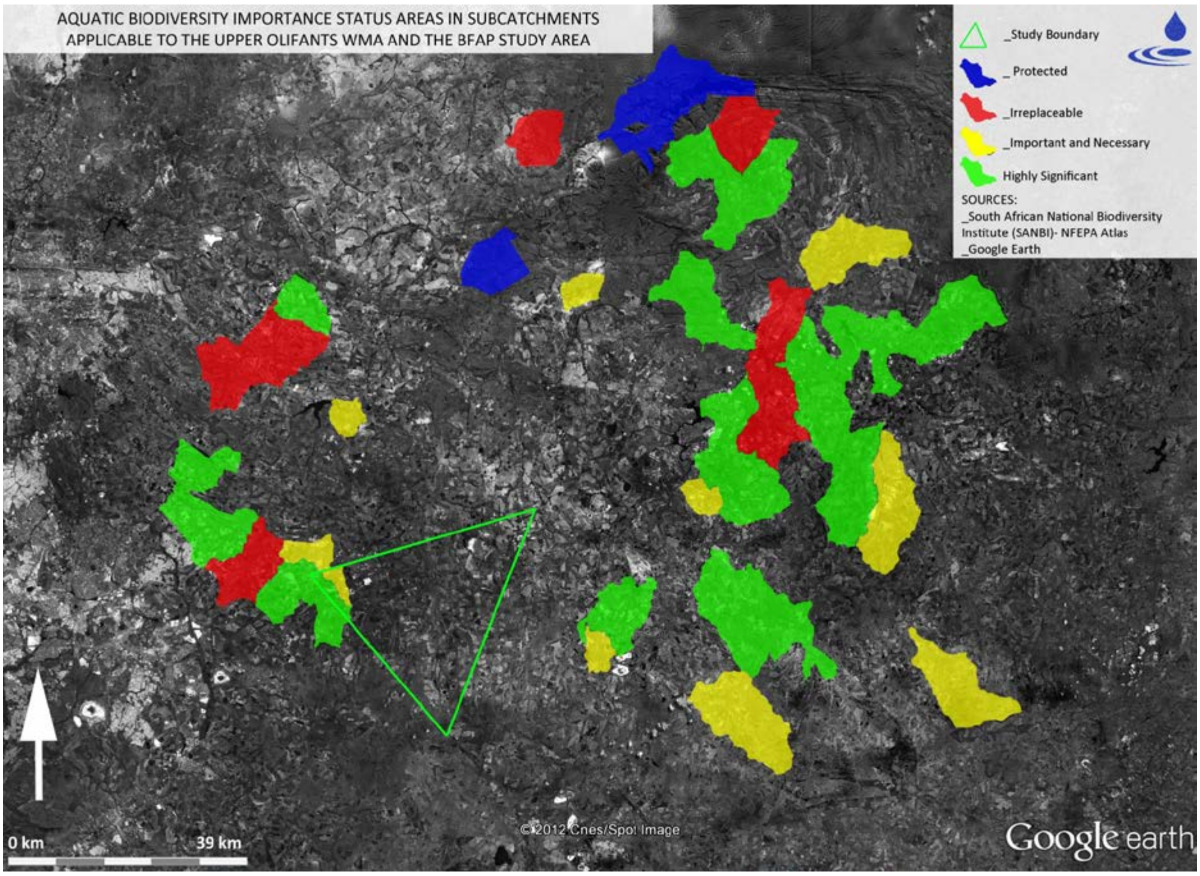
- Increased Heavy metals in Streams
- Addition of toxic and non-toxic metals
- Acid mine drainage
- Increased Suspended Solids
- Dissolved solids
- Increased hardness
- Increased sulphates
- Increased trace metal concentrations
- Decreased DO (Dissolved Oxygen)
- Decreased pH

Current rehabilitation research

Research on the rehabilitation of mining waste impounds has been conducted as early as the 1980s (Wells, 1987; Jewaskiewitz & Lombard, 1987) and probably earlier due to the heightened awareness of the effects of mining on water quality (Dallas & Day, 2004). Detailed information on remediation aspects on mines and mine seepage areas was produced in 2002 by Brown *et al*. Some means of rehabilitation include:

- Using water and vegetation as important measures in reducing the air and water pollution at rehabilitated sites (Wells, 1987; Dallas & Day, 2004; Nel *et al*., 2011);
- Chemical removal of sulphates (Dallas & Day, 2004);
- Inhibition of bacterial oxidation of pyrite for inhibiting the formation of acid drainage (Loos, Bosch, & Mare, 1990a; Loos, Conradie, Whillier, Mare, & Bosch, 1990b; Dallas & Day, 2004).

Biodiversity assessment & wetlands



Map 7: Aquatic biodiversity importance status areas
Source: South African National Bio-diversity Institute and NFEPA, 2011. Compiled on Google earth by MENCO Consulting 2012.

The Freshwater Priority Atlas and its potential in Agriculture

A national freshwater priority atlas was published and released during August 2011. The atlas (NFEPA) was a combined effort involving various stakeholders, namely the CSIR, South African National Biodiversity Institute (SANBI), Water Research Commission, Department of Environmental Affairs, Department of Water Affairs, Worldwide Fund for Nature (WWF), South African Institute for Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks) (Nel *et al*., 2011). The atlas aims at providing the first comprehensive study regarding the importance of freshwater ecosystems of South Africa and the need to maintain the areas identified as priority areas. The atlas will hopefully provide insight and knowledge into the decision making processes with regards to land use planning and sustainable development (Nel *et al*., 2011).

With the aid of systematic conservation planning, strategic spatial priority areas are provided within the context of a fair and impartial social and economic development: http://gsdi.geoportal.csir.co.za/projects/national-freshwater-ecosystem-priority-areas-nfepa-project.

As part of this, certain RAMSAR sites have also been included in the tlas, which are wetland areas identified by the Convention on Wetlands of International Importance. This convention is the only global treaty that specifically focuses and deals with one particular ecosystem, namely the conservation and wise use of wetlands and wetland resources: (http://www.ramsar.org/cda/en/ramsar-home/main/ramsar/1_4000_0__).

This underlines the importance of the active involvement of the Department of Agriculture, Forestry and Fisheries in collaboration with other government departments to identify the areas of uttermost importance for the sustainability of agricultural practices and hence social and economic development. From an ecological perspective, this would create a 'national ecosystem' wherein all sectors can sustainably co-exist within the areas wherein they are able to utilise the natural resources most suited to their industries. According to Venter (2012) from the Department of Agriculture, Forestry and Fisheries the department is currently involved these types of projects.

The proposed approach is similar to the one taken by the RAMSAR Convention, wherein certain agricultural areas are given a status similar to RAMSAR sites, excluding all other sectors from utilising these areas for purposes other than what they are suited. This project is still in its infancy, though, and requires support and enthusiasm from everyone that values South Africa's agricultural industry and the protection of natural resources.

Air pollution & the effects of coal dust

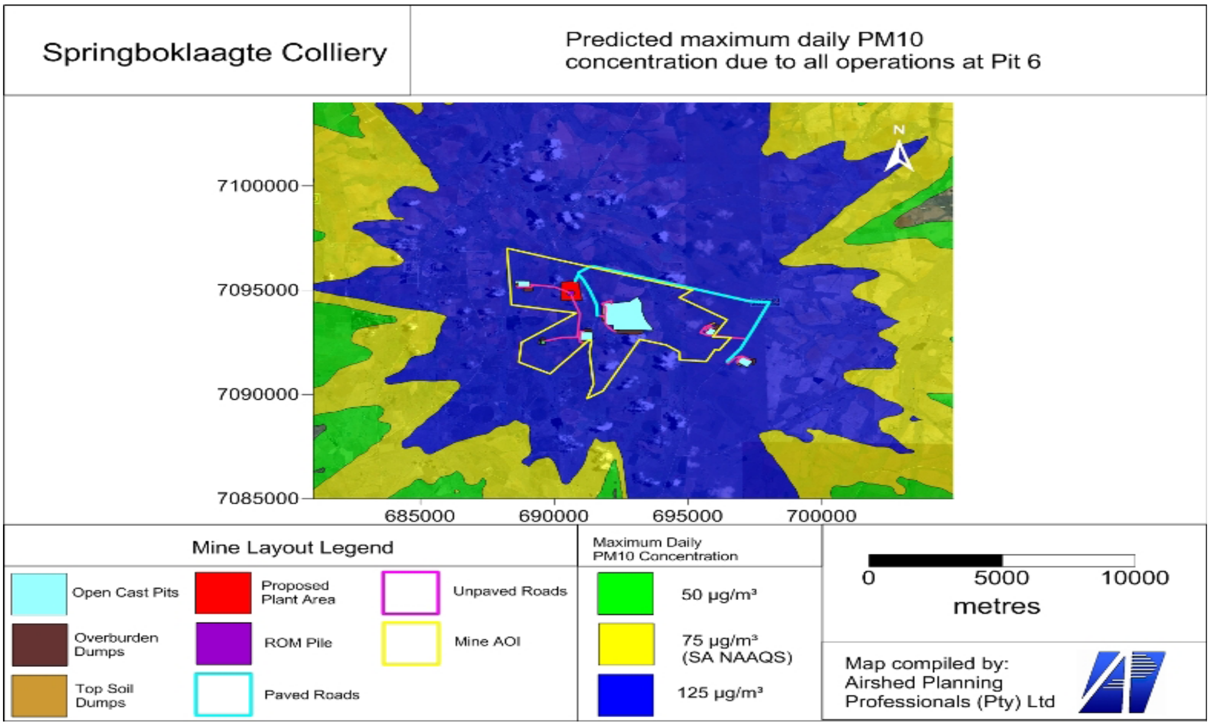


Figure 12: Air pollution effects from proposed Springboklaagte colliery
Source: Grobler and Liebenberg-Enslin (2011:34) Draft October 2011.

Within the pilot study area, we find the proposed Springboklaagte colliery. The proposed mine's air pollution impact assessment was done by Airshed Planning Professionals (Pty) Ltd, a consulting company located in Midrand, South Africa, specialising in regional air pollution impacts.

The effects of air pollution are well described in their report, 'Air quality impact assessment for the proposed Springboklaagte colliery, Mpumalanga'. Most of their findings were concluded based on data already available from mines in the vicinity, thus the impacts in the report were modelled from other sources, as the mine is not yet in operation. According to Grobler and Liebenberg-Enslin (2011:34), sources of ***atmospheric emissions*** at the proposed Springboklaagte Colliery and at the neighbouring collieries could include:

- *Fugitive dust from blasting, drilling, materials handling (overburden, interburden, waste rock, coal, discard), vehicle entrainment, wind erosion, tipping, crushing and screening;*
- *Sulphur dioxide, nitrogen oxide and carbon monoxide emissions from blasting operations; and*
- *Potential sulphur dioxide and volatile organic emissions from the spontaneous combustion of discard dumps.*

The effects of the emissions referred to above are shown in Figure 12, where the PM10 refers to particulate matter with an aerodynamic diameter of < 10 µm. This example was drawn to show the effects of one pit in a proposed mining area. The blue area (beyond the mining boundary) is well above the limit, according to the National Ambient Air Quality Standards (NAAQS).

Their conclusions for this area, called 'Block 6' are the following:

> *During the period July 2013 to January 2017 when Block 6 is mined the predicted daily concentrations exceed the NAAQS to all sides of the mine, including at almost all simulated sensitive receptors. The annual NAAQS is predicted to be exceeded slightly to the north and south east of the mine boundary, and the Trapvas, Kromdraai and Weltevreden sensitive receptors to the north and south east of block 6 are impacted.*

The air assessment document of Airshed Planning Professionals (Pty) Ltd, literature reviews on plant production were recorded. Some included reports of reduction in yield, while others mentioned less pollination. All of the mentioned findings showed negative effects on maize production, i.e. it will most likely decrease the average yield.

Harmens, Mills, Hayes, Williams and De Temmerman (2005) as cited in Grobler and Liebenberg-Enslin (2011:98) had the following results for particulate matter on vegetation:

> *Suspended particulate matter can produce a wide variety of effects on the physiology of vegetation that in many cases depend on the chemical composition of the particle.* ***Heavy metals*** *and other toxic particles have been shown to* ***cause damage and death*** *of some species as a result of both the phytotoxicity and the abrasive action during turbulent deposition* (Harmens *et al*., 2005).

According to the authors (Harmens *et al*. 2005; Naidoo and Chirkoot, 2004; Hirano, Kiyota, and Aiga, 1995; Ricks and Williams, 1974) cited in Grobler and Liebenberg-Enslin (2011:98) '**Heavy loads of particle** can also result in **reduced light transmission** to the chloroplasts and the occlusion of stomata' as well as decreasing the efficiency of gaseous exchange (Ernst, 1981) which **leads to water loss**.

According to Harmens *et al*. (2005, cited in Grobler and Liebenberg-Enslin, 2011:98), 'these **heavy particles** may also **disrupt** some of the other **physiological processes** such as bud break, **pollination and light absorption/reflectance'**. Spencer (2001) further suggests that the chemical composition of these dust particles will have an effect on plants and have indirect effects on soil pH.

Naidoo and Chirkoot (2004) found similar trial results as the authors mentioned above. Their findings were based on a study in the Richards Bay harbour, to evaluate the effects of coal dust on trees' production.

The study was conducted on ten mangrove trees from two different plots. From their study, it was evident that **coal dust** significantly **reduced photosynthesis** of upper and lower leaf surfaces.

The reduced photosynthetic performance was **expected to reduce growth and productivity**. In addition, trees in close proximity to the coal stockpiles were in poorer health than those further away. (Naidoo and Chirkoot, 2004).

To relate this back to maize production, it is clear that reduction in production is possible, as proven by the literature from this section. In our opinion, the effects of air pollution on cash crops are summarised by the Canadian Environmental Protection Agency (CEPA) cited in Grobler and Liebenberg-Enslin (2011:98) as:

> *Air pollution adversely affects plants in one of two ways. Either the **quantity of output or yield is reduced** or the **quality of the product is lowered**. The former (invisible) injury results from pollutant impacts on plant physiological or biochemical processes and can lead to significant loss of growth or yield in nutritional quality (e.g. protein content).*

Social impacts of mining on agriculture

Mpumalanga's growth in per capita compensation for certain skill levels, based on the two industries, agriculture and mining are compared in Table 7. According to these findings, we can see that growth in per capita compensation in the two industries is very similar.

Table 7: Growth in per capita compensation for the two industries (Mpumalanga)

Period 1995-2009	Agriculture, fishing & forestry, Growth in per capita compensation %	Mining and quarrying Growth in per capita compensation %
Compensation for skill level		
Highly-skilled	10.2	9.9
Skilled	7.2	9.9
Semi-unskilled	9.3	9.8

Source: Blignaut C.S. 2012 (forthcoming June 2012) from Quantec easy data

Table 8: Employment figures per sector (Mpumalanga)

Employment per industry for the year:	Agriculture, hunting, fishery and forestry	Mining and quarrying
2000	130 791	49 982
2005	115 914	38 796
2009	81 078	57 771
Employment per industry for the year:	**% of Agriculture, hunting, fishery and forestry in TOTAL employment**	**% of Mining and quarrying in TOTAL employment**
2000	17.5 %	6.7 %
2005	15.2 %	5.1 %
2009	8.7 %	6.2 %

Source: Blignaut C.S. 2012 (publication due May 2012) from Quantec easy data

Agriculture’s employment rate is decreasing, whereas mining is slowly increasing in the province. But taking into consideration that agriculture is becoming more capital intensive and is losing land (farms) to mining, this phenomenon makes sense.

Quantifying the social impact that mining has on agriculture is again a situation where the direct on-farm effects calculated are used as an example. For instance: a farmer would employ an unskilled worker, who does not necessarily have a matric certificate, but the person can read and write. He would then, at his own cost and time, develop the person’s driving ability and in the end give him/her the opportunity to get their driver’s licence. This person would now have a certain skill (Code 14 licence). According to the farmers interviewed, most of these workers are then ‘bought’ by the mines. It is then rather costly and difficult to replace these drivers and start the process all over.

Reports from farms that have been bought in the regions suggest that farm workers who do not have a matric certificated are not employed by the mines. They end up unemployed, with their entire families having to leave the farm.

Potential job losses in the pilot study area

With the focus on maize production in the pilot study area, an estimated 57 523 hectares of cultivated maize fields could potentially be out of production due to current and prospecting mining activities. Using the labour multiplier of 0.01 (BFAP, 2011) for maize production, a total of 575 employees would be removed from farms, and combined with their families this number could increase to 1 783 (assuming 70 % are married, with 2 dependants). The contrary could also be true, where mining could employ these workers, but from correspondence with neighbouring farmers, this is not necessarily the case.

Losses due to increased criminal activities

Quantifying the exact loss due to criminal activities is hard to pinpoint since many cases are not officially reported and available in the public domain. But from personal correspondence with farmers in the area, it is clear that theft of livestock, maize cobs and electrical cable is increasing at an alarming rate.

This has a negative effect on maize production due to increased security costs such electric fencing, guards, costs to armour electric pumps, and increased insurance premiums.

It should be noted that the increased criminal activities are not directly related to the increase in mining activities, as the mining industry are also severely affected by this. It's rather a source of concern for the entire province, and the sustainability of economic production.

Traffic on roads and related effects

The transport section was compiled by: BN Roberts (Pr Eng MBA) - Moyeni Professional Engineering

Based on a desktop approach and experience in the field of transport economics, some conclusions could be drawn from the pilot study area. But due to information and data constraints, an in depth analysis is currently not possible, as more details with regards to the mining activities would be needed. Some of the findings include the following:

The transport economic aspects include:

- Travel costs including fixed and operating costs.
- Travel time costs
- Accident costs
- Outsourcing costs.

Road network

The N12 is in excellent condition and, as in the Bethal / Hendrina area, lends itself to the export of mining products to Gauteng and to the Maputo port. The N17 is in relatively poor condition except for the link towards Gauteng.

Of the internal roads, the R50, R548 and the R29 offer good linkages. The R580 is a secondary route in the middle of the study area. The northern section of the study area has no Provincial roads to link activities.

The existing and future internal roads related to mining activities will no doubt change the road network to include many smaller roads.

Road condition

Except for the N12, most routes are in a relatively poor condition and require immediate maintenance.

Farming transport costs

Currently, the fixed costs are assumed to be R250 000 per annum per truck and R30 per km. This is also taken to indicate that farmers do not make use of outsourcing.

Transport impact of mining activities on the agriculture industry

As shown in Map 3 - Pilot study area – ‘Field crops lost due to mining and prospecting’, it expected that:

- Mining activities will, over 20 years, take over most of the agriculture activities in the specified areas.

- During the change, farmers will move off the land, with the associated reduction in farming-related and increasing mining-related transport flows.
- The post-mining reinstated land will most likely not be used for maize farming but instead rehabilitated for cattle farming.
- The 35 t trucks related to mining are normally larger than the 10 t farming trucks. This means that the axle loads on the roads will be some 10 times higher than is the current situation. This structural loading change is expected to reduce road life to a few years. As is the case with the coal transport to the Eskom power stations, the new mines will need to provide a major maintenance budget in their planning.
- Should the mines not maintain the roads they impact over the next 20 years, farming transport costs could double, to R500 000 pa and R40/km.
- Over time, the economies of scale for farming will rapidly diminish. At some stage farmers may elect to outsource their major transport needs. However, since the farming activities within the study are expected to reduce with some 20 % of current day activities, operators may not be available or if available will be expensive since there are little economies of scale present.

Concluding remarks

- Due to the 35 t trucks related to mining, roads will require major maintenance budgets to keep the road conditions in an acceptable state; a requirement for general, but farming transport in particular.
- Travel costs for farming are expected to double over time to some R500 000 pa and R40/km.
- The costs related to accidents and general safety are difficult to quantify but will exponentially increase should the roads not be maintained in a good condition including road signs and markings, guards rails, bridge railings and the like.

Health risks associated with coal mining

Not all the land will be bought by the mines, which implies that a portion of the farming community could possibly still live in the surrounding areas, yet the health risks are increasing rapidly. The findings from the WWF-SA (2011:58) showed that AMD drainage continues being the main risk of pollution, and it remains uneconomic to try and mitigate the effects.

Human exposure to AMD pollutants can occur through ingestion of contaminated water, food or through dermal absorption via water or air. According to Coetzee, L., Du Preez, H.H. and Van Vuuren, J.H.J., (in WWF-SA, 2011:58):

> *Metals such as aluminium, copper, zinc and arsenic (all related to AMD effects) can concentrate in plant tissue when plants are exposed to elevated concentrations of these metals in the vicinity of mining activities. If such plants are consumed by animals and humans, the metal concentrations may be carried along in the food chain. Animals that drink contaminated water and/or feed on contaminated plants have been shown to accumulate metals in their tissue or in their milk.*

The effects of mining on local coal mining communities are also sometimes overlooked. A social labour plan might detail how they will build houses and provide water, but, according to the West Virginia University Health Sciences Center, 2008 as cited in WWF-SA (2011:58):

> *Studies have looked at health effects in coal mining communities and found that community members have a* ***70 % greater risk of developing kidney disease*** *and a 64 % greater risk of developing chronic obstructive pulmonary disease (COPD) such as emphysema. They are also* ***30 % more likely to report high blood pressure*** *(hypertension).*

Again, agriculture is left with the turmoil created by the external effects of mining, as the rehabilitated land will most probably be affected by AMD (as this study has shown) and the community living on this land will have to bring in fresh water from somewhere else to make a living. AMD is clearly a toxic reality for the post-mining inhabitants and to the remainder of the current farmers living in the area.

Conclusion

This study has provided an overview of possible economic, environmental and social effects of mining in a pilot study area. Although the short-run economic impacts on farming level as well as medium impacts on maize markets were illustrated, a significant amount of research still has to be undertaken on the long-run macro-economic, environmental and social impacts. Both mining and agriculture play a critical role with respect to job creation and contribution to the gross value of the country. Over the short-run mining's contribution to the country's gross domestic product (GDP) exceeds the contribution of agriculture by a significant margin, yet over the long run, agricultural practises are more sustainable. Therefore, the long-run impacts on food security and employment become even more important to understand. Food security has many elements, of which accessibility and affordability of food are the most critical drivers. In Mpumalanga's GVA (Gross Value Added) calculations, the mining sector makes a significant contribution towards employment and social empowerment. The average GVA for the mining sector in Mpumalanga over the period 1996–2010 was 21.9 %, whereas agriculture's average GVA for the same period was 3.8 % (Quantec, 2011). Over the next few years, this trend will continue, yet the important question to raise is – what will happen to the GVA of the province when all the mineral resources have been depleted and the rehabilitated land can only support marginal agricultural production at best?

As already mentioned, the short-run economic contribution is not the only trade-off as the long-run environmental and social impacts cannot yet be quantified with absolute certainty. Other elements like the production of electricity and fuel from coal cannot be left out of consideration. However, through innovative policies, agriculture can also make a meaningful and sustainable contribution to both fuel and energy production over the long run, despite the fact that over the short run, coal offers a significantly cheaper source of energy. The Highveld (and the entire Mpumalanga) is expected to receive increased levels of precipitation, according to the CSIR (in Blignaut C.S., 2012:176) as well as an increase in heat units. The yields in maize are then expected to increase even more with improved technology, rotational cropping with soybeans, improved cultivation practises, and combined with the increased precipitation and heat units. These long-run impacts will have to be research and carefully balanced options proposed to government to ensure that the best decisions are taken now for the future generations of this country.

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Appendix A

Concerns further downstream

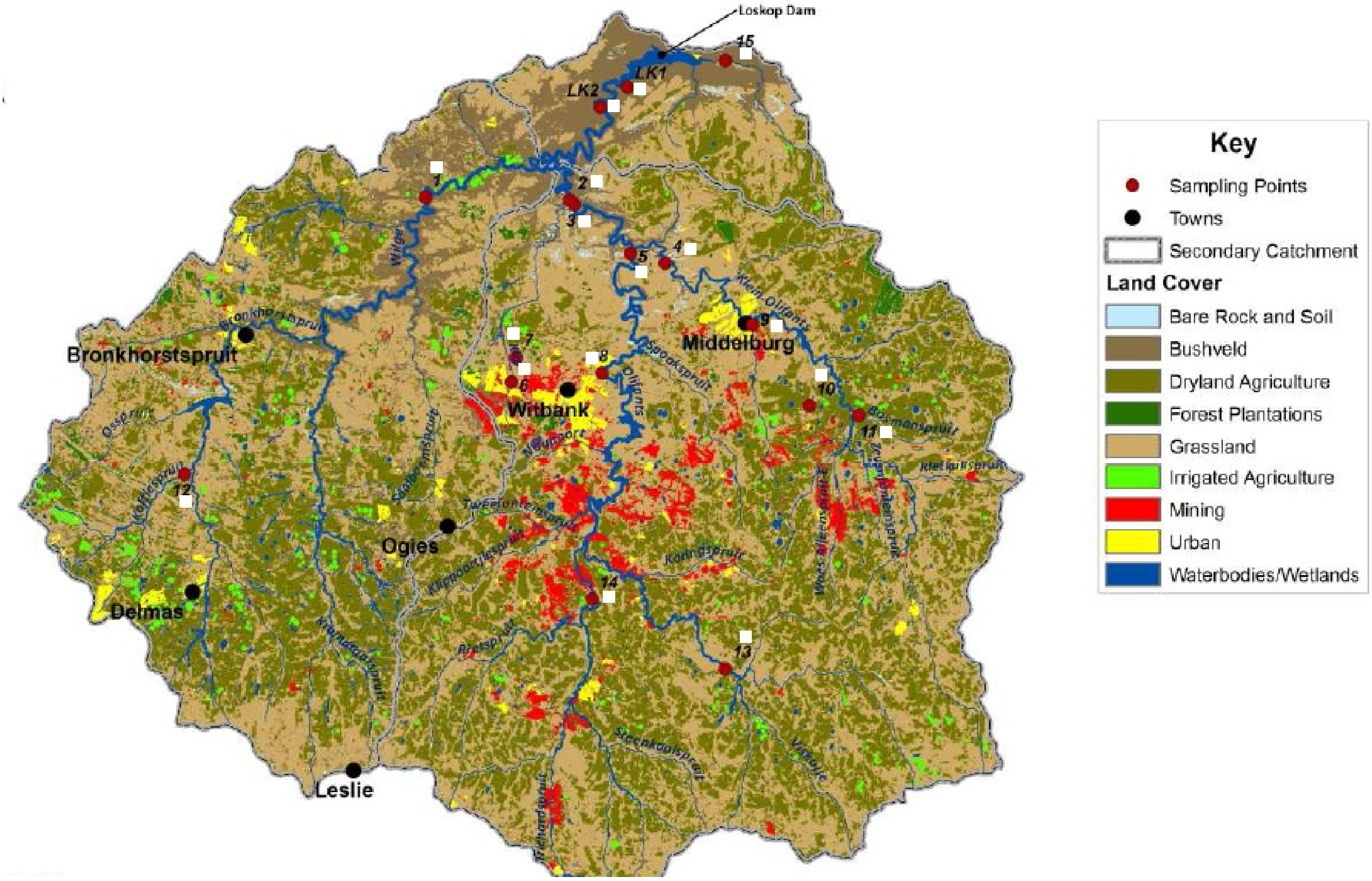

Figure 13: Upper Olifants testing stations – Seventeen sampling sites
Source: Oberholster *et al*. 2011 sourced from CSIR

According to the authors (Oberholster, Aneck-Hahn, Ashton, Botha, Brown, Dabrowskia, de Klerk, de Klerk, Genthe, Geyer, Hall, Hill, Hoffman, Kleynhans, Lai, le Roux, Luus-Powell, Masekoameng, McMillan, Myburgh, Schachtschneider, Somerset, Steyl, Surridge, Swanevelder, van Zijl, Williams and Woodborne, 2011), the following was observed in the Upper Olifants catchment, based on a study in March 2011:

> ***Seventeen sampling sites****, representing sites impacted by all of the different impacts (mining, industry, agriculture and sewage input) were selected within the upper Olifants catchment. Two sites were selected in the Wilge River catchment, one further upstream in the Koffiespruit (site 12) and one downstream in the Wilge River (site 1), just before its confluence with the Olifants River.*

These sites are mainly impacted by agriculture, with low levels of mining and industrial activity upstream of these sites.

Three sites were selected in the Klip River catchment (sites 2, 6 and 7), an area that is heavily impacted by mining and industrial activity. One site each was selected on the Steenkoolspruit (14), Klein-Olifants River (4) and Middelburg (9). Five sites were selected along the main stem of the Olifants River (sites LK2, 3, 5, 8 and 13), while two (sites 10 and 11) were located in the vicinity of intensive feedlot areas and were sampled only for microbial pathogens and EDC activity. Site LK1 is a pristine stream originating from a wilderness area in the Loskop nature reserve and site 15 (Kranspoortspruit) were selected as a reference site.

Land use Impacts on Water Quality

Sites 12 and 15 *in the upper reaches of the Wilge River and Kranspoortspruit, respectively, are the* ***least contaminated*** *sites in the study area and show low concentrations of water quality variables and low values for three key water quality indicators (sulphate to chloride ratio [SCR], corrosion potential [CPR] and sodium absorption ratio [SAR]). In contrast, the* ***entire Klip River catchment (comprising sites 2, 6 and 7****) is* ***acidic (pH < 6),*** *and recorded the* ***highest concentrations of heavy and trace metal ions in the study area; these include aluminium, iron, manganese, vanadium and zinc. The concentrations of metal ions at sites 2, 6 and 7 are well in excess of aquatic ecosystem guideline values and are likely to be toxic to aquatic life****. These metals are* ***most likely*** *to have originated* ***from acid mine drainage from abandoned coal mines and industrial activity in the catchment as well as sewage inflow****. The extent to which current mining activities contribute to heavy metal concentrations will need to be determined in further studies. Contamination of the main stem of the Olifants River (sites, 3, 5, 8 and 13) by trace metals is relatively low in comparison to the tributary rivers that feed into the Olifants River. The phosphate concentrations recorded during low flow conditions were however the highest for these sites in comparison to all other sites in the study area. High phosphate concentrations in association with low flow conditions indicates that sewage inputs from urban areas are the most likely sources of nutrient input in the catchment.*

Total area:

High SCR values across the study area indicate that the water quality in the system is already heavily affected by processes that could include mining, industry and wet or dry deposition of atmospheric emissions (e.g., from industry and power generation). This is further supported by the fact that sulphate is the dominant constituent of the high concentrations of total dissolved salts (TDS) in the catchment. The high CPR at many sites indicates that corrosion of metal pipes and pumps is likely to occur (or is already occurring). Insufficient maintenance of effluent and water pipes could therefore lead to additional water quality problems, now and in the future, as a result of leakages. The SAR levels indicate that the water in the main stems of the Olifants and Wilge Rivers is still suitable for irrigation purposes.

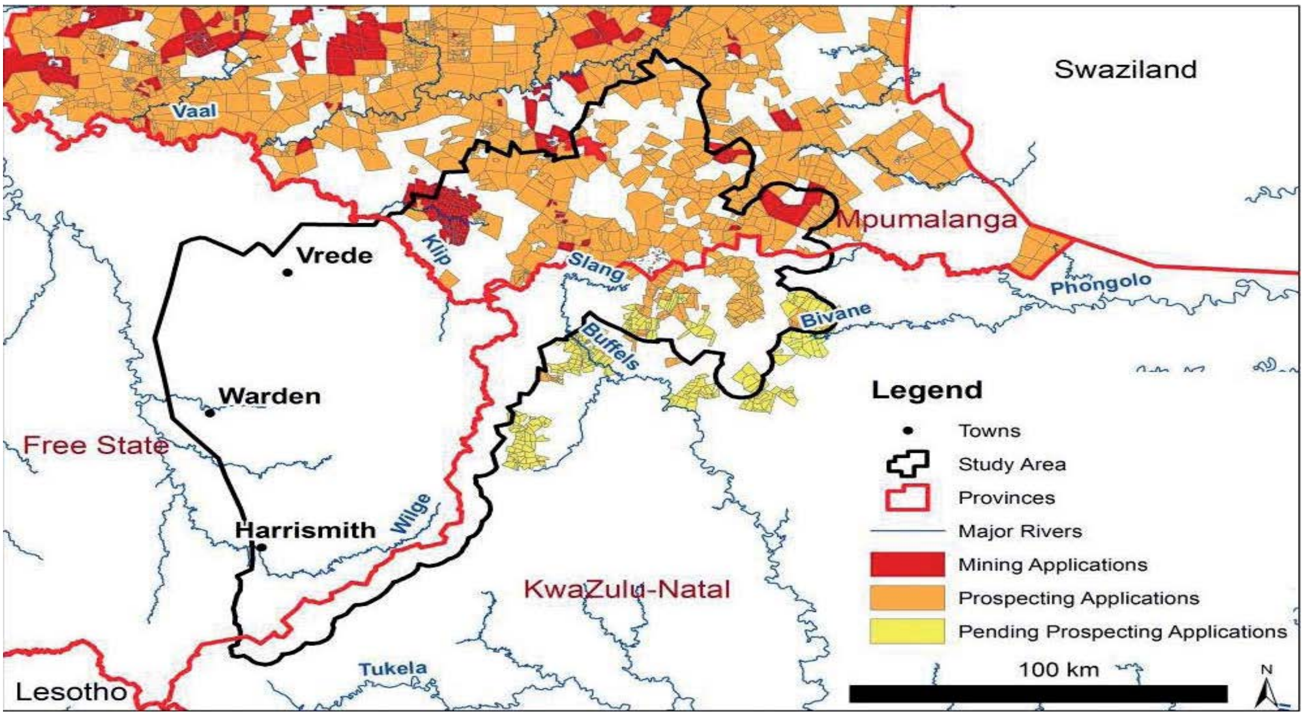

Figure 14: Upper Vaal new prospecting applications. Extent of mining, prospecting and exploration rights in Mpumalanga (2005–2010 orange) and post 2010 applications (yellow)
Source: WWF 2011:52

According to McCarthy *et al*. (2008:1):

> *The upper Vaal River catchment is relatively un-impacted by mining, but if all the applications for mining permits in this catchment are granted, it is likely that the Vaal River will suffer a similar fate to rivers in the Witbank area, creating serious water supply problems for the industrial heartland of the country*

To conclude the effects of these two catchments is not the purpose of this report; neither to give mining the blame for all the negative effects, as agriculture and the municipalities (inactive sewage works) also plays their part. We should rather focus on what the long term effects will be if the two largest irrigation schemes are affected by the contaminated waters in these two catchments, as this potentially where we are heading in view of what we have seen in the literature written. The Olifants catchment provides water to most of Mpumalanga's irrigation schemes, and the Upper Vaal, to all the irrigation that follow, but most importantly to Gauteng.

Potential further studies could involve

Coal as a source of power vs. Biofuels/renewable energy

An example was drawn from the new Kusile power plant, which first unit is scheduled to be in operation by 2014. It will consume an estimated 17 million tonnes of coal, and generate 37million tonnes of (CO2) annually (Greenpeace, 2011:2). The two plants Kusile and Medupi are expected to consume 10 % of South Africa's coal reserves BE at UP (2011:7).

It was further calculated by BE at UP (2011:17) the **external costs** (including social costs, pollution etc.) are estimated at between R 31.2 billion to R 60.6 billion **per year**. This is one coal generated power plant, with the potential of producing 4 800 MW power, what are the external costs of all the other combined?

Alternatives

According to BE at UP (2011:19):

> *'It would be possible to develop no less than 500 % of Kusile's proposed power generation capacity, assuming that renewable electricity generation capacity was funded from only 30 % of Kusile's external costs'*

	MW capacity and MWh generated that would equal a total annual cost of: R31 174 million		**Time it would take to equal Kusile's output**	**MW capacity and MWh generated that would equal a total annual cost of: R60 594 million**		**Time it would take to equal Kusile's output**
	MW	**MWh**	**Number of years**	**MW**	**MWh**	**# years**
Wind	9 881	25 100 975	1.3	19 206	48 790 295	0.7
Concentrated photovoltaic (PV)	3 923	9 209 235	3.5	7 625	17 900 550	1.8
PV (crystalline silicon)	7 135	12 125 835	2.7	13 869	23 569 724	1.4
Forest residue biomass	3 967	29 540 823	1.1	7 712	57 420 298	0.6
Municipal solid waste	1 919	14 290 024	2.3	3 730	27 776 390	1.2
Concentrated solar power, parabolic trough with nine hours storage	2 882	11 032 313	2.9	5 602	21 444 178	1.5

Figure 15: Opportunity cost of Kusile
Source: BE at UP (2011:19)

The alternative energy sources can be funded within 1.3 years, from only the external costs of running the plant for one year. Based on the table above, it is evident that alternatives exist, and they are feasible, sustainable and economic. But most of all, they will not deprive future generations from the privilege of being food secure.