

The Enabling Geophysical Agricultural Environment for Agriculture in Gauteng Province, South Africa

A. E. Nesamvuni¹, N. S. Mpandeli^{2*}, K.A. Tshikolomo³ and C. Kgowedi⁴

¹*University of Venda, School of Environmental Sciences, Department of Geography and Geo-Information Sciences, Private Bag X 5050, Thohoyandou, South Africa*

²*Water Research Commission of South Africa, Private Bag X 03, Pretoria, 0031, South Africa*

³*Limpopo Department of Agriculture, Private Bag X 9487, Polokwane, 0700, South Africa*

⁴*Gauteng Department of Agriculture and Rural Development, P.O.Box 8769, Johannesburg, 2000, South Africa*

KEYWORDS Comprehensive Agricultural Support Program. Municipalities. Hubs. Infrastructure. Land Use

ABSTRACT The results from this study show that poultry, livestock and vegetable are the most dominated agricultural commodities in areas such as the City of Tshwane, Sedibeng, Westrand, Johannesburg and Ekurhuleni municipalities. The results from this study further show that farmers across the province are practicing mixed farming. The results further highlighted that Kungwini municipality has more hubs (Kungwini hub 5, Kungwini hub 6 and Nokeng hub 7) compared to other municipalities such as Lesedi, which has two hubs (hub 3 in Midvaal and hub 4 in Lesedi) and Emfuleni, which has hub 1 and Midvaal, which has hub 3. The results clearly outlined that more crops are produced under dry land than irrigated land and this is due to insufficient funds provided by CASP. Lastly, the results show that Sedibeng municipality, City of Tshwane, Westrand has more number of farms focusing on poultry, livestock and vegetable production. The aims of this study are to evaluate and assess production status of different agricultural commodities in Gauteng Province, and to quantify the type of agricultural commodities produced across municipalities in the Gauteng Province.

INTRODUCTION

According to Maponya and Mpandeli (2012, 2015), climate variability and change is a reality and it is the greatest environmental challenge that has an impact on agricultural production in many ways. Agricultural production depends on climatic conditions such as temperature and precipitation. Climate is a primary determinant of agricultural productivity, and any significant changes in climate in the future will influence crop and livestock productivity, hydrological balances, input supplies and other components of managing agricultural systems (Jayne et al. 2003; Chitja et al. 2015; Maponya and Mpandeli 2015). It is well known that rainfed agriculture is predominant across the globe. It is reported that almost eighty-eight percent of the cultivated land across the globe is in used by rainfed production systems, providing sixty percent of the world food production, whereas in sub-Saharan Africa (SSA), dry land agriculture makes up more than ninety-five percent of farm output (Kauffman et al 2003; Botha 2006). In semi-arid regions,

for example, rainfed agriculture has to contend with unreliable rainfall, poor soils and recurrent droughts with subsequent production failures (Fofana et al. 2003; Stroosnijder 2003; Botha 2006). Increase in human population together with its associated increases in demands for food items compel agricultural research to focus on efficient use of rainfed agriculture. This scenario is further compounded by the high climatic variability and changes in dietary requirements due to health considerations. In South Africa, as is the case in other developing countries, levels and incidence of poverty tend to be disproportionately high amongst the rural population whilst Gauteng Province (GP) equally not immune on this issue. According to Botha (2006), the poorest of the rural households mostly live in semi-arid and arid areas and rely heavily on rainfed crop production for their livelihoods, sometimes often farming on marginal and fragile soils. According to the Ohio Geospatial Program: Agriculture and Natural Resources (2003) and Petja et al. (2013), Sustainable Agriculture and Rural Development (SARD) practices have potential to reduce hunger and poverty while sustaining the ecosystems that poor rural people rely on for livelihoods (International Institute for Sustainable Development 2010; Petja et al.

*Address for correspondence
E-mail: sylvesterm@wrc.org.za

2013). Due to lack of research, rural areas face challenges related to agricultural sustainability, agricultural efficiency, business diversification, and long-term growth and planning (Ohio Geospatial Program: Agriculture and Natural Resources 2003; Petja et al. 2003).

Aims of this Study

- (a) Evaluate and assess production status of different agricultural commodities in Gauteng Province.
- (b) To quantify the type of agricultural commodities produced across municipalities in the Gauteng Province.

Contextualization of the Study Site

Gauteng Province is one of the populated provinces in South Africa. According to the South African National Census of 2011, it is estimated that around 12.3 million people are liv-

ing in Gauteng Province. Gauteng Province has four biggest metropolitan cities and these are Tshwane, Johannesburg, Ekurhuleni and Mogale. Gauteng Province is surrounded by provinces such as Limpopo, North West, Free State, Kwa-Zulu Natal and Mpumalanga. Cities such as Johannesburg and Tshwane have higher population densities compared to Mogale and Ekurhuleni.

RESEARCH METHODOLOGY

Study Area

The study area is situated in the District Local Municipalities of Gauteng Province (Fig. 1).

Data Collection

This research used a mixture of both primary and secondary data sets for analysis as an approach. Long-term environmental and climate

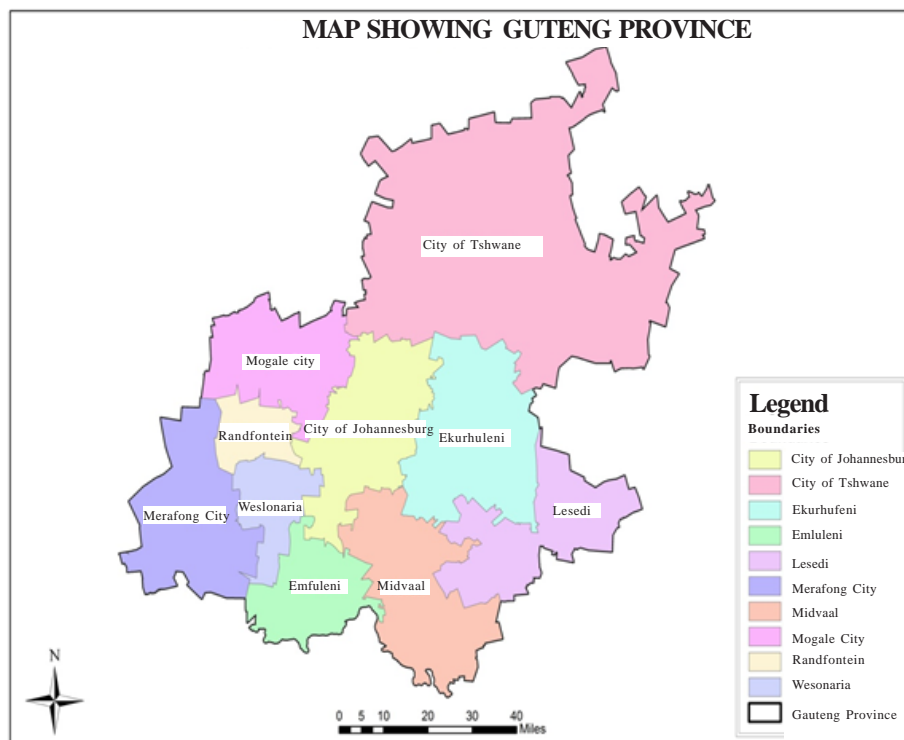


Fig. 1. Map of Gauteng Province showing different municipalities

data was acquired from the Agricultural Research Council in GIS format (ARC-ISCW 2008). Most of the data was processed to a national scale and as such subject to coarse resolution. This therefore warranted collection of field data to verify and validate such data at a local and farm scale. Other topographic data was acquired from the Department of Rural Development and Land Reform. The areas in Gauteng Province covered a large area, which necessitated appointment of field workers and consultants to conduct field surveys. Data was then analyzed to correct the national vector data to a local scale. The first stage of the field surveys involved the documentation of the variables needed to evaluate agricultural potential at a farm scale. The variables involved the state of natural resources and environmental parameters, which cover amongst others the real extent of arable land available,

climatic situation, soil analysis and crop suitability. Farm boundaries were demarcated using GPS for easy integration into a GIS system. Data on the previous and current land use was acquired from the departmental archives and satellite images.

RESULTS AND DISCUSSION

Important Agricultural Sites-Municipalities

Important Agricultural Sites (IAS's) are areas outside the boundaries of the seven hub areas classified as high potential agricultural land and/or currently utilized for cultivated agriculture.

In this paper, Figure 2 shows the location of the important agricultural sites in relation to the Gauteng local municipality boundaries. It was noted that Table 1 indicates the information on

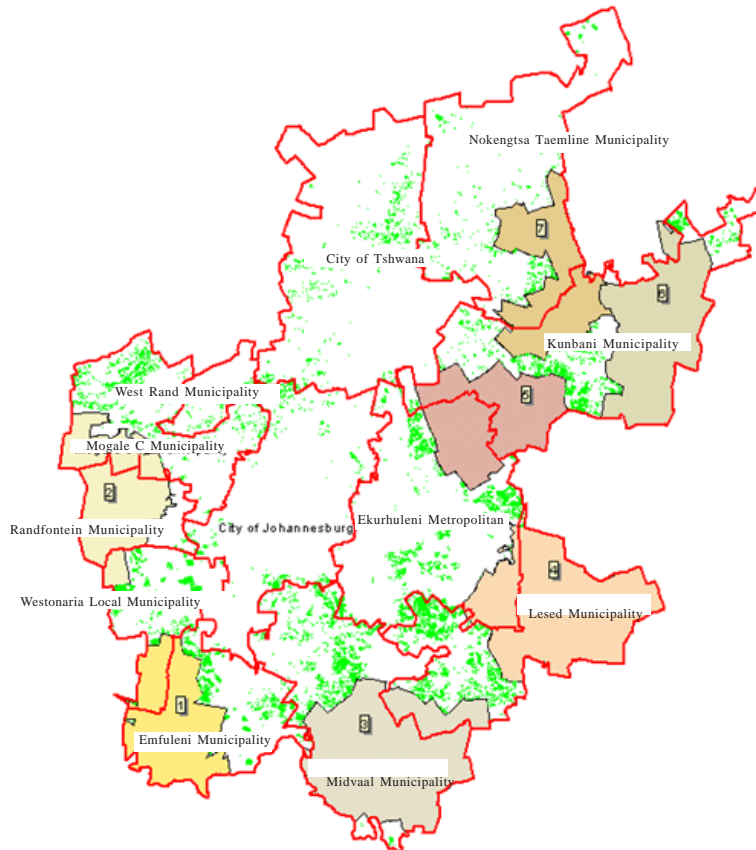


Fig. 2. Location of important agricultural sites in Gauteng Province

the agricultural sites in the Gauteng province. The information on agriculture is provided per municipality, and hence this assists in identifying which municipality has higher production than the other. The above information also assists in identifying reasons on why some municipalities have lower production than others and perhaps assist in remediating the problems. The above information shows that the Randfontein municipality has higher percentage of land for agriculture compared to the other municipality with one hundred percent of land (Fig. 2).

Municipalities such as Nokeng tsa Taemane and Westonarea are also treading closely with ninety-eight percent and ninety-four percent agricultural land, respectively. Johannesburg and Ekurhuleni Metropolitan Cities have the least agricultural land compared to other municipalities with twenty-one percent and twenty-three percent, respectively (Table 1). The reason for low agricultural land is because of the high percentages in development and mining land. The background information does not provide an idea of what kind of agriculture is being practiced in the municipalities (Table 1).

Table 2 gives a summary of number of farms per commodity per municipality during the CASP financial years. Looking at Table 1, it is evident that the CASP program did not cover all municipalities and this is something that can be looked at as a way forward on why only the municipalities in Table 2 were sponsored for the four commodities. From the summary in Figure 2 one can see that the number of farms in crop production is very low compared to the other commodities throughout all municipalities with a total of 28 farms across all municipalities. The reason for farmers not practicing crop farming in the Gauteng area may be due to different aspects of agriculture such as not enough water in the area to sustain crop production or maybe the soil is not suitable for the crop production and also lack of information on both agronomic and livestock practices.

Table 1: Important agricultural sites in Gauteng Province

	<i>Important agricultural sites - Zonation percentages</i>			
	<i>Agri- cul- ture</i>	<i>Deve- lop- ment</i>	<i>Open space</i>	<i>Other (Tourism, Mining, etc).</i>
City of Johannesburg	21	9	54	16
City of Tshwane	57	30	13	0
Ekurhuleni Metro	23	45	23	9
Midvaal	58	34	1	7
Emfuleni	79	21	0	0
Lesedi	77	21	0	2
Mogale City	61	20	18	1
Randfontein	100	0	0	0
Westonaria	94	6	0	0
Kungwini	76	21	3	0
Nokeng tsa Taemane	98	2	0	0

Based on the results from Figure 3 it can be seen that West Rand municipality and Johannesburg Metropolitan City do not have crop production. The reason for this may be because of different phenomena such lack of water or the soil is not suitable enough for the crop production. There is also possibility that this municipality does not have agricultural programs focusing on the crop production. The results in Figure 3 show that City of Tshwane, Sedibeng, Westrand, Johannesburg and Ekurhuleni Metropolitan Cities have more than 10 farms focusing on poultry. However, it was noted that City of Tshwane and Sedibeng municipality have more than 50 farms dealing with poultry activities. It is only Cities of Johannesburg and Ekurhuleni, which have less than 10 farms focusing on livestock activities. Before the data was summarized, West Rand and Johannesburg municipalities did not have livestock production as well and this could be attributed to lack of crop production and water scarcity. These are things that need to be researched on to have an idea of why the two municipalities lack the two commodities.

Table 2: Summary of commodity comparison per municipality during CASP financial years

<i>District Municipality</i>	<i>Poultry</i>	<i>Livestock</i>	<i>Vegetable</i>	<i>Crops</i>	<i>Total</i>
City of Tshwane	54	54	43	7	158
Sedibeng	92	32	29	19	172
Westrand	25	17	19	0	61
JHB Metro	10	7	16	0	33
Ekurhuleni	19	5	12	2	38
Total	200	115	119	28	462

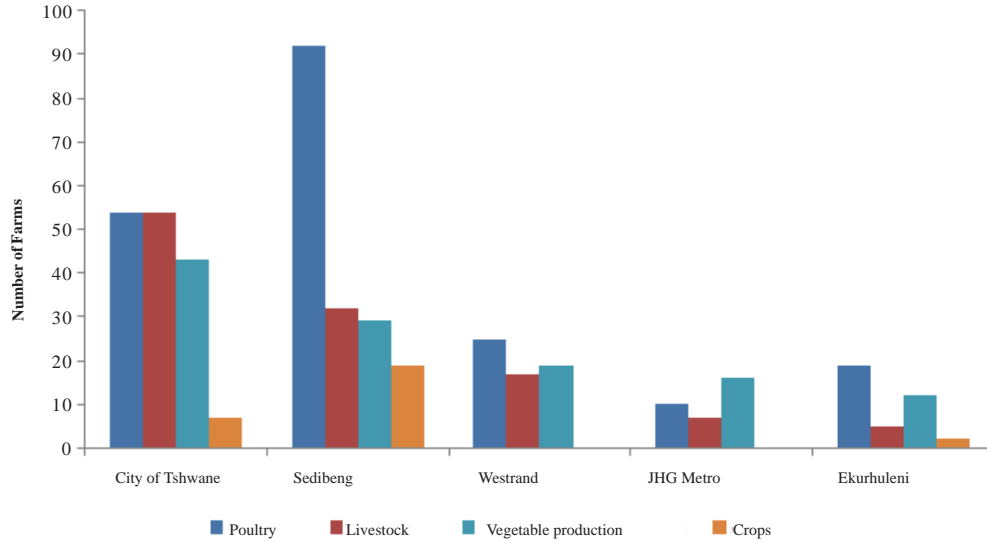


Fig. 3. Summary of commodities per municipalities

The following sections and tables list the production status statistics for important agricultural sites, summarized for each of the local municipalities.

Production Status for IAS’s in Gauteng Province

City of Johannesburg

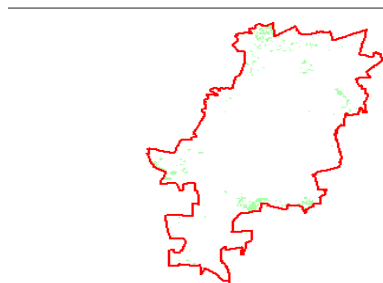
The City of Johannesburg is one of the important agricultural areas. Table 3 shows that crop production is being practiced in the City of Johannesburg municipality. An area of 2.81 percent is used for crop production in the city but from the CASP table it shows that no crop farming has been funded in the municipality. The

lack of funding for crop production in this municipality should be investigated. Poultry production in the municipality is greater than crop production. Table 3a shows that the majority of farmers are producing vegetable compared to poultry in the Johannesburg Metropolitan. This is not surprising because some of the households are producing products in their backyards especially in townships.

Table 3a: Poultry and crop production comparison with infrastructure during CASP financial years

District Municipality	Poultry	Vegetable	Crops	Infra-structure
JHB Metro	10	16	0	0

Table 3: IAS’s: City of Johannesburg



Crop	Land use	Area (Ha)	% of Mun area
Other	Not known	4287.48	2.61
Beans	Irrigation	30.23	0.02
Beans	Dry-Land	31.55	0.02
Maize	Irrigation	127.77	0.08
Maize	Dry-Land	141.32	0.09
Sunflower	Dry-Land	1.41	0.00
Total Area: IAS:		4619.76	2.81
Total Mun Area (ha)		164.452	

City of Tshwane

The results from Table 4a show that more poultry (54) are produced in the City of Tshwane compared to (43) vegetable gardens. The reason for this shift is unknown except may be to highlight that farming practices vary from municipality to municipality due to several factors including soil types, climatic conditions and also market opportunities. In Tshwane Metropolitan City, the background information of the municipality shows that there is crop production that is being practiced, and it shows that 3.26 percent of the municipality area is crop production. CASP data show that seven (7) crop farms were funded by the CASP project throughout the six financial years. It may be assumed that the crop production may also be used for poultry feed in the municipality. Comparing the number of crop farms in the municipality with the rest of the other three commodities, crop farming has the least number. Although there is higher crop production compared to the Johannesburg Municipal City, the number of crop farms is still low compared to other commodities, and the reason for this needs to be looked at in the CASP overview.

Table 4a: Poultry and crop production comparison with infrastructure during CASP financial years

District Municipality	Poultry	Vegetable	Crops	Infrastructure
City of Tshwane	54	43	7	Fence -1 Pump - 1 Borehole - 3 Irrigation system- 1

Ekurhuleni Metropolitan

The results from Table 5a show that poultry (19) and vegetable (12) are the most dominant

commodities in the Ekurhuleni Metropolitan compared to other crops and those crops produced under tunnel system. The results further show that farmers in the Ekurhuleni metropolitan areas are practicing crop diversification such as beans, maize, sunflower and sorghum. This forms a part of the coping and adaptation strategies due to high climatic variability and change.

In the Ekurhuleni Metropolitan City, crops produced are beans and maize in both irrigation and dry land production. More land for crop production is in dry land production. The results show that few crops are produced under irrigated land than dry land area and this could be due to lack of infrastructure and also lack of understanding of technologies (Table 5, 5b). The crops produced may also be used for poultry feed in the metropolitan city.

Emfuleni Municipality

Emfuleni municipality has high crop production area compared to cities of Johannesburg and Tshwane Metropolitan Cities, with 7.21 percent of crop farming in the area, although there are no farms funded in the area by CASP project. This raises a question of why this municipality has not been funded by the project and whether it can be funded in the future. Crop production is not the only commodity not funded by CASP but also other commodities such as poultry, horticulture and animal farming have not been funded in the municipality. According to the National Department of Agriculture (2008), in 2004-2005, about 150,000 hectares were planted to soya beans producing a total of about 272,500 ton of beans. In 2009, the area planted with soya beans had increased to 311,000 hectares and total production to 566,000 ton beans (Department of

Table 4: IAS's: City of Tshwane (this will be done)

Crop	Land use	Area (Ha)	% of Mun area
Other	Not known	6131.19	2.80
Beans	Irrigation	48.23	0.02
Beans	Dry-Land	17.83	0.01
Maize	Irrigation	403.30	0.18
Maize	Dry-Land	524.00	0.24
Sunflower	Dry-Land	7.25	0.00
Total Area: IAS:		7131.80	3.26
Total Mun. Area		218.743	

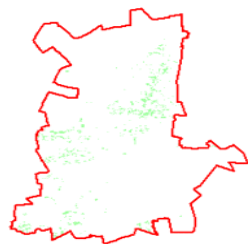


Table 5: IAS's: Ekurhuleni Metropolitan

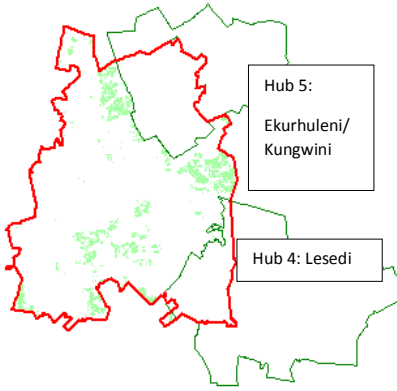
	<i>Crop</i>	<i>Land use</i>	<i>Area (Ha)</i>	<i>% of Mun area</i>
Hub 5: Ekurhuleni/ Kungwini	Other	Not known	8069.92	4.19
	Beans	Dry-Land	838.62	0.44
	Maize	Irrigation	325.44	0.17
	Maize	Dry-Land	4542.27	2.36
	Sunflower	Dry-Land	610.19	0.32
	Sorghum	Dry-Land	4.52	0.00
	<i>Total Area: IAS:</i>			<i>14390.96</i>
<i>Total Mun. Area</i>			<i>192.377</i>	
Hub 4: Lesedi				

Table 5a. Poultry and crop production comparison with infrastructure during CASP financial years

<i>District Municipality</i>	<i>Poultry</i>	<i>Vege -table</i>	<i>Crops</i>	<i>Crop Infra-structure</i>
Ekurhuleni	19	12	2	Tunnels- 2

Table 5b: Production status: Ekurhuleni Metro

<i>Crop</i>	<i>Land Use</i>	<i>Area (ha)</i>	<i>% of Hub Area</i>
Not in Production	Urban, built-up, industrial, etc	3596.53	7.90
	Vacant, grazing, open area	24546.63	53.89
	Previously cultivated	1449.73	3.18
Other	Not known	7553.72	16.58
Beans	Irrigation	81.43	0.18
Beans	Dry-Land		2.89
Maize	Irrigation		1.23
Maize	Dry-Land		14.15
			100.00



Agriculture, Forestry and Fisheries 2011). However, despite substantial increases in local production, South Africa remains an importer of soya beans, mostly in the form of oil cake (Department of Agriculture, Forestry and Fisheries 2011; Averbek 2013).

In Emfuleni municipality, 46.8 percent and 0.46 percent of the land is occupied by portions of hubs 1 and 3, respectively. Crops produced in

lower and the area is [maize pro-]wer pro-] used for [hat farm-] applying [hat all the] under dry

Table 6: IAS's: Emfuleni

	<i>Crop</i>	<i>Land use</i>	<i>Area (Ha)</i>	<i>% of Mun area</i>
Hub 1: Emfuleni	Other	Not known	5462.98	5.53
	Beans	Dry-Land	121.41	0.12
	Maize	Irrigation	64.35	0.07
	Maize	Dry-Land	1028.48	1.04
	Sunflower	Dry-Land	442.04	0.45
<i>Total Area: IAS:</i>			<i>7119.26</i>	<i>7.21</i>
<i>Total Mun. Area</i>			<i>98.730</i>	
Hub 3: Midvaal				

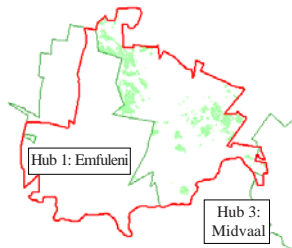


Table 7: Production status: Emfuleni

<i>Crop</i>	<i>Land use</i>	<i>Area (ha)</i>	<i>% of Hub area</i>
Not in Production	Urban, built-up, industrial, etc.	56.77	0.12
	Vacant, grazing, open area, etc.	21657.94	46.41
	Previously cultivated	6639.33	14.23
Other	Not known	9827.97	21.06
Beans	Dry-Land	50.68	0.11
Maize	Dry-Land	6323.74	13.55
Sunflower	Dry-Land	2108.16	4.52
		46664.59	100.00

land areas and no crops are produced under irrigated areas. In Emfuleni, all the farmers are producing their crops under dry land areas. Maize crop is the most produced in the area compared to sunflower, beans and others, however, it is not surprising that maize is the most commonly produced in the area because it is a staple food across the SADC region (Table 7). According to Averbeke et al. (2013), growing maize for marketing as green maize is attractive, because the value of green maize is higher than that of maize grain. They further highlighted that green maize also known as “maize on the cob”, table maize, green mealies and garden maize is a healthy and popular snack in South Africa. In some areas especially towns and cities across the country, green maize is boiled and sold as a takeaway food by street traders. Sometimes it is also sold uncooked, usually by “bakkie traders” in bundles of four to six cobs for customers that do not want boiled products (Averbeke et al 2013). In the Thohoyandou area, for example, smallholder farmers have been producing green maize as a commodity for at least three decades (BENSO and RAU 1979, Averbeke et al 2013), and they continue to do so hitherto. According to Manyelo (2011), the trade of green maize in this area was controlled by street traders, who selected and purchased cobs whilst these were still attached to the plants growing in farmers’ plots.

Kungwini Municipality

Kungwini municipality like Emfuleni has a higher amount of crop farming area with 6.05 percent of land compared with Johannesburg and Tshwane Metropolitan City. This means there are crop farms in the municipality but no farms have been funded by the CASP project. Like Emfuleni municipality, other commodities in the Kungwini municipalities have not been funded either by CASP. Again Table 7a shows that beans and sunflower are produced under dry land area and it is only maize, which is produced under both irrigation and dry land areas (Table 7a).

In Kungwini municipality 18.77 percent, 37.39 percent and 11.48 percent are occupied by portions of hubs 5, 6 and 7, respectively. Crops produced in the municipality are beans, maize, sunflower, sorghum and other crops not specified. Irrigation and dry land farming is practiced in the municipality. Maize dry land farming is the most practiced in the municipality compared to the other crops with 16166.65 hectare of land being used for maize dry land farming. The Kungwini municipality is practicing crop diversification including beans, maize, sunflower and sorghum. It is interesting to see that sorghum is also produced in the area because sorghum crop

Table 7a: IAS's: Kungwini

<i>Crop</i>	<i>Land use</i>	<i>Area (Ha)</i>	<i>% of Mun area</i>
Other	Not known	9316.55	4.42
Beans	Dry-Land	134.88	0.06
Maize	Irrigation	422.59	0.20
Maize	Dry-Land	2828.92	1.34
Sunflower	Dry-Land	38.63	0.02
<i>Total Area: IAS:</i>		<i>12741.57</i>	<i>6.05</i>
<i>Total Mun. Area</i>		<i>210.777</i>	

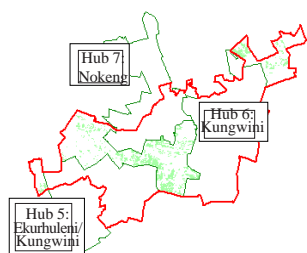


Table 8: Production status: Kungwini

<i>Crop</i>	<i>Land use</i>	<i>Area (ha)</i>	<i>% of Hub area</i>
Not in production	Urban, built-up, industrial, etc	540.03	0.38
	Vacant, grazing, open area	90674.34	63.60
	Previously cultivated	3241.54	2.27
Other	Not known	27291.97	19.14
Beans	Irrigation	97.02	0.07
Beans	Dry-Land	1748.61	1.23
Maize	Irrigation	2500.25	1.75
Maize	Dry-Land	16166.65	11.34
Sunflower	Dry-Land	257.94	0.18
Sorghum	Dry-Land	48.44	0.03
		142566.79	100.00

is well known for being a drought tolerant crop compared to most of the agronomic crops such as beans and maize (Table 8).

Lesedi Municipality

Lesedi municipality has 9.93 percent of the municipality area designated for crop farming, which is very high compared to the already mentioned municipality. Meaning there are many farms in the area, which are catering for crop production compared to Johannesburg and Tshwane Metropolitan City. This raises a question of why the metropolitan municipality has not been funded by CASP project, and also the other commodities have not been funded in this city. Crops, which are being farmed in the municipality or metropolitan are beans, maize, sunflower and sorghum in both irrigation and dry land (Table 9).

In Lesedi municipality 10.91 percent and 55.21 percent of land is occupied by portions of hubs 3 and 4, respectively. Crops produced in the municipality are beans, maize, sunflower, sorghum and other crops not specified. Irrigation and dry land farming is practiced in the

municipality (Table 10). Maize dry land farming is the most practiced in the municipality compared to the other crops with 16093.01 hectare of land being used for maize dry land farming.

CONCLUSION

The results from this study show that the CASP program did not cover all municipalities and this is something that can be looked at in the way forward as why only the municipalities in Table 2 were sponsored for the four commodities. Figure 2 shows that number of farms in crop production is very low compared to the other commodities throughout all municipalities with a total of 28 farms across all municipalities. The reason for farmers not practicing crop farming in the Gauteng area may be due to different aspects of agriculture such as not enough water in the area to sustain crop production or maybe the soil is not suitable for the crop production and also lack of information on both agronomic and livestock practices.

Emfuleni Municipality has high crop production area compared to Cities of Johannesburg

Table 9: IAS's: Lesedi

<i>Crop</i>	<i>Land use</i>	<i>Area (Ha)</i>	<i>% of Mun area</i>
Other	Not known	7069.13	4.75
Beans	Dry-Land	529.99	0.36
Maize	Irrigation	283.30	0.19
Maize	Dry-Land	6349.51	4.26
Sunflower	Irrigation	27.46	0.02
Sunflower	Dry-Land	331.21	0.22
Sorghum	Dry-Land	197.77	0.13
<i>Total Area: IAS:</i>		<i>14788.37</i>	<i>9.93</i>
<i>Total Mun. Area</i>		<i>148.917</i>	

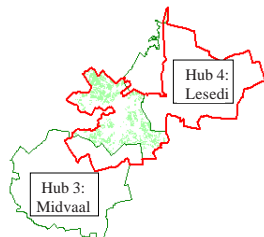


Table 10: Production status: Lesedi

<i>Crop</i>	<i>Land use</i>	<i>Area (ha)</i>	<i>% of Hub area</i>
Not in Production	Urban, built-up, industrial, etc	812.24	0.82
	Vacant, grazing, open area	52818.95	53.65
	Previously cultivated	2488.82	2.53
Other	Not known	21374.45	21.71
Beans	Irrigation	141.00	0.14
Beans	Dry-Land	3765.97	3.82
Maize	Irrigation	448.07	0.46
Maize	Dry-Land	16093.01	16.34
Sunflower	Dry-Land	423.88	0.43
Sorghum	Dry-Land	93.53	0.09
		98459.92	100.00

and City Tshwane Metropolitan City, with 7.21 percent of crop farming in the area, although there are no farms funded in the area by CASP project. This raises a question of why this municipality has not been funded by the project and whether it can be funded in the future. Crop production is not the only commodity not funded by CASP but other commodities such as poultry, horticulture and animal farming have also not been funded in the metropolitan municipality. In Kungwini municipality 18.77 percent, 37.39 percent and 11.48 percent are occupied by portions of hubs 5, 6 and 7, respectively. Crops produced in the municipality are beans, maize, sunflower, sorghum and other crops not specified. Irrigation and dry land farming is practiced in the municipality. Maize dry land farming is the most practiced in the municipality compared to the other crops with 16166.65 hectare of land is used for maize dry land farming. The Kungwini municipality is practicing crop diversification including beans, maize, sunflower and sorghum. It is interesting to see that sorghum is also produced in the area because sorghum crop is well known for being a drought tolerant crop compared to most of the agronomic crops such as beans and maize (Table 8).

RECOMMENDATIONS

A number of recommendations emerge that could be considered in the paper and may require further research. The results from this paper show that farmers in Gauteng Province should be encouraged to practice crop diversification as a climate risk management strategy. Based on the results from this paper, it was noted that the majority of farmers in the study areas

are relying on government support especially on inputs and infrastructure, this method is not recommended due to the fact that it is not sustainable and it needs to be reconsidered. It is recommended that local farmers could be encouraged to use drought-resistant cultivars during drought periods. It is important to note that drought-resistant cultivars are suitable for countries such as South Africa due to the fact it is a water scarce country.

REFERENCES

- Agricultural Research Council – Institute for Soil, Climate and Water 2008. *Climate Database System*. Pretoria, South Africa.
- BENSO and RAU 1979. *The Independent Venda*. Pretoria: Bureau for Economic Research: Cooperation and Development (BENSO).
- Botha JJ 2006. *Evaluation of Maize and Sunflower Production in Semi-arid Area Using in-field Rainwater Harvesting*. PhD Thesis. Bloemfontein: University of Free State.
- Chitja, J, Mthiyane CCN, Mariga IK, Shimelis H, Murgani VG, Morojele PJ, Naidoo K, Aphane OD 2016. Empowerment of women through water use security, land use security and knowledge generation for improved household food security and sustainable rural livelihoods in selected areas in Limpopo Province. University of Kwazulu –Natal, Pietermaritzburg, South Africa.
- Department of Agriculture, Forestry and Fisheries 2011. *Soyabean Market Value Chain Profile, 2010/2011*. Pretoria.
- Dorward A, Kydd J, Poulton C 2005. Beyond liberalisation: Developmental coordination policies for African smallholder agriculture. *IDS Bulletin*, 36: 80-85.
- Fofana B Wopereis M, Zougmore R, Breman H, Mando A 2003. Integrated soil fertility management an effective water conservation technology for dryland agriculture in sub-Saharan Africa. In: D Beukes, M de Villiers, S Mkhize, H Sally, L van Rensburg (Eds.): *Proceedings of the Symposium and Workshop on Water Conservation Technologies for Sustainable Dryland Agriculture in Sub-Saharan*

- Africa (WCT)*, Bloemfontein, South Africa, pp. 109-117.
- International Institute for Sustainable Development 2010. Sustainable Agriculture and Rural Development (SARD) Initiative. From <http://www.iisd.org/measure/gov/sd_strategies/national.asp> (Retrieved on 27 July 2010).
- Jayne TS, Yamano M, Weber D, Tschirley R, Benfica A, Chapoto Zulu 2003. Smallholder income and land distribution in Africa: Implications for poverty reduction strategies. *Food Policy*, 28(3): 253-275.
- Kauffman JH, Mantel S, Ringersma J, Dijkshoorn JA, Lynden GWJ, Dent DL 2003. Making better use of green water under rainfed agriculture in sub-Saharan Africa. In: D Beukes, M de Villiers, A Mkhize, H Sally, L van Rensburg (Eds.): *Proceedings of the Symposium and Workshop on Water Conservation Technologies for Sustainable Dryland Agriculture in Sub-Saharan Africa (WCT)*, Bloemfontein, South Africa, pp. 103-108.
- Maponya P, Mpandeli NS 2015. Climate change and agricultural production in South Africa: Impact and adaptation options. *Journal of Agricultural Science*, 4(10): 48-60.
- Maponya P, Mpandeli S 2015. Climate change status in the Mutale Local Municipality: A case study of the smallholder farmers in Vhembe district, Limpopo Province. *Journal of Human Ecology*, 52(1, 2): 1-8.
- Ohio Geospatial Program: Agriculture and Natural Resources 2003. MAP@SYST: Promoting the Diversified Use of Geospatial Technologies (GPS, GIS and Remote Sensing) for Addressing Community, Agricultural and Environmental Issues. Agricultural and Natural Resources, Ohio, USA. From <<http://geospatial.osu.edu/education/map@syst.html>> (Retrieved on 27 July 2010).
- Petja MB, Nesamvuni E, Nkoana A 2013. Using geospatial information technology for rural agricultural development planning in Nebo Plateau, South Africa. *Journal of Agricultural Science*, 6(4): 10-17.
- Stroosnijder L 2003. *Technologies for Improving Rainwater Use Efficiency in Semi-arid Africa*. In: D Beukes, M de Villiers, A Mkhize, H Sally, L van Rensburg (Eds.): *Proceedings of the Symposium and Workshop on Water Conservation Technologies for Sustainable Dryland Agriculture in Sub-Saharan Africa (WCT)*, Bloemfontein, South Africa, pp. 92-102.
- Van Averbeke W 2013. Improving Plot Holder Livelihood and Scheme Productivity on Smallholder Canal Irrigation Schemes in the Vhembe District of Limpopo Province. *WRC Report No. TT 566/13*. P. 285. Pretoria, South Africa, Water Research Commission of South Africa
- Van Averbeke W, Ralivhesa K, Mbuli S, Khosa TB, Manyelo 2013. *Growing Green Maize on Canal Schemes in Vhembe: Production Guidelines*. Pretoria, South Africa, Water Research Commission of South Africa.

Paper received for publication on June 2015
Paper accepted for publication on March 2016