AN ESTIMATION OF THE AGRICULTURAL ECONOMIC AND LOCAL ECONOMIC IMPACT OF PHASE 1 OF THE SKA

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1. Background and context

The news that South Africa was awarded one of the main sites for the major international astronomy project, the Square Kilometre Array (SKA) Telescope, was a major achievement for South Africa and for South and southern African scientific communities. It made every South African proud. South Africans were proud on the basis of the belief that it will bring positive impacts to the country and stimulate and promote a knowledge economy.

Under the assumption that people and farming activities will compromise the security and functioning of the project, and the need of the SKA South Africa office to deliver a radio silent zone, such an approach would necessitate (according to the SKA) cessation of all farming activities on 36 farms covering 117 676 ha in the Carnarvon, Williston, Van Wyksvlei, and Brandvlei regions of the Northern Cape Karoo. If we include the initial two farms - Losberg and Meysdam (for Meerkat) - a total area of 130 000ha would be lost to agricultural and allied activities. However, the SKA acquisition programme has only earmarked 32 farms or 107 200 ha and has come to alternative arrangements with 4 owners on a total area of 10 415 ha. This implies that some farming activities will continue. The cessation of farming activities on the designated 107 200 ha is the main focus of this report which will illustrate the impact on human lives, agricultural production and the economies of the local towns if it actually happens.

This is not only an emotional issue for the owners (ranging from individual owners to Closed Corporations, Trusts and a proprietary limited company ('Pty Ltd')) and their workers and families, but is also a major issue facing the local economy of the neighbouring towns. For this reason the core aspect to be investigated, is the economic multiplier impact of the potential loss of productive land on the local and national economy.

The intention to acquire this large area of land brings about an unavoidable conflict over land rights in the SKA area. This has already surfaced and is therefore making the acquisition of land and the valuation of land highly contested. Under these conditions where land has emotional and family value net present value of production could be a poor indication of the true value of land. For example, some properties might be *erfgrond*, which will not normally be let go in market transactions for the NPV of productive value because owners also attach identity and bequest value to this land. Any valuation that omits these private costs of being expropriated is not reasonable.

2. A description of the region and its farming activities

The earmarked farms in this region are situated in the dry and semi-arid area of South Africa known as the Karoo. This part of the Karoo is located in the Northern Cape Province - the province with lowest population density due to its semi-desert characteristics. However, despite high poverty levels, it is the

province with the 3rd highest per capita income in South Africa. It should however be mentioned here that most household incomes are reliant on the agricultural sector in the province.

Average rainfall is in the order of 230mm per annum (as a 16 year average reported by farmers). The semi-arid nature of the region in which the farms are located makes extensive sheep production the dominant farming activity. The average grazing capacity for this region is in the order of 6-10 hectares per ewe. One farmer reports, for example, a flock of 860 ewes on 4900 ha (roughly 6ha per ewe) and a weaning percentage in the order of 110%. Some farmers have seen an improvement in weaning percentages from 70% a few years back due the introduction of electrical fences to control predators. Although farming operations in this area are characterised by low input intensity, they produce valuable agricultural output in the form of meat, hides and skins as well as wool and mohair and a little bit of hunting activity – mainly for biltong.

The Karoo region is well known for the well-respected and valuable Karoo Lamb meat product. Karoo Lamb recently became recognised as South Africa's first Geographical Indication in the food industry. The national Department of Agriculture, Fisheries and Forestry (DAFF) and the Northern Cape Provincial Department of Agriculture supported the establishment of the certification mark that protects the Karoo Lamb name against misappropriation and assists farmers to extract a premium for their lamb. The number of animals slaughtered under the Karoo Lamb certification mark is still low, but soon, with export markets opening, there will be opportunities to expand. In 2015, the Carnarvon abattoir became the only red meat abattoir in South Africa to pass a very strict international food safety audit. This specific certification status will support the potential export opportunities of Karoo Lamb to the EU and the USA. It is now the only red meat abattoir in South Africa to have this impressive export credentials.

A meeting was organised in the Carnarvon district on 22 February 2016 to obtain detailed information from the affected farmers to prepare this agricultural and local economic assessment. However due to their sensitivity and objections to the SKA project, the local farming community only provided aggregate figures on flock sizes and animals marketed per year. The local farming community attending the meeting reported a total number of 21 000 dorper ewes and a total of 28 000 lambs marketed. In the absence of detailed data per farm a spread of grazing capacity was used to establish whether the reported number of 21 000 ewes was realistic.

Some farms (especially those on the mountain ranges) certainly operate at stocking rates of 6ha/ewe but a large number of farms would have stocking rates that is more likely to be between 8 ha and 10ha[1]. We argue that 6 ha per ewe for all the farms is on the high side (suggesting good grazing) since the reported

[1] Farmers reported grazing capacity of 32-36 ha per Large Stock Unit. According to research done at Grootfontein (Botha, 2012) a dorper ewe is equivalent to 0.15 LSU and its lamb 0.11 LSU. This means that the carrying capacity for a dorper ewe and her lamb (0.26LSU) should be ranging between 8-10ha.

average grazing capacity from the Carnarvon farmer study group is 36 ha/LSU (see Appendix 1) or alternatively 9ha per ewe. If we accept that the variation in grazing capacity across the farms is between 6 and 9 ha and if we apply an average grazing capacity number (see Table 1) we get to a more moderate estimate of 16 000 ewes as a realistic number for the sheep flock on the 107 200ha.

Table 1: Details of the farms earmarked for the core area of Phase 1 of the SKA (revised list supplied by SKA in April 2016)

Farm No.	Farm name	Farm size (ha)	Certified KMOO farm	Size of flocks for different grazing capacity (# of ewes)		
				6ha/ewe	8ha/ewe	10ha/ewe
63	Dubbelde vlei	3471	Y	579	434	347
65(1)	Botterleegte	5494	N	916	687	549
65	Botterleegte	289	N	48	36	29
66	Brakputs	7 996	N	1333	1000	800
70	De Hoek	4667	Y	778	583	467
72	Rooizand	3 809	N	635	476	381
74	Groot Paarde Kloof	7 779	N	1297	972	778
76	Jaskloof	3 681	N	614	460	368
96	Blaauw Heuvel	5 465	N	911	683	547
495	Pofadderfontein	1 522	N	254	190	152
496	Swartfontein	2288	N	381	286	229
494(02)	Janseboom	2 220	N	370	278	222
495(02)	Pofadderfontein	1523	N	254	190	152
495(03)	Pofadderfontein	1 757	N	293	220	176
496(01)	Swartfontein	3 234	N	539	404	323
496(02)	Swartfontein	945	N	158	118	95
64	Schietpoort	3 165	N	528	396	317
64(01)	Schietpoort	1 571	N	262	196	157
64(2)	Schietpoort	1576	N	263	197	158
65(02)	Lovedale	5382	Y	897	673	538
67(01)	Bitterwater	2080	N	347	260	208
67(02)	Swartfontein	3397	N	566	425	340
69(02)	Visserskloof	4 355	Y	726	544	436
69(01)	Visserskloof	8 730	?	1455	1091	873
69(03)	Visserskloof	4361	?	727	545	436
71(1)	Varsrivier	4386	N	731	548	439
71	Zout Rivier	1 462	Y	244	183	146
71(02)	Zout Rivier	1 462	N	244	183	146
71(03)	Zout Rivier	1462	N	244	183	146
72(01)	Rooisand	3 809	N	635	476	381

76(01)	Saailaagte	3 660	Y	610	458	366
66(1)	Brakputs	263	N	44	33	26
	Total	**107 261**	**8**	**17 877**	**13 408**	**10 726**

Table 2: Farms now exempted from the acquisition programme

Farm No.	Farm name	Farm size (ha)	Certified KMOO farm	Size of flocks for different grazing capacity (# of ewes)		
				6ha/ewe	8ha/ewe	10ha/ewe
497(01)	Nieuwe Uitzicht	2590	N	432	324	259
75(01)	Rietpoort	947	N	158	118	95
75(02)	Rietpoort	1 706	N	284	213	171
497	Waterval	5172	Y	862	647	517
	Total	**10 415**	**1**	**1 736**	**1 302**	**1 042**

To this number of animals we should also add 50 head of cattle and 100 goats. We should keep in mind that Mr van der Colff, owner and farmers of the De Hoek farm covering 4613.542 hectares (Farm number 70) is a well known "stud breeder" with slightly higher output values per head than the other farms producing mainly slaughter animals. Wool production only takes place on the Pofadderfontein Farm (owned by Deltacolours Farm 495 covering 1 522 hectares) with a flock of around 300 pure Merinos.

These details together with the weaning percentage at each farming operation are key in estimating the annual off-take that goes into the red meat supply chain. Some of the farmers report weaning percentages of 110% while other farmers report much lower weaning percentages (60-70%), attributing the reduction to stock losses incurred as a result of the increased number of predators on the vacant land of the current SKA site. It is important to remind readers that a 30% to 40% drop in weaning percentages makes a profound difference to farm income as shown in some recent research published by Natrass and Conradie (2015).

This section provided a brief overview of the region and the farming activities on the farms to be impacted by Phase 1 of the SKA project. We now present an overview of methods used to estimate the economic impact if total cessation of farming activities does take place.

3. Research approach and methodology

In order to estimate the agricultural economic impact as well as the local economic impact of the proposed total cessation of all farming activities one needs to understand the current value of agricultural production on the 107 200 ha and the input purchasing patterns of these farmers. Farmers provided aggregate data in terms of the size of their flock, nature of production activities, marketing and purchasing points and the number workers and worker families housed on these farms. Due to the over-aggregated nature of the data provided by the local farming community, which lacks details on gross income per farm

and is therefore insufficiently reliable, alternative ways were used to estimate the value of production and input expenditure. This information was obtained from the business accounts of the individual farmers at the local abattoirs and the main suppliers of feeds and general farming requisites in the two main towns.

The business accounts at the various cooperatives only provide us with direct costs such as diesel and oil, feed and various basic fencing and maintenance items we also need to estimate the money spend on other businesses that provide services to the farming community. These are the first round (or direct) backward linkages to the local economy. For this process we have made use of the representative data from farmer study groups in the Carnarvon area maintained by Louis du Pisanie (NWKV) (See Appendix 1). These enterprises budgets provide a detailed account of the first round (direct) backward linkages of semi-arid livestock production. With that information in hand we were able to estimate the contribution of existing farming activities to the revenues of various local enterprises.

Agriculture also has many indirect and multiplier impacts on other businesses inside and outside the immediate region. For a more complete picture one needs to understand the spill-over or multiplier effects of the sector by setting up a detailed input-output table.

Input-output analysis is a quantitative technique for studying the interdependence of production sectors in an economy. An input-output table identifies the major sectors in an economy and the financial flows between them over a stated time period (usually a year). It indicates the sources of each sector's inputs, whether purchased from other firms in the economy, imported or earned by labour (household wages and salaries). It also provides a breakdown of each sector's output, which can be sales to other sectors and to final demand (household consumption, government consumption, capital formation and exports). The interdependence between the individual sectors of the given economy is normally described by a set of linear equations, representing fixed shares of input in the production of each output. Thus, by disaggregating the total economy into a number of interacting sectors, input-output analysis provides an effective tool for sectoral and impact analysis.

Such an exercise should require a detailed survey of the local economy. While this which was not possible due to the lack of time and budget we could make use of a new disaggregated input-output model for the South African economy prepared by Sifiso Ntombela, PhD student at the Department of Agricultural Economics, Extension and Rural Development of the University of Pretoria in collaboration with the economy-wide modelling experts at the Department of Economics at the University of Pretoria. We then shocked[2] this model with the

[2] A shock to the model or the economy is the loss of agricultural output that will emanate from the cessation of farming activities. "Shocking" the model is to reduce the agricultural output so that the effect on the other industries and the rest of economy can then be estimated.

loss of agricultural output that will emanate from the cessation of farming activities on the 107 200 ha in question.

Our first task was therefore to estimate the loss in output as indicated earlier. This was based on the actual output value of the most recent season (2015). At the same time we continued with a process of obtaining data from the farmers as well as the various main business in the affected towns to cover the majority of the information needs as discussed above. It is for the second round effects of this farming activity, which is, not captured through the direct method that we have applied the input-output model referred to above to provide a more complete picture.

To initiate the process of understanding the true value of agriculture in the local economy it is however necessary to present at first a more conceptual understanding of the various roles of agricultural in society. These aspects are discussed next as a prelude to the estimates of the economic contribution of the affected farms.

4. The roles of agriculture

Given that we need to unpack the potential impact of the cessation of farming activities as proposed by the SKA it is important to highlight the multifunctional role of agriculture and its broader contribution to society since this is often not well understood.

Agriculture's direct, private contributions to farm households are tangible, easy to understand and simple to quantify. Rural households produce and consume food, sell commodities to earn profits and provide income for farm workers. Many of agriculture's direct contributions to non-farm households, to urban centres and even to the national treasury are also easy to recognize and to measure. Like other economic sectors, agriculture produces export earnings and tax revenues for public spending needs.

The sector contributes to overall economic growth in many other ways, including supplying raw materials to the agro-processing sector. As farm incomes increase, households save more and spend more, stimulating growth and investment in other sectors. Real incomes of urban households are affected by the long term trends in real food prices. Such positive direct cross-sector linkages are mediated via market channels, in particular through lower prices, labour migration and capital flows from agriculture.

The agriculture sector also contributes less tangible, non-market mediated services and benefits. The classic environmental externality is a good example. Most of us are familiar with the negative externalities associated with agriculture such as soil erosion, pollution and loss of biodiversity. A wide range of policy measures are used to internalize externalities, 'making the agricultural polluter pay' for harming soil and water with pesticides and fertilizers, or even for causing bad odours or too much noise. Agricultural activities can, however,

generate positive externalities too. Important examples include watershed services, wildlife habitat, biodiversity benefits and carbon sequestration.

This section briefly explores a range of these non-market mediated agricultural benefits, from environmental services to food security and social viability benefits. Take food security, for example. We know that when children are consistently well fed, they miss fewer days of school and they have much better learning outcomes. When their parents are well fed, they have more productive days at work, they are healthier, stronger and can earn more income.

Aside from the private, direct return to these households, increased earnings (and even more money to spend on health care, education, and productivity enhancing investments), families with higher levels of food security provide indirect, public benefits. The health, well-being and income benefits that come with greater food security enables parents to be better mothers and fathers. Farm families are able to participate more in local organizations, contributing to a more stable and thriving rural community. These outcomes yield significant benefits to others, not the least of which is a better chance for prosperity, peace and stable institutions. These food security benefits contribute to society in ways that cannot be measured easily by economic growth.

It can also be argued that rural communities are usually established and stable. If the farming that supports them disappears then the communities destabilize and the appeal of urban migration increases. The economic advantages of keeping people on the land are not apparent if the urban industrial sector is short of labour, but if, as in South Africa, there is extensive urban unemployment, it makes economic and political sense to keep people in the rural areas that are contributing to the economy.

a. Poverty, food security and employment role

Poverty reduction and food security are at the heart of our national development goals and essential to many international development assistance efforts. Agriculture's role in poverty alleviation and food security works via various channels and links through which agricultural growth contributes to poverty reduction at national, urban and rural levels. These channels are stable food prices, employment creation, higher real wages, and farm income.

Results from earlier studies we have completed (Kirsten, et al., 2007; Vink and Kirsten, 2005) demonstrate that the pro-poor role of agricultural growth can be dramatic, and much more effective than other sectors at reducing poverty and hunger in both urban and rural areas. Agricultural growth has a strong, durable and positive impact on poverty often significantly greater than that of other economic sectors.

Noticeably, this pro-poor outcome is observed not only for the poorest and most agrarian countries, but also for the higher income economies as well. Chile and Mexico are examples as illustrated by the work of the Food and Agricultural Organization of the United Nations (FAO) in the early 2000's (see FAO, 2004 and

Brezziani & Valdes, 2007). As a whole, the results suggest that poverty reduction policies should take into consideration the strategic importance of agricultural growth and its transformation, the output mix (especially towards labour intensive exports), and the various channels through which agriculture may contribute to poverty alleviation.

In a closely related set of studies, Brezziani & Valdes (2007) examined agriculture's role in food security, concluding that in the medium and long term, the economic growth of the agricultural sector appears to be the primary channel for achieving household food security. This is especially relevant in low-income economies (such as the Northern Cape) where agricultural growth can contribute to food security through its effect on poverty reduction, in addition to its food production role.

In the context of the poverty and employment role of agriculture Table 3 provides the current employment levels of the farms earmarked for acquisition. We compare the employment on the farms with the most recent employment numbers provided by Quantec as reported in the 2015 Kayamandi report on the SKA. This suggests that there are 646 people employed in the agricultural sector in the two local municipalities affected by the SKA investment. Based on the numbers from the survey on the farms we estimate that 112 people (inclusive of the farmers/owners) are employed on the farms earmarked – equivalent to **17.3%** of all agricultural employment in Kareeberg and Karoo Hoogland. This is again an illustration of the substantive role of the farms in question.

Table 3: The population in the districts, towns and farms impacted by the SKA Phase 1 plan.

Place	Population numbers	
Kareeberg LM	**Total (2011)**	**11 673**
	Carnarvon	6 612
	Vosburg and Van Wyksvlei	1 944
	Rural / farm population	*3 116*
Karoo Hoogland LM	**Total (2011)**	**12 588**
	Williston	3 368
	Fraserburg and Sutherland	6 942
	Rural / Farm population	*2 278*
Farms earmarked for acquisition (107 000ha)	**Total population (2016)**	**308**
	Farmers	21
	Farmer dependents	56
	Farmworkers	47
	Farmworker dependents	106
	Casual workers (33) and dependents	78

Source: STATSSA (Census 2011) and data provided by Kareeberg Forum (2016)

b. Environmental role

Agricultural activities occupy and influence vast landscapes. Farmers work and live in watersheds, grasslands, hillsides, coastal plains, forests, and river deltas. These various agro-ecosystems provide a wide range of local, national and global benefits and services in the form of positive externalities and public goods. Politicians, policy makers and planners often think that land in rotation is unproductive land and available for alternative investments. This needs to be

challenged. Rotational grazing in the context of the Karoo has a longstanding history, and is essential for protecting biodiversity and fostering sustainability and also critical for environmentally sound farming practices. At the same time policymakers and planners forget about the biodiversity services, watershed benefits, carbon sequestration potential and landscape amenities provided by agricultural activities and rural communities. It is quite evident that these dimensions are ignored in reflecting on agriculture's contribution.

Agriculture's impact on the environment is often (although not always) perceived to be negative but through proper policies and proper incentives and sustainable farming practices agriculture has the potential to provide the following environmental benefits:

- Ecosystems resilience
- Soils conservation (reducing and preventing soil erosion and off- site impacts, including reservoirs and waterways used for irrigation, drinking water, recreations, and hydro-power)
- Hydrological benefits (water volume, retention, availability, quality)
- Disaster prevention (floods and landslides)
- Biodiversity (wild species and wildlife conservation)
- Air quality (reduction in green house gas emission, carbon sequestration)
- Genetic diversity
- Soil quality, nutrient supply, salinity and moisture balance
- Rural landscape (land features and amenities shaped by agriculture, including those associated with cultural practices, historic buildings and landmarks)

It is the latter contribution that makes the Karoo such an attractive tourist destination: vast open and clean spaces and beautiful vistas and sunsets, all of which promotes a unique dimension of tourism – 'escapism'. Getting away from noise, people and signal is in demand from an increasing urbanized population. The peace and tranquility of the Karoo stimulates creativity for writers, artists, photographers and bird watchers. This benefit to society comes free of charge but at the cost of the farmer/landowner. Taking farmland out of production and to alternative or industrial use will thus deprive society of this important benefit. It is however so that the tranquility and silence of the Karoo is also beneficial for astronomy work and therefore agriculture can in tandem with the SKA provide double the environmental amenities presented here. It does not need to be the SKA or the farmers, in opposition. It should be both working together - their coexistence in this open landscape could stimulate even more tourism.

c. Social viability

Robust agricultural growth has the potential to prevent population concentration in the capital and other metropolitan cities, and to lead to a more balanced distribution of population over space. A balanced distribution of population can be welfare enhancing, cost effective, and socially viable. Furthermore, a lower rate of rural out-migration means reduced pressures on rural towns and the urban areas and reduced urban costs of pollution,

congestion, crime, and unhygienic living conditions. Avoidance of such costs is a positive contribution of agriculture. So if agriculture is effectively destroyed or removed as an economic activity the urban costs will now be borne by local municipalities who are already under financial stress.

The global literature (*cf.* Brezianni and Valdes, 2007) on the non-market roles of agriculture examines three aspects, which are inter-related to the social role of agriculture: (i) in rural-urban migration flows; (ii) as a system of social protection; and (iii) as a contribution to social capital. Research has focused mainly on the rural-to-urban migration component of social viability, or more specifically rural viability.

Agriculture can play an important positive or negative role in shaping rural economic opportunities, in supporting a balanced geographical development and in countervailing over-concentration in a few urban centres. Agricultural employment therefore makes an important contribution for the spatial distribution of population.

Agriculture-derived activities, such as services for agriculture (inputs supply, veterinary or mechanization and repair services, transportation) and agriculture processing and commercialization, play a major mediating function in the way agriculture shapes rural-to-urban migration. Thus the influence of agriculture on rural-to-urban migration is largely a function of the sector's impact on – and relationship with – other rural activities, and their employment, income and distributive features. These are dimensions often ignored by planners and politicians who mistakenly see agriculture as only a one-dimensional activity.

International studies also established that increased (or sustained) agricultural employment reduces out-migration, and that increased secondary sector employment reduces it even further. Part of this secondary sector is agro-processing (such as the abattoirs in Williston and Carnarvon), in most cases oriented to exports (out of the region), which are usually dependent on local agricultural production. Thus, it appears that the expansion of export oriented, labour intensive agriculture is correlated with lower out-migration rates, an example of how agriculture can play an important role in geographically diversified development and, as a consequence, counter over-concentration in large cities.

Another important facet of the social viability dimension of the roles of agriculture is the 'buffer role' of agriculture. This refers to the sector's ability to act as an informal or traditional form of safety net that is capable of absorbing increases in urban unemployment resulting from major macro-economic shocks. This contribution allows for a more flexible adjustment of the labour market and increases in the economy's resilience to external shocks, thereby reducing the time lag for a full recovery. Agriculture's ability to act as a buffer hinges especially on the sector's social safety net role in which family or community ties act as a substitute for incomplete or absent formal safety nets, private insurance and credit markets. This role assists individuals affected by shocks to avoid a dramatic shortfall in consumption while recovering their income-earning capacity. The housing and other services provided by farmers to their workers

and their families act for example as an important buffer in times of unemployment. Again, if agriculture is destroyed this critical safety net role will disappear.

If we take the numbers in Table 3 above we estimate that the proposed land acquisition process will impact a total of **308** individuals. The social safety net and buffer as well as a full-time livelihood that agriculture provided to these individuals and their families will have been destroyed if the land acquisition process goes ahead and all agricultural activity on the land ceases. This represents about 6% of the total rural population in the two local municipalities or 1.5% of the total population of the two district municipalities.[3]

Earlier we referred to the social capital role of agriculture – also in the context of social viability. Many of the farmers bring with them many generations of social ties and years of experience. This knowledge is important in the context of their mentorship role but they also play a key role in local organisations and institutions, as well as heritage and identity. These include annual town festivals, the regional agricultural show, the churches and the old age home and a number of charities and non-governmental organizations. Farmers keep many of these organisations alive through contributions in kind and through their time input in terms of management and coordination. The social capital of farmers is core to the social fabric of any rural town and especially where farmers have been farming for generations it will never be replaced through alternative investments. The indigenous knowledge and social networks embedded in these farmers and their families are critical for various organisations in the local community – the church, the local government and the farmers' organizations and also the different sports clubs. A new non-agricultural investment is highly unlikely to replace this valuable social capital; although it may (and should) complement it.

We now turn to the market role of agriculture, which can easily be documented by facts and figures, which we obtained from the farmers and the local businesses serving the farming sector.

d. Production of food and fibre

Estimating the output value can be done through a variety of approaches: (a) using the grazing capacity to estimate the total sheep flock and then estimating the offspring numbers to establish the number of animals (lamb vs old animals) sold or (b) obtaining the volumes and sales values recorded at the abattoirs and marketing agents for the farms in question.

If we apply method (a) we have earlier estimated a total ewe population of around 16 000 ewes. Based on good weaning percentages of around 100% and including the one feed lot producer the number of animals marketed in a season is in the range of 13 500 lambs and around 6000 old animals.

[3] This takes into account permanent residents of the two local municipalities. There may be others seasonally present.

Based on the numbers obtained from the abattoirs and other businesses (method b) we estimate the value of the outputs produced by the affected farmers as follows:

Table 4: Reported annual values of production from the earmarked farms (2015) (only 13 farms)

Business	Meat / Live animals	Hides and offal	Wool
Carnarvon abattoir *	R1 808 011	R250 270	
Williston abattoir *	R3 552 029		
Cavalier **	R4 341 488		
BKB/CMW			R342 000

* *See details in Annexure 2*

*** See details in Annexure 2 and 3*

The information provided by the three meat companies is however incomplete and only applies to 13 out of the 32 farms. As we illustrate in Annexure 2 we had to use the three-year average value for Gross Farm Income of the Carnarvon study group to get to a more realistic estimate for the revenue from meat sales for the earmarked farms. Using the three-year average of R136/ha we estimate a total gross farm income from meat (and live animal) sales of R15,567 million. If we add the wool income from the one merino farmer and revenue from biltong and trophy hunters a total estimated value of output of **R16 million** per annum for the 107 000ha in question seems therefore to be a reasonable (but conservative) estimate. It could be as high as R23 million if we use different assumptions. It has to be noted that this is an annual value that will be produced *ad infinitum* thus creating a sustainable income and job opportunity for a very long time. No investment and no change in land use will have the ability to create the same revenue stream for such a long period of time on the same area of land.

e. Agriculture as a market for other industries

Agriculture also provides an important market for other sectors of the economy and for a number of related businesses and entrepreneurs. The sheep farming industry for example buys a variety of inputs that vary from veterinary medicine, fencing equipment, fuel, pipes and other irrigation equipment and animal feeds. At the same time financial institutions, hardware stores as well as construction entrepreneurs also see the farmers as the most important market for their products and services. The manufacturing industry is obviously not located in the local economy but the retailing of these items via cooperatives, hardware stores and retail stores is the key dimension of the economies of the affected local towns that we should consider.

The financial layout of the affected farmers on basic farm requisites as obtained from the relevant businesses in the various towns is provided below:

- Williston Cooperative: R 5 016 000
- BKB Carnarvon: R602 000
- KVB Carnarvon: R668 000

- Jacobs Broers Carnarvon: R650 000

Farmers obviously also buy farm inputs (and often groceries) from companies and retailers located outside the immediate region – this include Prieska, Upington, Kimberley, Bloemfontein and the Western Cape. What we have estimated here is an indication of the direct impact on the local economy.

In addition to these main business linked to the different farms there are also entrepreneurs providing a range of services to the farmers in the region and who all is likely to lose considerable business if we have a scenario of total cessation of all agricultural activities. These include:

- Mechanics
- Borehole and, more recently, solar pump experts
- Hunters (for predators)
- Pregnancy testing and ram fertility testing
- Stud breeders
- Sheep shearers and wool graders
- Fence makers
- Livestock marketing agents

The various individuals responsible for scanning pregnant ewes in preparation for the lambing season typically charge between R2.50 and R10 per ewe. But the majority charge R2.50 and that is done at least twice a year. So the income from this activity for these entrepreneurs should be at the minimum equal to R90 000 per annum.

Hunters to contain predators typically receive around R600 per animal. Since these things are not formally recorded it is difficult to put a value to this but most hunters would typically earn around R6000 per month. In this region we will typically have about 1 hunter for every 15 000ha and therefore the estimate of around 7 individuals making a living from these activities on the 107 000ha sounds reasonable.

5. The local and economy wide impact of cessation of farming activities

The nature and extent of the various roles of agriculture documented in Section 3 already provide a clear assessment of the important economic contribution of the farms in the earmarked region. If we now utilise a representative enterprise budget (see Annexure 1) for extensive small stock production in this region, we are able to estimate the value of the total backward linkages for the local economy originating from the production value of 107 200 ha (or 16 000 small stock units). This provides a more accurate estimation than the broad estimates provided earlier although it still excludes direct production costs such as veterinary medicine and supplementary feed. Furthermore we need to take into account the two farms that are non-topical operations – a feedlot and stud breeder - whose direct production costs and production value will be substantially higher.

Backward linkages

The turnover reported by the different cooperatives and other retailers is estimated at R6.9 million and provides a realistic value since it will include all expenditure on feed, veterinary medicine and costs related to fuel and oil and a large chunk of the maintenance on machinery and fixed improvements reported in Table 4 below. If wage expenditure (R1.16 million) is included and we include all items below line 3 in Table 5 we estimate a total value of expenditure in the local economy equal to R9.09 million per annum.

Forward linkages

On the output side we have three local enterprises that depend fully on the livestock industry in the Karoo Hoogland and Kareeberg Local Municipalities, namely Carnarvon abattoir, Williston abattoir and BKB. The proposed cessation of livestock farming activities will have a marked impact on the output and profitability of these enterprises. As shown earlier Carnarvon abattoir will loose R2.058 million and Williston abattoir R4.049 million in turnover. The loss of a large number of slaughter animals caused by the cessation of farming activities is equivalent to 8.24% of the average annual slaughter volumes at the two abattoirs. Any abattoir business is very sensitive to throughput volume and obviously this loss in slaughter numbers would compromise the profitability of both these abattoirs and could lead to downsizing the labour force at these two abattoirs.

Table 4: Value of backward linkages from the affected farms

Item	**Value**
Fuel and oil	R735 156
Maintenance and repair of machinery and pumps	R231 032
Maintenance and repair of fixed improvements (buildings, kraals, fencing)	R359 785
Accountants	R54 424
Banking costs	R47 031
Telephone	R169 200
Internet service providers	R34 118
Electricity	R69 255
Municipal Tax	R71 834
Predator control	R136 526
Licenses	R17 676
Short term insurance	R306 448
Hand tools	R23 251
Clothing for labourers	R2 792
Other	R5 832
Total	**R2 358 069**

Manufacturing and retailing enterprises outside the region also benefit from the output generated on the farms in question. The livestock sales to Cavalier based in Gauteng (R10 million) and the sales of wool (R340 000) through BKB for the wool export market are relevant here.

Economy wide impact

The direct estimates of the backward and forward linkages as well as the value of the production value reported above only present a partial picture of the true value of the agricultural activity on the farms earmarked for acquisition by the SKA. The linkages and multiplier effects goes far beyond the local economy and in order to estimate the total value to the South African economy of the production activity on these farms we make use of the SAM/CGE database for 2011 which was disaggregated into 7 primary agricultural sub-industries and 10 sub-industries for processing agriculture. This disaggregation enables us to estimate the macro-economic effect of the cessation of faming activities, which will result in a drop of R16 million in the South African red meat industry.

The model was 'shocked'[4] with the loss of R16 million in the red meat/livestock industry. The CGE/SAM model estimates the linkages of the red meat industry with the rest of the economy and is therefore in a position to estimate the macro-economic impact of the loss of R16 million in the red meat industry. The loss of R16 million is equivalent to a reduction in the red meat industry of 0,053337%.

The main macro results of the model (described in Annexure 4) are as follows:

- GDP decline: -0.00000456% (Value equivalence: R31 million accumulative loss including R16 million direct loss from primary agriculture (Red Meat and Wool) and about R15 million from the processed meat industry and textile industries and other industries)

- Employment: -0.0001091% (In 2011 there were 14.336 million employed people and therefore the reduction is equivalent to a loss of 1 565 jobs).

Impact on neighbouring farms

One important impact of the cessation of all agricultural activities on a concentrated area of land is the sudden and exponential increase in the number of predators. It is difficult to predict this but the recent example of a similar case of large land acquisition in the immediate vicinity of the SKA core area should provide us with a good indication what is likely to happen. The potential impact is well illustrated by the establishment of the Alkantpan ammunition testing terrain outside Van Wyksvlei.

[4] A shock to the model or the economy is the initial loss of R16 million of output caused by the cessation of farming activities. "Shocking" the model is to reduce red meat output by R16 million so that the effect on the other industries and the rest of economy can then be estimated.

Alkantpan is an area equivalent to 85 000 hectares acquired in 1987 by the South African Defence Force for a missile and ammunition testing terrain. After a few years farmers on the neighbouring farms found it very hard to farm profitably with small stock due to high losses of livestock caused by the rapid increase in the predator population on Alkantpan. It has been observed that there are a number of dominant breading pairs of jackals on Alkantpan resulting in the younger animals being pushed out to hunt on the neighbouring farms. As result weaning percentages dropped from a reasonable 90-100% to as low as 60%. This clearly illustrates that the impact of a cessation of farming activities cannot be estimated only in relation to the loss in production on the land in question but should also include the loss in production value on the surrounding farms caused by predators. Eventually many farmers left their farms because it has become impossible to farm. No management plan and no grazing plan have proven to be successful to prevent these huge losses.

Research in other parts of the Karoo (see Drouilly forthcoming) show that the juvenile jackals travel over large distances during dispersal. This also confirms the argument here that the effect of land use change is not limited to the farms that will be acquired but that the surrounding farms are likely to suffer increased losses due to higher levels of predation. This implies that that the loss in agricultural value estimated here is likely to be undervalued by a fairly large margin. It has the additional implication that SKA's mitigation and compensation plan should also consider these dimensions.

The cessation of farming activities on Alkantpan since 1987 and the losses in production value on the neighbouring farms all contributed to the rapid decline in the town economy of Van Wyksvlei. Once a bustling town found in the 1880s it is now home to majority of mainly unemployed people depending on migrant incomes, government jobs and social grants. The Van Wyksvlei dam which was built in 1882 was the first state funded irrigation dam in South Africa and supported an active irrigation farming community in most of the early 1900s and later also a very productive small stock farming region. Consistent low rainfall reduced the potential for irrigation in the area resulting in livestock production becoming the only viable farming activity. This industry now also lost its viability due to the predation problem created by Alkantpan.

6. Summary of impacts

In this brief report we have approached the task of estimating the economic impact from different angles to ensure that all possibilities are covered. The following data sources and processes have been involved:

Output values

- Data obtained from farmers
- Data obtained from abattoirs and other businesses buying product from the earmarked farms

Input values

- Sales reported by various cooperatives and other retailers

- Indirect costs and overhead costs linked to individual entrepreneurs were estimated from a representative enterprise budget

Economy wide effects

Using the output values from the 107 200ha in question we applied the 2011 version of the multi-sector SAM/CGE model for the South African economy.

These different approaches gave the following impacts:

- Loss in annual agricultural production value: R16 million
- Loss in throughput at the two abattoirs equivalent to 8.24% of annual slaughter volumes
- Drop in sales and business volumes amongst local business and entrepreneurs equivalent to R9.09 million
- South African economy will shrink by an estimated value of R31 million annually and the economy will shed 1 565 jobs
- Loss in production value on neighbouring farms adjacent to the SKA core due to increased predator activity

7. A proposal for a compromise solution: using farmers as guardians of the SKA project.

The analysis presented here clearly suggests an important economic role of the farmers on the earmarked farms. Not only are these farms important for the economic and social future of the different communities but the future of South Africa's iconic meat product, Karoo Lamb will also be severely impacted by the potential cessation of all farming activities. The results also illustrate to what extent the economy of the two local municipalities will be impacted with a resulting loss in economic opportunity and jobs. It is unlikely that the SKA investment will replace any of these economic and job losses due to the specific nature of the investment and the current skills set of people that will be affected.

Given the emotional and social impact of the proposed land acquisition and the increased antagonism against the SKA project emerging from the farming community as well as the towns' people we need to find a compromise solution.

Farmers are natural custodians of the land, and their actions and production activities are geared to sustain production for as long as possible. It is therefore possible to capitalise on this existing advantage, and to use this protective attitude and approach to the benefit of the SKA. It is therefore possible and perhaps a much more sensible solution for the SKA to form a partnership with the affected farmers and use them as the guardians/gate keepers of the SKA core site. One can for example introduce strict access control for the 130 000ha and allow the farmers to continue farming in exchange for a supportive role to the SKA. Instead of appointing security staff at high costs one can employ the farmers and their workers as the protectors of the SKA perimeters. Farmers

could even be asked to employ and house additional workers for this purpose. Providing basic infrastructure, accommodation and water to SKA staff could also be something to be considered. If necessary, one can introduce certain conditions for obtaining the right to maintain productive activity on the land in question. This could include negotiations on restrictions related to the use of certain equipment and household utilities.

The fundamental argument here is that we should employ the farmers as partners and gate keepers to the SKA and let them continue their farming operations – which in any case is per definition a low noise activity – so that the local economy and many lives are not disrupted. At the same time the SKA is protected and supported and becomes integrated into the farming and community life in and orderly fashion. The SKA and Karoo Lamb could jointly become the true icons of "Brand South Africa". Effectively, as has been shown elsewhere (see, for example, the Greater Cedarberg Biodiversity Corridor approach undertaken by Cape Nature); farmers and non-agricultural activity are able to work in complement to each other as part of a harmonized landscape (see the broader Landscape Initiatives approach of Cape Nature in addition).

Instead of paying R500 – R700 million for the land one can compensate each farmer at R25/ha per year (adjusted annually for inflation) for the strict conditions under which farming should continue and for performing selected duties in support of the SKA investment. However for those land parcels where dishes will be erected and land will permanently be lost for productive purposes, compensation needs to happen at a higher rate. Most likely the market value of land should apply for these pieces of land lost for the servitudes and dish location.

This proposal will translate in an annual cost of R2 680 000 ($190 000) or a total investment (in real terms) over the 50-year life span of the project of R134 million. To this one should add the cost of the land parcels that need to be procured but in any case the total capital required is likely to be substantially less than outright acquisition of all the land in question. At the same time SKA would have obtained many cudo's and gained the loyalty of, and the support from the community and at the same time it ensures that the negative economic consequence estimated in this report are prevented. This is surely a win-win solution.

A final option for consideration to minimise the negative impact is that the SKA subsidises the two abattoirs since these two enterprises in essence ensure the economic survival of Williston and Carnarvon. Annual payment of around R2.5 million each to the two abattoirs will compensate them for the loss in revenue and will prevent the potential thread of financial ruin and closure. Again, the R5 million total compensation amount will only be a small way in ensuring that at least some of the jobs in the town are saved. It still does not deal with the lives of the 308 people that have been compromised and therefore the first proposal above will probably be much more beneficial to all involved.

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Annexure 1: Enterprise budget for the Carnarvon farmer study group (Prepared by Louis du Pisanie, NWKV)

CARNARVON STUDIEGROEP

Algemene Inligting	**Groep Gemiddeld**	**Laagste**	**Hoogste**
Drakrag (ha/GVE)	36	30	39
Hektaar beskikbaar (plaasgrootte)	19 033	6 480	33 432
Hektaar benodig vir huidige GVE	15 839	5 942	25 719
Potensiële GVE (100% kapasiteit)	564	171	1 114
Huidige GVE	466	156	857
% van Kapasiteit	**85,4%**	**76,9%**	**91,7%**
Gemiddelde reënval (mm)	200	197	201
Bo/onder gemiddelde reënval jaar	192	150	217

Oorhoofse koste (OK)

	Groep Gemiddeld		**Laagste**	**Hoogste**	**Laagste**	**Hoogste**
Oorhoofse koste	**R/KVE**	**% v BPW**	**R/KVE**	**R/KVE**	**% v BPW**	**% v BPW**
Permanente arbeid	*R 72,53*	*11,0%*	R 36,22	R 93,29	7,0%	16,8%
Brandstof, olie & smeermiddels	*R 45,95*	*7,4%*	R 31,33	R 57,76	3,8%	10,9%
Meganisasie: Instandh & herstelwerk	*R 14,44*	*2,4%*	R -	R 25,06	0,0%	4,1%
Vaste verbeteringe: Instandh & herstelwerk	*R 22,49*	*3,4%*	R 14,70	R 31,25	2,8%	4,3%
Boekhouersfooi	*R 3,40*	*0,5%*	R 0,20	R 6,61	0,0%	0,9%
Bankkoste	*R 2,94*	*0,4%*	R 1,05	R 7,50	0,2%	1,0%
Telefoon	*R 10,58*	*1,5%*	R 2,80	R 27,75	0,5%	3,8%
Posgeld	*R 0,01*	*0,0%*	R -	R 0,06	0,0%	0,0%
Internet diensverskaffer	*R 2,13*	*0,3%*	R -	R 10,66	0,0%	1,5%
Elektrisiteit	*R 4,33*	*0,7%*	R -	R 19,44	0,0%	3,2%
Water (buiten gewasse)	*R 4,92*	*0,7%*	R -	R 10,36	0,0%	1,2%
Grondbelasting	*R 4,49*	*0,7%*	R 1,75	R 7,68	0,3%	1,0%
Ongediertebeheer	*R 8,53*	*1,2%*	R -	R 24,37	0,0%	3,3%
Lisensies	*R 1,10*	*0,2%*	R -	R 1,75	0,0%	0,3%
Skryfbehoeftes	*R 0,11*	*0,0%*	R -	R 0,32	0,0%	0,1%
Kortermynversekering	*R 19,15*	*2,8%*	R 1,40	R 48,45	0,3%	6,6%
Ledegeld & subskripsies	*R 0,81*	*0,1%*	R -	R 1,44	0,0%	0,2%
Advertensies	*R -*	*0,0%*	R -	R -	0,0%	0,0%
Kursusse en opleiding	*R -*	*0,0%*	R -	R -	0,0%	0,0%
Klein gereedskap	*R 1,45*	*0,2%*	R -	R 3,84	0,0%	0,5%
Oorpakke & besermde klere	*R 0,17*	*0,0%*	R -	R 0,87	0,0%	0,1%
Plaasbenodighede	*R 0,36*	*0,0%*	R -	R 1,82	0,0%	0,2%
Ander	*R 1,56*	*0,2%*	R -	R 7,79	0,0%	0,9%
Totale Oorhoofse koste	***R 221,46***	***33,9%***	**R 142,97**	**R 328,94**	**25,5%**	**44,8%**

Boerdery opsomming/KVE

Produsent en Jaar	**Groep Gemiddeld**	**Laagste**	**Hoogste**
Bruto Produksiewaarde/KVE	R 659,42	R 515,98	R 897,53
Direkte kostes/KVE	*R 107,77*	R 18,55	R 206,30
Bruto Marge/KVE	R 551,65	R 420,17	R 691,23
Oorhoofse koste/KVE	*R 221,46*	R 142,97	R 328,94
Netto Boerdery Inkomste/KVE	**R 330,19**	**R 198,56**	**R 462,18**

Boerdery opsomming/Ha

Produsent en Jaar	**Groep Gemiddeld**	**Laagste**	**Hoogste**
Bruto Produksiewaarde/Ha	R 123,26	R 92,67	R 157,46
Direkte koste/Ha	*R 19,26*	R 4,12	R 36,19
Bruto Marge/Ha	R 103,99	R 71,82	R 121,27
Oorhoofse koste/Ha	*R 40,97*	R 31,77	R 57,71
Netto Boerdery Inkomste/Ha (gebruikte ha)	**R 63,02**	**R 33,94**	**R 81,09**
Netto Boerdery Inkomste/Ha (werklike ha)	**R 53,44**	**R 29,23**	**R 73,71**

Annexure 2: Livestock sales of affected farms: Actual values reported by Carnarvon and Williston abattoirs and Cavalier as well as estimated values using study group averages.

Farm No.	Farm name	Total size	Williston	Carnarvon	Cavalier	Actual value AVG estimate	Gross Farm income avg R136/ha
63	Dubbelde vlei/Dubbele Vlei	3 550				720 650	482 800
65	Botterleegte	5 717			1 651 971	1 160 551	777 512
65	Botterleegte	289				58 667	39 304
66	Brakputs	7 959			1 720 204	1 615 677	1 082 424
70	De Hoek	11 167	776 831			2 266 901	1 518 712
72	Rooizand	3 811	827 544			773 633	518 296
74	Groot Paarde Kloof	7 757	1 156 253			1 574 671	1 054 952
76	Jaskloof	3 602				731 206	489 872
96	Blaauw Heuvel	5 376				1 091 328	731 136
495	Pofadderfontein	1 548		23 558		314 244	210 528
496	Swartfontein	3 396				689 388	461 856
494(02)	Janseboom	2 229				452 487	303 144
495(02)	Pofadderfontein	1 761				357 483	239 496
495(03)	Pofadderfontein	1 761				357 483	239 496
496(01)	Swartfontein	2 270				460 810	308 720
496(02)	Swartfontein	3 209				651 427	436 424
64(01)	Schietpoort	1 571				318 913	213 656
64,00	Schietpoort	3 142		774 960		637 826	427 312
64(2)	Schietpoort	1 575				319 725	214 200
65(02)	Lovedale	3 432				696 696	466 752
67(01)	Bitterwater	2 091				424 473	284 376
67(02)	Swartfontein	3 396				689 388	461 856
69(02)	Visserskloof	4 485		1 259 763	320 070	910 455	609 960
69(01)	Visserskloof	8 641			285 396	1 754 123	1 175 176
69(03)	Visserskloof	4 381			211 010	889 343	595 816
71(01)	Varsrivier	4 350				883 050	591 600
71	Zout Rivier	1 359	272 672			275 877	184 824
71(02)	Zout Rivier	1 458			152 837	295 974	198 288
71(03)	Zout Rivier	1 455				295 365	197 880
72(01)	Rooisand	3 823				776 069	519 928
76(01)	Saailaagte	3 644				739 732	495 584
66(1)	Brakputs	263				53 389	35 768
			R3 033 300	**R2 058 281**	**R4 341 488**	**R23 183 615**	**R15 567 648**

Annexure 3: Sales of livestock to Cavalier in Boksburg *(only farmers that sell 100% of market ready animals to the Cavalier agent)*

2015

Maand	C.J Oberholzer Jnr.	Bedrag	C.J.Oberholzer Snr.	Bedrag	D.R Oberholzer	Bedrag	Totaal	Totaal Skaap	Gem
Jan					6	5 222,00	5 222,00	6	870,33
Feb.	16	14 976,20	28	24 301,90	21	14 669,50	53 947,60	65	829,96
	11	7 248,50			91	77 146,30			
Bees	10	49 848,00							
April	45	38 422,50					38 422,50	45	853,83
Bees	3	10 972,00							
Mei					32	27 166,00	27 166,00	32	848,94
Junie	31	29 175,00					29 175,00	31	941,13
Aug.	11	10 582,00					10 582,00	11	962,00
Sept.			35	37 786,00	53	54 908,00	92 694,00	88	1 053,34
					33	26 055,00	26 055,00	33	789,55
Okt.					45	45 898,00	45 898,00	45	1 019,96
Nov.			65	69 006,00	65	69 006,00	138 012,00	130	1 061,63
Des	115	124 172,25	83	79 917,00			204 089,25	198	1 030,75
							-	0	#DIV/0!
	242	285 396,45	211	211 010,90	346	320 070,80	671 263,35	684	981,38

Maand	W.Louw	Bedrag	W.L Louw	Bedrag	A.M Louw	Bedrag	Totaal	Totaal Skaap	Gem
Jan	108	99 134,00	108	99 134,00			198 268,00	216	917,91
Feb.	77	68 678,00	77	68 678,00	56	46 656,90	184 012,90	210	876,25
Maart	121	103 828,35	121	103 828,35	9	6 595,05	214 251,75	251	853,59
	149	123 585,60	149	123 585,60			247 171,20	298	829,43
Mei	119	132 196,05	119	132 196,05			264 392,10	238	1 110,89
	84	86 459,00	84	86 459,00			172 918,00	168	1 029,27
	123	126 824,75	123	126 824,75			253 649,50	246	1 031,10
Junie	45	31 890,00	45	31 890,00	40	42 416,00	106 196,00	130	816,89
	33	30 523,50	33	30 523,50			61 047,00	66	924,95
Bees	3	8 402,00	3	8 402,00			16 804,00	6	2 800,67
	77	84 468,00	77	84 468,00			168 936,00	154	1 096,99
	67	74 281,10	67	74 281,10			148 562,20	134	1 108,67
Aug.	68	76 292,00	68	76 292,00			152 584,00	136	1 121,94
Sept.	83	55 921,50	83	55 921,50			111 843,00	166	673,75
	51	53 975,00	51	53 975,00			107 950,00	102	1 058,33
	75	84 238,00	75	84 238,00			168 476,00	150	1 123,17
Okt.	55	55 266,00	55	55 266,00	6	6 350,30	116 882,30	116	1 007,61
	81	81 025,90	81	81 025,90	35	50 818,75	212 870,55	197	1 080,56
Nov.	42	42 758,50	42	42 758,50			85 517,00	84	1 018,06
	59	56 092,75	59	56 092,75			112 185,50	118	950,72
Des	43	39 224,50	43	39 224,50			78 449,00	86	912,20
	107	103 482,25	107	103 482,25			206 964,50	214	967,12
	35	33 424,25	35	33 424,25			66 848,50	70	954,98
	1705	1 651 971,00	1705	1 651 971,00			3 456 779,00	3556	972,10

Maand	M.D Oberholzer	Bedrag	L.Oberholzer	Bedrag	N. Oberholzer	Bedrag	Totaal	Totaal Skaap	Gem
Junie	558	709 865,00					709 865,00	558	1 272,16
Sept.	20	21 588,00	15	16 198,00			37 786,00	35	1 079,60
	327	387 296,00					387 296,00	327	1 184,39
Des	24	22 478,25	10	10 008,75			32 487,00	34	955,50
	196	188 343,00					188 343,00	196	960,93
	367	390 634,50			21	20 004,75	410 639,25	388	1 058,35
	1492	1 720 204,75	25	26 206,75	21	20 004,75	1 766 416,25	1538	1 148,52
						Totaal	5 894 458,60	5778	1 020,16

Annexure 4: Description of CGE/SAM model to estimate the economy-wide impact of the loss in output as a result of the SKA Phase 1 programme

CGE models are well suited to analysing policy questions such as those identified in the previous section. The strength of the CGE methodology lies in its ability to capture the various inter-linkages in the real economy in great detail. Since data for only one reference year is required for the initial solution to the model, more detail can usually be incorporated in our analysis compared to many other econometric methodologies that require large time-series datasets in order to produce robust simulation results. The superiority of CGE models over other partial equilibrium modelling options is clear, since the research question demands that the impact of the policy change under investigation be assessed on an economy-wide basis. CGE models have also been established as a superior methodology to Input-Output or SAM multiplier models, despite being based on the same underlying set of national accounts. The ability of CGE models to accurately reflect resource constraints and the impact of relative price changes in the economic decision making process, and ultimately the structure of the economy, are of significant importance in conducting accurate and credible policy analysis. Our choice of GEMPACK software, instead of other available packages, is motivated by the clear benefits that GEMPACK offers to the modeller. A detailed comparison between software packages was documented in Horridge et al. (2013) in which GEMPACK was determined to be the clear winner for CGE applications.

We use the University of Pretoria General Equilibrium Model (UPGEM) to conduct our analysis of proposed policy shocks on the agricultural sector and South African economy as a whole. CGE models such as UPGEM provide industry-level disaggregation in a quantitative description of the whole economy and postulate neo-classical production functions and price-responsive demand functions, linked around a supply-use matrix in a general equilibrium model that endogenously determines prices and quantities.

The specifications in UPGEM recognise each industry as producing one or more commodities, using as inputs combinations of domestic and imported commodities, different types of labour, capital and land. The multi-input, multi-output production specification is kept manageable by a series of separability assumptions. This nested production structure reduces the number of estimated parameters required by the model. Optimising equations determining the commodity composition of industry output are derived subject to a CET function, while functions determining industry inputs are determined by a series of CES nests. At the top level of this nesting structure intermediate commodity composites and a primary-factor composite are combined using a Leontief or fixed-proportions production function. Consequently, they are all demanded in direct proportion to industry output or activity. Each commodity composite is a CES function of a domestic good and its imported equivalent. This incorporates Armington's assumption of imperfect substitutability for goods by place of production (Armington, 1969). The primary-factor composite is a CES aggregate of composite labour, capital and, in the case of primary sector industries such as agriculture, land. Composite labour demand is itself a CES aggregate of the different types of labour distinguished in the model's database. In UPGEM, all industries share this common production structure, but input proportions

and behavioural parameters vary between industries based on base year data and available econometric estimates, respectively.

The version of UPGEM used in this study is based on a 2011 reference year database that draws mainly from the 2011 supply-use tables published by Statistics South Africa; South African reserve Bank and Department of Agriculture, Forestry and Fisheries. The standard UPGEM database distinguishes 40 industries and commodities, and 11 occupation groups. However, in order to simplify the presentation of results in this study, we first aggregate the database to 14 sectors and a single representative household. From there, we split the agriculture sector and relevant industries within the food manufacturing sector to produce a database that distinguishes 32 industries and commodities.

The source data was originally adapted for use in a CGE framework by the Department of Economics at the University of Pretoria. The subsequent work to split the agriculture and food manufacturing parts of the database to provide additional detail was completed as part of this study. The disaggregation and mapping process is informed by two documents namely the Standard Industrial Classification (SIC) and Central Product Classification (CPC), both downloadable from Statistics South Africa (www.statssa.gov.za). The core database contains three sets of information, namely:

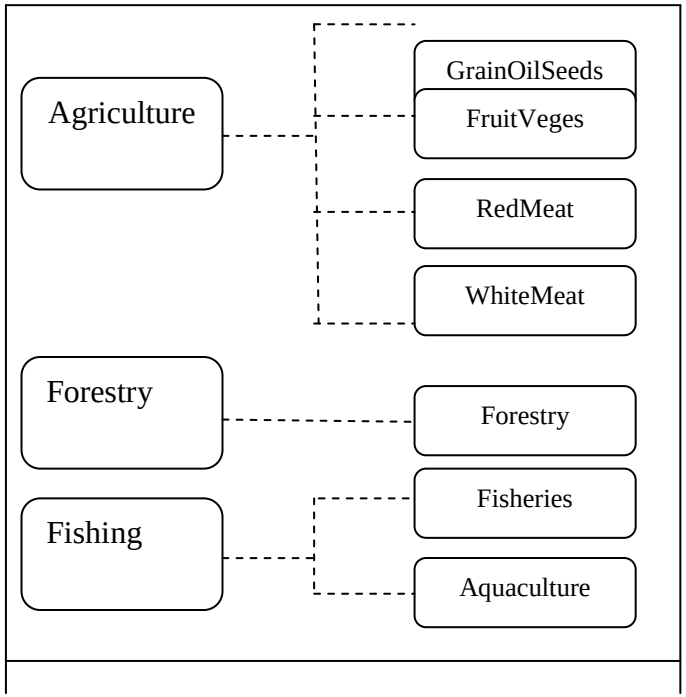
- **Coefficients** represent the basic flows of commodities between users, commodity taxes paid by users and margins flows that facilitate the flow of commodities. Coefficient values are computed from the Supply-Use Tables published by Statistics South Africa. Estimates for industry level capital stocks and depreciation rates are also included here.

- **Behavioural parameters** which are elasticities that influences the degree to which economic agents change their behaviour when relative prices changes. For this study, the behavioural parameters estimated by De Wet (2003) will be adopted. These parameters have been compared to behavioural parameters used in Punt (2013) and Bohlmann et al. (2015) and no significant differences between the studies were found. The behavioural parameters include various Armington intermediate, investment and household demand elasticities. Substitution elasticities for labour and primary factors sub-structures are also included. Although, parameters from De Wet (2003) and Punt (2013) have been assessed, a sensitive analysis of different parameters on the simulated results will be performed to determine the appropriate levels of parameters in this study. The GEMPACK software has a special feature called Systematic Sensitivity Analysis (SSA) which allows for efficient sensitivity analysis on behavioural parameters.

- **Government accounts** which include South African financial accounts with the rest of the world and relevant interest rate parameters.

Mapping process to disaggregate of agriculture and food industries

Unprocessed Agriculture



Processed Agriculture