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## Capacity of *Pseudomonas syringae* pv. *glycinea* Strains and their Method of Application on *Striga hermonthica*-infested Maize and Sorghum

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**Abstract:** One variety of Maize (8338-1) and two varieties of Sorghum (CK60B and Mokwa local) were grown in potted soils with 3,000 seeds *Striga hermonthica*. Three strains of *Pseudomonas syringae* pv. *glycinea* designated as 16/83, 19/84 and 8/83 were tested for their effects on germination of *S. hermonthica* seeds via inoculation. Results showed that application of bacteria by root dip or seed pelleting method in Sorghum demonstrated greater heights (~6.72 cm) for all the three bacteria over the non-inoculated control. For CK60B, average stover dry weight in the control was the lowest (0.71 g/plant). All the 3 isolates improved stover dry weight (2.5 g/pot) over the non-inoculated control on the Maize host. *S. hermonthica* infection indices were significantly different between plants grown in steam pasteurized soil and those grown in natural soil. The knowledge of these application methods in reducing sources of variation in bacterial studies on *S. hermonthica* is discussed. [Life Science Journal. 2011;8(S1):1-10] (01) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** bacterial treatment; *Pseudomonas syringae*; root dip; greenhouse; seed pelleting; *Striga*

### 1. Introduction

Microorganisms have frequently been introduced into soil to promote certain agriculturally-beneficial activities, e.g. suppression of plant pathogens, and promotion of plant growth (Babalola, et al., 2007a) and are increasingly being considered as control agents for *Striga hermonthica* (Babalola, et al., 2007a; Babalola et al., 2002; Elzein et al., 2006) *Pseudomonas syringae* are known for antagonistic activities *in vitro* and *in planta* (greenhouse experiment). *Pseudomonas syringae* pv. *glycinea* cause bacterial blight of soybeans (*Glycine max* (L) Merr.) (Volksch and May 2001). *Pseudomonas syringae* pv. *glycinea* attacks all ground parts of the soybean during its development from seedling to adult plant.

The interest in the use of introduced microorganisms for biological control of *S. hermonthica* has been driven in part by trends in agriculture toward greater sustainability and increased public concern for problems associated with practices to control parasitic weeds. The results from these advances bear directly on two fundamental sources of inconsistency in the

performance of microorganisms introduced for biological control, namely, inadequate colonization of the target site and variability in the expression or level of activity of the mechanism(s) responsible for pathogen suppression. These have until now retarded their commercial development and widespread use. Once introduced bacteria invade the plant vascular system, chemotaxis may not be an important criteria for infection but chemotaxis and mobility are required to locate and colonise plant roots out of the soil and possibly to colonise preferred niches in the developing root protoxylem (Yao and Allen 2006).

*Striga* attack graminaceous crops such as maize, sorghum, pearl millet, finger millet, upland rice and sugarcane across Africa. Effective control of *S. hermonthica* will require that the biological control agents greatly stimulate suicidal germination. *Striga* suicidal germination connotes *Striga* seeds are stimulated to germinate without the means to survive (nutrient and water) hence they die. *Azospirillum brasilense* suspended in chemical germination stimulant (GR24) caused *Striga hermonthica* seed germination to abort by not allowing the lengthening of the emerged radicles (Miche et al., 2000). None of the methods available can by itself effectively controls *S. hermonthica*. Since *S. hermonthica* plants

are very prolific, producing large numbers of minuscule seeds that are easily spread to other locations, effort to reduce *S. hermonthica* damage to crop plants in the field can only be achieved through the integration of various methods in a package.

The composition of the microbial association on the root surface can be modified by the introduction of bacterial cells on the surface of seed, roots or tubers. The introduced microorganisms should be capable of surviving and proliferating in the plant rhizosphere (zone where interactions between soil, microorganisms and plants take place), throughout the whole period of growth or, at least a decisive part thereof (Hynes et al., 2008). Certain parts of the microbial population colonizing the root surface are bacteria of the genus *Pseudomonas*. Plant growth promoting rhizosphere bacteria possess a number of physiological properties, which are important to colonization of the surface of plant roots and enhancing the growth and health of plants.

Biofertilizers or “Microbial inoculants” are preparations containing microbial cells ready for application to seed, soil or composting areas with the objective of increasing the numbers of such microorganisms, and to accelerate certain microbial processes to augment the extent of the availability of nutrients, in a form that can be easily assimilated by plants. Microbial cells are introduced to the target plant or location by drench application (Babalola et al., 2007a) and seed bacterization (Babalola et al., 2007b; Kumar et al., 2009). Also documented are seedling treatment (Babalola et al., 2007b), bioformulation, biopreparation and dual treatment (Lavania et al., 2006).

Plant pathogenic bacteria offer unique potential in the field of biological weed control because of their ease of culture and small size (Zidack and Quimby 2002). Biological control agents are known to be less effective and more inconsistent than chemical pesticides, and these shortcomings have been attributed to the failure of the inoculant to become established and/or to express antagonism in soil (Roberts and Lohrke 2003). The signaling molecules for Gram-negative bacteria are named autoinducers, usually acylated homoserine lactones (AHLs). The Gram-positive bacteria use peptide-signaling molecules for quorum sensing. At a particular population density, bacteria exert a concerted action; the signals activate transcription factors that induce specific genes in the bacteria. An example of rhizobacteria that utilize AHL signals to regulate the expression of traits important in plant-

microbe interaction is *P. syringae* (Shepherd and Lindow 2009; Taguchi et al., 2010). The activity of biological control agents is influenced profoundly by extrinsic factors of the environment and this explains, in part, why biological activities are more erratic in disease control than chemicals in some systems. Understanding the effect of bacteria application methods to host crop seeds is a necessity to improving effectiveness of targeted biological control by bacterial treatment. Should this be lacking, it shall constitute additional constraint to biological control delivery methods. *Pseudomonas syringae* pv. glycinea strains 16/83, 19/84, and 8/83 are used as a means to stimulate germination of *S. hermonthica* seeds because they produce ethylene. Although ethylene is involved in the regulation of numerous physiological processes in plants, it is also produced by PGPR (Babalola 2010).

The bulk of reports on *S. hermonthica* control did not evaluate bacteria application methods. Neither was there any critical study on Maize or Sorghum as an entity to this effect, nor was there any bacteria application manipulation method to reduce the long-standing weed problem to a non-economic level. Since there are numerous interactions in a non-sterile (natural) soil, and various indigenous bacterial populations are therein, the study extends to using sterile soil inoculated with known bacteria application method on *S. hermonthica* infested plant. The objectives are therefore to determine the consequences of bacteria application methods to cereal crop as a measure to reduce *S. hermonthica* debilitating effects and to evaluate the effects of the *P. syringae* pv. glycinea strains 16/83, 19/84, and 8/83 on host plants.

## 2. Material and Methods

**Sterilization of glassware and other materials.** All glassware used in this study were washed in detergent and rinsed in sterile water. Powdered vermiculite was wrapped with aluminium foil and sterilized in the autoclave at 121°C for 15 min. Deionised water was dispensed into conical flasks, the mouth plugged with non-absorbent cotton wool, and wrapped with aluminium foil before sterilization in the autoclave. Soil pasteurization was done at 100°C for 4 h in Lindig (boiler) machine (Model SF Burner, MP1192, R.W. Beckett Corp. Elyria, Ohio, U.S.A.).

**Media preparation, sterilization and growth conditions of *Pseudomonad* isolates.** *Pseudomonas syringae* 16/83, *P. syringae* 19/84 and

*P. syringae* 8/83 were kindly provided by Dr DK Berner (USDA). All bacterial isolates were grown at 28°C in King's medium B (KB medium). The medium was solidified with 1.5% agar (BDH Laboratory supplies). The flasks were then sterilized at 121°C for 15 min. in the autoclave. These were transferred to the laminar flow hood (ENVIRCO, Environmental Air Control, Inc.) where the agar medium was poured into sterile Petri dishes and allowed to set. Inoculation was done in a sterile environment in the laminar flow hood. Stock cultures of all isolates were kept at -80°C in 35% glycerol. Cultures on solid media were stored at 4°C until use. Cells of isolates were prepared for either root dip or seed pellet by growing in KB broth for 48 h (25°C, 180 rpm). Cells were harvested by centrifugation (20,000 x g, 4°C, 10 min.), washed twice with sterile distilled water. Bacterial suspensions in 20 ml of 0.1 M (pH 7.0) sterile phosphate buffer were adjusted to give a cell density of approximately  $1.4 \times 10^6$  colony forming units (cfu)/ml.

**Seed pelleting.** Seeds of Maize (var. 8338-1) and Sorghum (var. CK60B and Mokwa local) were treated with *P. syringae* strains by coating with a mixture of 24 h grown bacterial cells ( $10^6$  cfu/ml) that were suspended in 1% methylcellulose (MC). Finely ground vermiculite was sterilized and added to freshly inoculated wet seeds in a beaker and mixed rapidly for 2 min. until seeds are evenly coated. The coated seeds appear as off-white tablets and were allowed to harden overnight by spreading on a clean surface prior to sowing in a pasteurized potted soil (4 kg) infested with *S. hermonthica* (~3,000 seeds /pots). Other batches of seeds were coated with a mixture, which did not contain bacterial cells (MC + powdered vermiculite) this served as control.

**Root dip.** Maize and Sorghum seeds were pregerminated for 3 days at 27°C in the incubator (Gallenkamp). The root tips were excised to make entry points for bacteria and they were incubated in bacterial cell suspensions ( $1.4 \times 10^6$  cfu/ml) for 1 h. Seedlings with root tips, which did not receive bacterial treatment served as control.

**Pot experiments.** Planting was done in greenhouse soil infested with 3,000 germinable *S. hermonthica* seeds per 4 kg potted soil. The experimental site was at the International Institute of Tropical Agriculture (IITA) Ibadan in Oyo State (Latitude 7° 43'N longitude 3° 9'E), Nigeria. The test crops were susceptible Maize (8338-1) and Sorghum varieties (CK60B and Mokwa local). After bacterial treatment, the inoculum-coated seeds or seedlings

were placed 5 mm below the surface of the *S. hermonthica*-infested soil in each pot. Host plants were thinned to 1 per pot after germination. The plants were kept in a relatively moist condition at approximately water-holding capacity by watering daily to allow the bacteria to thrive.

**Statistical analysis.** The pots were left in the screenhouse under the ambient environmental conditions in Ibadan, Nigeria. The pots were arranged in completely randomized blocks. Each treatment was designed with five replicate. Each data point represents mean for a treatment. Date to first emergence of *S. hermonthica* and plant growth parameters were obtained and subjected to analysis of variance (ANOVA). T-test was done to compare seed pellet to root dip method. All statistical analyses were carried out using SAS statistical package (SAS 2003).

### 3. Results

The experiment performed was on the incidence of *S. hermonthica* infection in Sorghum (var. CK60B) grown from seed treated with *P. syringae* pv. *glycinea* strains 16/83, 19/84 and 8/83 using two different application methods (Table 1). To investigate the possible difference due to seed inoculation by root dip and pelleting methods the emergence of *S. hermonthica* from pots were determined (Figs 1 and 2). *S. hermonthica* did not start to emerge until 29 days after planting (DAP) (Table 1). The values which range from 29 days to 35 days (both from root dip treatment) did not differ significantly between the two methods of seed inoculation, based on means separation by a General Linear Models Procedure. The data trend was that the root dip and the pelleted bacteria application method tend not to be very different although some differences occur among other discrete dependent variables examined.

Table 2 presents the effect of *P. syringae* 16/83, *P. syringae* 19/84 and *P. syringae* 8/83 applied either by seed pelleting or dipping cut roots in bacterial suspension, on host plant height, and stover dry weight in Sorghum (varieties, CK60B and Mokwa local). For *P. syringae* 16/83, the pelleted treatment gave a higher height for CK60B and Mokwa local over the root dip treatment. This was also the apparent trend of the differences in the treatment types of *P. syringae* 19/84 among the Sorghum varieties used in this study. *P. syringae* 8/83 evidently resulted in higher heights for the root



dip treatment over the seed pelleting treatment types among Sorghum varieties. The differences were not statistically significant at 5% level of probability. Throughout the entire experimental period, application of bacteria by root dip or seed pelleting method in Sorghum (varieties CK60B and Mokwa local) demonstrated greater height for all the three bacteria over the non-inoculated control with ~6.82 cm in CK60B and ~6.72 cm in Mokwa local (Table 2). For CK60B, average stover dry weight in the control was the lowest (0.71 g/plant). The bacterial treatment improves stover dry weight (2.88 g/plant) of var. CK60B. Similar experiment with var. Mokwa local showed no appreciable difference between non-inoculated control and the bacterial treated Mokwa local.

Maize seeds (8338-1) coated with *P. syringae* either 16/83 or 19/84 grew to a height significantly ( $P < 0.05$ ) different from those subjected to root dip application (Table 3). The significant increase in Maize height was not observed in Maize coated with *P. syringae* 8/83 (Table 3). Average stover dry weights, root fresh weights and root lengths for each of the bacteria application method do not significantly differ among bacterial strain but differs between inoculated and non-inoculated water check. *P. syringae* 16/83 and *P. syringae* 19/84 substantially improved the dry weight. Differences occurred among treatments for stover dry weight (Table 3). All the 3 isolates improved stover dry weight (2.5g/pot) over the non-inoculated control on the Maize host. For 8338-1 variety in the control experiment the pelleted treatment gave increased dry weight compared to the root dip treatment. A similar trend was observed in *P. syringae* 16/83 and *P. syringae* 19/84. The important point of the data (Table 3) is that plant heights of the control and treatments are not significantly different.

For the effect of soil pasteurization on rhizosphere bacteria competence in *S. hermonthica*-infested soil, *S. hermonthica* infection indices were significantly different between plants grown in steam pasteurized soil and those grown in natural soil (Table 4). The results revealed that plants grown in natural soil had lower number of days to first *S. hermonthica* emergence (~11 days earlier) than those in pasteurized soil (Table 4). There was generally an increase in *S. hermonthica* count (26 shoot/pot, in pots where dieback of *S. hermonthica* did not exceed emergence) with increase in number of WAP for most of the pots. The numbers of *S. hermonthica* stems at 3 WAP and subsequently were greater in natural soils as compared to those in pasteurized soil.

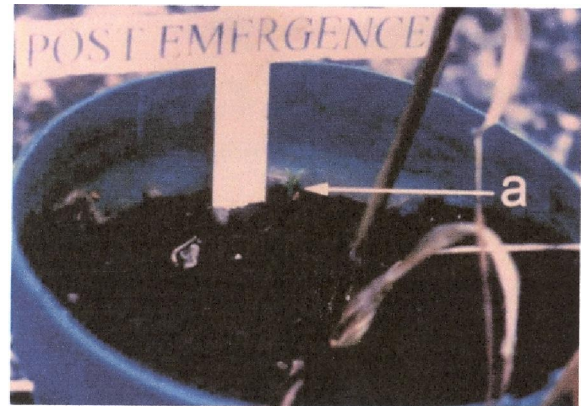


Figure 1. Potted maize plant showing newly emerged *S. hermonthica*

a= *S. hermonthica* 3 days after emergence



Figure 2. Photograph of washed root showing underground portion of host plant root and above ground *S. hermonthica*. (a) Above ground portion of *Striga* (3 days after emergence), leaves already turned green. (b) Underground portion of host plant root (magnification = X0.5).

#### 4. Discussions

The quantity of *S. hermonthica* used for the infestation was not treated as an experimental variable and so all through the experiments 3,000 *S. hermonthica* seeds were used for infestation per pot. The bacteria application analysis gave an insight into the possibility of pelleted treatment being more efficacious for suicidal germination than root dip treatment. The most important of all is that the bacteria in both pelleted and root dip application

systems were efficacious. It occurred in all that overtime the bacteria efficacy declines. The inconsistency of the results which has been ascribed to poor colonization of the roots by plant growth promoting rhizobacteria (PGPR) as a result of environmental effects (Roberts and Lohrke 2003) is a major problem. When two or more research findings are to be compared, the prevailing environmental factor in each experiment must be put into consideration.

If the stimulation for *S. hermonthica* germination is to be optimized then root dip application method will be opted for considering *P. syringae* pv. glycinea 16/83 and 19/84. This study is the first documented evidence that advocate for bacteria application by root dip technique in the suicidal germination of *S. hermonthica*. *P. syringae* pv. glycinea 8/83, 19/84 and 16/83 are however because of their pathogenicity or problems of environmental contamination quite difficult to apply to large-scale agriculture.

This result indicates that the efficacy of future weed control by bacteria is dependent on facilitated host penetration. Among the reference strains (*P. syringae* pv. glycinea 16/83, 8/83. and 19/84), the findings that the inoculated and pelleted method of bacteria application are only significantly different for date to first emergence of *S. hermonthica* and host plant height are very consistent. These studies demonstrate that differences occurred among treatments for seed germination. The effect of microbial application systems may be said to be secondary. This is not surprising as many factors like root fresh weights, root lengths and stover dry weights which were influenced by the presence of bacteria was little affected by bacteria application systems.

In this study (Table 1) *P. syringae* pv. glycinea strains (16/83, 8/83, and 19/84) increased germination rates of *S. hermonthica* tested leading to shorter number of days to *S. hermonthica* emergence. Observed effects are indicative of a common cause related to growth regulators. Among the substances implicated from previous literature are indoleacetic acid (e.g. Patten and Glick 2002) and ethylene (Babalola et al., 2007b). Although the work of Berner et al. (1999) was laboratory based, the result obtained from the bacterial strains on the percent *S. hermonthica* seed germination clearly agrees with this study. The *Pseudomonas syringae* pv. glycinea strains stimulated, on average, more germination of *Striga aspera*, *Striga gesneroides* and *S.*

*hermonthica* seeds than did direct application of ethylene gas (Berner et al., 1999); their efficacy is the fundamental premise for their application for use in this study. As suggested by Cook (2000) the inconsistencies in the efficacy of biological control may be due to the use of a single strain of the agent.

Among the *P. syringae* pv. glycinea strains the findings were consistent that the root dip and pelleted methods of bacteria application were only significantly different in number of days to *S. hermonthica* emergence and host plant height. It was observed that Mokwa local does not usually support the trend observed for CK60B and Maize in relation to mean *S. hermonthica* count (Table 4).

The objective of the comparison analysed was to explain discrete dependant variables important in biological control decisions whether to adopt the factors in treating the bacterial strains, host plants, and the flowering parasitic plant. A likely conclusive measure is that at crop level, host plant seeds coated with vermiculite formulated with methylcellulose and incorporated with the bacteria (pelleted treatment) and cut root dipped in bacterial suspension (root dip treatment) have different efficacy factors. If stimulation is to be optimized then root dip bacterial seed treatment will be opted for considering *P. syringae* 16/83 and 19/84. Specifically Ahonsi (2000) provides the first detailed report of investigation on the possible use of soil-borne bacteria for *S. hermonthica* control through inhibition of *S. hermonthica* seed germination in the soil. However, this study is the first documented evidence to confirm that the treatment of host plant seedlings by root dipping in bacterial suspension stimulates the germination of *S. hermonthica*. *P. syringae* 8/83, 19/84 and 16/83 are, however, quite difficult to apply in large-scale agriculture because of their pathogenicity on soybean and problems of environmental contamination.

Observation in this study confirms the reports of Aflakpui et al. (2002) that the parasitized plants had more root biomass and hence a higher root: shoot ratio than non-infested controls. In this work, essentially, it was noted that further studies on modifying inoculum formulation needs to be examined to improve on the rhizosphere competence of the bacteria. According to Kim et al. (1996), populations of indigenous fluorescent pseudomonads were also significantly ( $p < 0.05$ ) greater under modified soil atmospheres than under the ambient atmosphere. These results, according to them, suggest that the reported inconsistency in biological control

activity of several rhizosphere bacteria may in part be due to the effect of soil atmosphere composition on the ability of these bacteria to establish in the rhizosphere (Roberts and Lohrke 2003). Results from this work clearly indicate that plants with pelleted seed show longer days to *S. hermonthica* emergence than the root dip treatments. This late emergence may be due to the effect of the binder and solid filler employed: the layer of these may probably be a limiting factor. The fact that replicates of pots with the same treatment structure had different days for their *S. hermonthica* emergence indicates that various factors influence days to emergence. In this research

it is shown that the effect of bacteria application method differs considerably between bacteria species, each having a characteristic biotic potential.

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Table 1. Effect of method of bacterial seed inoculation on *S. hermonthica* emergence<sup>x</sup> in Sorghum variety CK60B

<i>P. syringae</i> pv. <i>glycinea</i> strain	Application method	Date to emergence of first <i>S. hermonthica</i> (days)
Control	Root dip <sup>y</sup>	35.11
	Seed pellet <sup>z</sup>	34.04
	LSD (0.05)	3.2
16/83	Root dip	34.00
	Seed pellet	34.00
	LSD (0.05)	11.2
19/84	Root dip	29.00
	Seed pellet	33.80
	LSD (0.05)	11.3
8/83	Root dip	32.00
	Seed pellet	34.67
	LSD (0.05)	9.1

<sup>x</sup>Mean separation within columns according to General Linear Models Procedure (P = 0.05).

Data are means of twenty four to thirty replicates

<sup>y</sup>Sorghum seeds were pregerminated for 3 days at 27°C; excised root tips were incubated in bacterial cell suspension (10<sup>6</sup> cfu/ml) for 1 h

<sup>z</sup>Sorghum seeds were coated with a mixture of bacterial cells suspended in 1% methylcellulose formulated with powdered vermiculite

Table 2. Effect of bacteria application methods on host plant height and stover dry weight on Sorghum in *S. hermonthica* infested potted soil.

Sorghum variety	<i>P. syringae</i> glycinea strain	pv.	Application method	Plant height (cm) at 9 WAP	Stover dry weight (g/plant)
CK60B	Control		Root dip <sup>x</sup>	14.85	0.59
			Seed pellet <sup>y</sup>	15.60	0.71
			LSD (0.05)	2.60	0.30
	16/83		Root dip	19.60	2.78
			Seed pellet	25.00	2.88
			LSD (0.05)	10.30	1.30
	19/84		Root dip	21.80	2.31
			Seed pellet	24.67	2.13
			LSD (0.05)	7.50	1.60
	8/83		Root dip	21.00	2.83
			Seed pellet	20.20	1.77
			LSD (0.05)	3.70	1.00
Mokwa local	Control		Root dip	20.2	3.20
			Seed pellet	17.0	3.58
			LSD (0.05)	5.20	1.75
	16/83		Root dip	22.80	3.53
			Seed pellet	29.53	1.53
			LSD (0.05)	7.46	2.48
	19/84		Root dip	22.73	2.68
			Seed pellet	24.13	2.37
			LSD (0.05)	7.54	1.25
	8/83		Root dip	27.47	4.13
			Seed pellet	25.27	2.63
			LSD (0.05)	6.12	1.29

The results are means of five replicates; <sup>x</sup>Root dip = a 3-day pregerminated cut root dipped in bacterial suspension

<sup>y</sup>Seed pelleting = seeds were coated with a mixture of bacterial cells suspended in 1% methylcellulose formulated with powdered vermiculite.



Table 3. Effect of bacteria application methods on Maize (8338-1) parameters in *S. hermonthica* infested potted soil

<i>P. syringae</i> pv. glycinea	Application method	Plant height (cm)	Stover weight (g)	dry weight (g)	Root weight (g)	fresh weight (g)	Root length (cm)
Control	Root dip <sup>x</sup>	32.00	3.20	32.00	41.6		
	Seed pellet <sup>y</sup>	33.36	3.40	30.64	43.58		
	LSD (0.05)	±8.50	±2.86	±31.43	±41.43		
16/83	Root dip	22.4	3.7	22.40	38.40		
	Seed pellet	39.00	4.8	35.20	35.20		
	LSD (0.05)	±21.40	±3.20	±28.80	±9.60		
19/84	Root dip	27.23	3.40	14.64	37.11		
	Seed pellet	44.21	4.18	22.13	34.04		
	LSD (0.05)	±10.21	±2.8	±11.92	±12.94		
8/83	Root dip	35.71	5.74	42.86	42.86		
	Seed pellet	32.85	4.29	37.14	35.71		
	LSD (0.05)	±7.14	±2.86	±22.86	±7.14		

The results are means of five replicates; <sup>x</sup>Root dip = a 3-day pregerminated cut root dipped in bacterial suspension

<sup>y</sup>Pelleting = seeds were coated with a mixture of bacterial cells suspended in 1% methylcellulose formulated with powdered vermiculite.

Table 4. Effect of soil pasteurization on *P. syringae* competence in *S. hermonthica* infested soil planted with either Maize or Sorghum

Soil treatment type	Source crop	<i>S. hermonthica</i> infection indices						
		No. of days to <i>Striga</i> emergence	<sup>x</sup> Count	Count	Count	Count	Count	<i>Striga</i> Emergence count mean
			3	4	5	6	7	
			WAP <sup>y</sup>	WAP	WAP	WAP	WAP	
Pasteurised	CK60B	31.67	2.9	5.3	8.2	13.0	18.9	9.66
	Mokwa local	35.83	2.3	3.3	7.0	15.5	26.0	10.82
	8338-1	36.33	2.3	3.3	3.7	3.3	5.7	3.66
	SE		±0.17	±0.17	±0.15	±0.09	±0.05	
Natural	CK60B	22.77	5.4	12.1	18.0	23.8	20.9	16.04
	Mokwa local	26.67	3.32	4.5	5.2	4.2	6.5	4.74
	8338-1	23.87	6.13	10.0	14.2	17.0	17.9	13.05
	SE		±0.25	±0.22	±0.18	±0.16	±0.12	

<sup>x</sup>All counts were made as *S. hermonthica* shoot/pot; <sup>y</sup>WAP = Weeks after planting

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## Determinants Of Loan Repayment And Bank Loan Default Among Small Scale Farmers In North West Province, South Africa

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**Abstract:** The study examined the factors which influence loan default among small scale farmers in North-West Province, South Africa. It specifically identifies socio-economic characteristics of the responded and quantitatively determines some socio-economic characteristics of farmers that influence the level of loan defaults. A simple random technique was used to select 160 farmers from Molopo, Rustenburg, Lichtenburg, Zeerust, Ganyesa and Kuruman. A structured questionnaire was developed based on the study objective and related literature to collect data which were analyzed using frequency count, percentages and multiple regression analysis. The result shows that farmers had a mean age of 58.5, and majority had primary education. The mean monthly income among farmers was R831 while the mean monthly was R1403. Significant determinants of loan defaults among farmers were educational level ( $t = 3.09$ ), monthly expenditure ( $t = 5.05$ ) amount of loan ( $t = 6.11$ ) financial management scale ( $t = 6.26$ ) and time of loan disbursement. This implies that the significant variables should be giving proper policy considerations in order to improve loan repayment among small scale farmers. [Life Science Journal. 2011;8(S1):11-18] (02) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** small scale farmers, loan default, socio-economic characteristics, South Africa

### Introduction

Delivering productive credit to the rural poor has been a problem-plagued undertaking. Providing low-cost, efficient credit services and prompt recovery are the ideal aims of rural finance. Agricultural credit is expected to play a critical role in agricultural development (Duong and Izumida, 2002). Farm credit has for long been identified as a major input in the development of the agricultural sector. The decline in the contribution of the sector to the economy has been attributed to the lack of a formal national credit policy and paucity of credit institutions, which can assist farmers among other things. The provision of this input is important because credit or loan-able fund (capital) is viewed as more than just another resource such as labour, land, equipment and raw materials as it determines access to all of the resources on which farmers depend (Rahji and Adeoti 2010). Agricultural sector is situated within the framework of the rural economy and the financial markets. A key feature of the sector is the dominance of smallholding farm families, rural households, agricultural households, or farm households. They cultivate less than 5 hectares. Hence, they look insignificant individually but collectively they form the foundation on which the nation's economy rests (Falusi, 1995). Agricultural household models (Singh et al; 1986; Sadoulet and de Janvry, 1995) suggest that farm credit is not only necessitated by the limitation of self-finance, but also

by uncertainty pertaining to the level of farm inputs and output and the time lag between inputs and output (Duong and Izumida, 2002). The farm household is typically located in an environment characterized by a number of market failures. A frequent cause of market failure is limited access to working capital / credit (Duong and Izumida, 2002). According to Swinnen and Gow (1999), access to agricultural credit has been severely constrained in developing countries. This is because of the imperfect and costly information problems encountered in the financial markets. Such problems are known to be particularly important in agriculture (Stiglitz, 1993). Agricultural lending involves giving out of credit (in cash and kind) to small- scale farmers for the purpose of farming. There is no doubt about the crucial roles of credit in economic development. In South Africa the corporations and former Agribank were established to supply credit to the previously disadvantaged small black farmers. Currently, Land Bank serves as the main credit provider to farmers in addition to other commercial banks.

However, agricultural lending is a risky enterprise because repayment of loans can seldom be fully guaranteed. Generally in spite of the importance of loan in agricultural production, its acquisition and repayment are fraught with a number of problems especially in the small holder farming (Awoke, 2004). It is reported in empirical studies that large rate of default has been a perennial problem in most

agricultural credit schemes organized or supported by governments. Most of the defaults arose from poor management procedures, loan diversion and unwillingness to repay loans. For this reason, lenders devise various institutional mechanisms aimed at reducing the risk of loan default (pledging of collateral, third-party credit guarantee, use of credit rating and collection agencies). In the context of providing credit to the rural asset-poor, what is required is institutional innovation that combines prudent and sustainable banking principles with effective screening and monitoring strategies that are not based on physical collateral (such as land).

Several authors (Afolabi 2010, Udoh 2008 and Dayanandan and Weldelessie 2008) have established that credit markets in developing countries work inefficiently due to a number of market imperfections. The literature cites a number of market imperfections which lead to loan default. These imperfections include: Interest rate ceilings usually imposed by the government; monopoly power in credit markets often exercised by informal lenders (Udoh, 2008), large transaction costs incurred by borrowers in applying for loans and moral hazard problems. Also, low repayment performance discourages the lender to promote and extend credit. Thorough investigation of the various aspects of loan default is of great importance both for policy makers and the lending institutions. Ugbomeh et al (2008) noted that credit repayment performance could be influenced by a myriad of factors such as interest rate, unstable prices of agricultural commodities, and the social relations and responsibilities of the borrower.

Currently in the North-West, small and emerging commercial farmers' problems of accessing agricultural credit due to their previous debts which has affected their credit worthiness and as a result

other banks do not accept them. There is high uncertainty of some factors, which may be militating against the performance of these farmers hence, the continual default, which need to be investigated in order to reverse the trend. The main objective of the study is to determine the factors, which influence loan repayment default among small farmers in the North West Province. The specific objectives were to identify the personal characteristics of the farmers, farming enterprises, level of fungibility and to establish relationships between these variables and loan repayment default

## Materials and Methods

The study was conducted in Molopo, Rustenburg, Lichtenburg, Zeerust, Ganyesa and Kuruman villages of the North West Province. The population of the study was all farmers who had accessed agricultural loan from the bank. Simple random sampling was used to select one hundred and sixty respondents around the North West province. A structured questionnaire which designed based on review of the related literature and objectives of the study was used to collect data from the sample. A questionnaire comprised of personal characteristics of farmers, farming enterprises, level of fungibility and loan repayment default. The questionnaire was face validated by Lecturers in the Department of Agricultural Economics and Extension of North-West University. Data collected were analyzed using Statistical Package for Social Sciences (SPSS), with frequency counts, percentages, means, standard deviation and multiple regression analysis. The dependent variable was the amount of loan defaulted by farmers and the independent variables are listed in the model below.

$$Y_i = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 \dots\dots\dots + e_i$$

Where

$Y_j$  Default rate

$a$  represents the intercept

$b_i$  represent regression coefficients

$X_i$  represent explanatory variables

$e_i$  represent the error term

$X_1$  = Age of the respondents

$X_2$  = No. of years at school

$X_3$  = No of children studying

$X_4$  = Total monthly income



$X_5$  = Number of loans granted

$X_6$  = Number of cattle kept

$X_7$  = Financial management skill (possess skills =1 do not = 0)

$X_8$  = Record keeping (Keep farm records = 1 Do not keep farm records = 1)

$X_9$  = Technical support (Receive support = 1 Do not receive support = 0)

$X_{10}$  = Fungibility (fungibility = 1 non-fungibility = 0)

$X_{11}$  = Transaction cost for farmers

$X_{12}$  = Loans (Sufficient = 1 Insufficient = 0)

$X_{13}$  = Time loan was released (Timely = 1 Untimely = 0)

## Results and Discussion

Table 1 presents the personal characteristics of farmers covered in this study

Table 1: Personal characteristics of farmers (n = 160)

Personal characteristics	Description
Age	Mean = 58.5
Educational level	Predominantly standard 4
Monthly income	Mean = R831
Monthly expenditure	Mean = R1403.5
Household size	Mean = 6
Household member employed on the farm	Mean = 58.5
Contribution to household income by working members	Mean = R644
Keeping farm record	Predominantly Yes 84%

The results of the types of land tenure and farming enterprises among farmers were shown in Table 2.

Table 2: Types of land tenure and farming enterprises among farmers

Tenure system	Farming enterprises			Total	Total percentage
	Livestock	Crop	Crop and Livestock	Total	
Own land	30	22	12	64	40
Hired land	2	16	3	21	13.13
State land	0	29	0	29	18.12
Communal land	27	1	18	46	28.75

The results of the types and number of loans among farmers were shown in Table 3.

Table 3: Types and number of loans among farmers (n = 160)

Number of loans	Short term	Medium -term	Long- term
1	42(26)*	65(104)	7(11)
2	6(4)	33(53)	17(27)
3	10(6)	0 (0)	0(0)

\*Figures in parenthesis are percentages

The reasons for loan default among farmers were shown in Table 4.

Table 4: Reasons for loan default among farmers (n = 160)

Reasons	Frequency	Percentages
Poor yield	59	36.9
Drought	37	23.1
Low profit	12	7.3
Poor marketing	3	1.9
High transaction costs	11	6.9
Late disbursement of funds	38	23.8

The results of the multiple regression analysis among farmers were shown in Table 6.

Table 6 Result of multiple regression analysis (n=160)

Variables	Regression Coeff (SE)	t	p
Constant	.130 (2644)	2.033	0.00
Age	.002 ( 10.5927)	-.542	.591
Number of years at school	.004(4.1913)	3.091	.004
Children studying	.024 (1.2388)	-.752	.456

Total monthly expenditure	000 (1917.46 )	5.054	000
Number of loans granted	.033 (0.6934)	6.114	000
Number of animals	.001 (22.26)	.092	.927
Lack of financial management skills	.040 (0.5043)	6.266	000
Lack of record keeping	.057 (0.5492)	6.253	.001
Technical support	.051 (0.4423)	7.119	000
Fungibility	.066 (0.3172)	7.744	000
Transaction costs	0.057 (0.265)	086	.005
Incomplete loans granted	.047 (4960)	7.338	000
Timing of loan disbursement	.049 (4521)	-2.465	.018
F	38.61		
p	0.001		
n	160		
R Square	0.95		
Adjusted R	0.89		
Durbin Watson	1.9		

## Discussions

From Table 1, the results indicate that most of the farmers are in the old age category. The average age of the respondents is 58.54 with the highest and lowest age being 77 and 30 years respectively. This scenario poses a challenge to the stakeholders in agriculture specifically the succession plan to these elderly people when they leave agriculture due to retirement. It also has direct effect on the repayment rate or farmers default rate and their efficiency in farming because of their inabilities to manage funds and to be productive as the following Table 1 also highlight low educational level (average years in school is three, which is equivalent to standard one). Literacy and numeracy are the prerequisite to modern farming. The household average monthly income is

R832.12 with the lowest and highest been R200 and R5000 respectively. The results show that the respondents incur more expenditure than their total monthly income. The households' monthly average expenditure is R1403.46 with the lowest expenditure being R200.00 and the highest being R1621.20. Table 1 reflects the average number of household members to be five with the largest households having twelve members. About 77% of the households have at least two members who are employed and who can supplement the respondent's expenditure by at least R644.71 on average. In a study that identified socio-economic characteristics of the respondents and quantitatively determined some socio-economic characteristics of farmers that influence their level of loan repayments in Oyo state Nigeria, Afolabi (2010) noted that 60.23% of the respondents were more than

50 years old; 83.92% operated 4.9 hectares or less as farmland; and 17.83% obtained their loans from formal sources.

The results show that 69% cannot keep record for their production due to high illiteracy level. It is believed that the higher the educational level, the higher the chances that the farmers may keep farm records. This is in line with the finding of Adam and Vogel (1986) that stress literacy and numeracy as a prerequisite for modern agriculture. Some of the respondents with standard ten did not keep records this can be attributed to low technical assistance either from the extension officers or the bank officials. From all respondents who indicated that they keep records it was found that none of them keep formal records, they either keep their records in the middle of production or after harvesting time when they are preparing for the market. Farmers should have a complete annual inventory of assets and liabilities, a complete listing and description of income and expenses, a summary of cash-flow analysis of each enterprise.

It was discovered that only 40% of the respondents have their own land (Table 2). Out of these 40%, thirty respondents practice animal production, twenty-two respondents practice crop production and only twelve respondents indicated that they practice both productions. Under hired land, 13.13% tenureship was discovered in the study area, of these two farmers practice animal production, sixteen respondents practice animal production and only three respondents practice both productions. State land is mainly used for crop production as indicated in Table 4.2 that 18.12% respondents are using state land. Almost twenty nine percent of the respondents are using communal land for their production, of which twenty-seven respondents are involved in livestock production. Only one respondent indicate that he is using State land for crop production only and eighteen respondents show that they are using state land for both productions. There are different types of loans offered by the different banks for farmer's assistance. Number of loans taken by farmers varies from one to three. Most of them were offered medium term loans (98%). From the category of medium term loans 65% of the respondents have only one loan offered to them and 33% of the respondents have two loans offered to them. Number of loans offered to a farmer has a direct impact on loan repayment because they are required to settle installments with different banks at different times, and when taking into consideration the commitment that the emerging farmers are confined within, it is

difficult for them to manage their cash-flow and thus causes farmers to default (Afolabi 2010).

The result shows that 96% of farmers defaulted irrespective of the number of loans they received. Only four percent of the respondents never defaulted in their repayments. Most of the respondents (36.88%) defaulted because of poor production, 23.13% defaulted because of drought and 7.3% percent of respondents default because they did not have profit in their production. Late disbursement of funds by financial institutions appears to be the second important reason, which caused the default of farmers in the study area. One can conclude that the number of loans taken by farmers has no bearing to default. Above stated factors are also highlighted by Donald et al., 1976 as the factors of concern when coming to farmers default. Afolabi (2010) reported that in Oyo state Nigeria, 3.85% of the respondents attributed crop failure as the reason for their inability to repay their loan as at when due while 46.79% claimed that family commitment was their problem. About 17.31% and 32.05% of them said that untimely disbursement of loan and high cost of production was their major difficulty in meeting their loan obligations. High level of crop failure among the respondents would translate to lower level of income and hence high incidence of loan default. Increased expenses to meet family needs would reduce the level of income available to meet loan obligation. Untimely disbursement of loan can negatively affect loan repayment because agricultural production is time specific. So, instead of utilizing the loan for agricultural purposes, farmers may divert the loan because it did not coincide with the time they need it for agricultural production. High cost of production can make agricultural ventures less profitable and hence negatively affect the borrowers' loan repayment capacity.

### **Determinants of loan default**

The regression estimates of the relationship between dependent variable and predictors were determined. Eleven predictors were used and nine predictors had statistical significant impact on the amount of loan repaid by the farmers. Significant predictors were: number of years at school ( $p=0.01$ ), total monthly expenditure, number of loans, possession of financial management skills, technical support received by farmers, fungibility, have incomplete loan, and loan offered in time ( $p=0.00$ ). These variables are supported by the value of F-statistics, which is 38.61 that, shows significant relationship between the dependent variable and the predictors. The value of  $R^2$  is 0.954 and adjusted  $R^2$  is

0.886. This means that the predictor's account for 88.6% change in the default rate of the respondents and 11.4% is accounted for by other unknown factors, which are not included in the model. Durban- Watson value is 1.9, which indicates that there is no auto-correlation between the variables.

The number of years at school shows a significant impact on default rate of the respondents. This suggests that one unit increase in number of years at school will decrease the default rate of respondents by 21.6 % when other factors are held constant. It then implies that if literacy level of farmers can be improved, their management can also improve and they might be able to repay their loans. The results indicate that a unit increases in the farmers total monthly expenditure will results in 33.7% increase in the loan default rate when other factors are held constant. This suggests that when farmers are faced with more monthly expenditures, they use loan funds to cover their financial obligations. A unit increase in the number of loans received by a respondent will result in 52.5% increase in default rate with other factors held constant. This implies that when farmers are given more loans they default, as they are unable to repay multiple premiums as stated in their loan contracts. The major problem might be low production from their enterprises and some of the loan funds are not used in the manner that they will generate income. This might also suggest that loans are divided to cater for production and household needs for which the loan is not meant for (fungibility).

A unit increase in the lack of financial management skills of the farmers will increase default rate of respondents by 47.5% other factors held constant. The current situation shows that farmers lack financial management skills and their production is very low. Therefore, to assist them from defaulting, one should consider financial management skills as the priority in their production. This is in line with the findings by Duong and Izumda (2002) which shows that understanding of financial management will generate a continuous flow of information concerning the farm profitability, liquidity and reducing default risk and provision of a basis for forward planning.

Lack of technical assistance from either the banks officials or extension officers causes the default rate to increase by 61 %. This suggests that the farmers might have not received proper assistance from relevant stakeholders. A unit increase in fungibility will cause respondents default rate to increase by 61.2% with other factors held constant. It is confirmed in the literature by Rahji and Adeoti

(2010) that loans are sometimes given for unrealistic expected outcomes and sometimes are used for the purpose not applied for by farmers.

The results show that a unit increases in transaction costs will increase farmer's default rate by 59.2% with other factors held constant. This suggests that the transaction costs incurred by the respondents are very high which can be attributed to the distance coupled with frequent traveling of farmers to the bank to inquire about their applications and also poor communication between financial institutions and the respondents. The study done by Udoh (2008) showed that the transaction cost of borrowing constitutes serious impediment to the acquisition of the credit and they have advocated to cost-reducing policy innovation in agriculture lending. Most of respondents are been given insufficient loans as highlighted by the results due to different reasons provided by financial institutions. The regression result shows that a unit increase in granting of incomplete loans will cause the default rate to increase by 65.30%. This is the highest significant level shown by the regression results and it suggests that farmers need to be assisted with the adjustment of business plan if the loans required have been reduced. Dayanandan and Weldelessie (2008) indicated that the amount of credit, educational status, experience in credit utilization, off-farm and non-farm income, follow-up and the repayment period and livestock ownership were the significant determinants of loan repayment among farmers in Northern Ethiopia.

The study has clearly shown that majority of small scale farmers in North West province of South Africa farmers were at least 50 years old had low formal education, and earn less than R1000.00 as monthly income. In terms of land tenure system, most farmers cultivate their personal land holding and had accessed loans for at least once for a medium term period. The most prominent reasons for loan default is poor yield and late disbursement of funds Significant determinants of loan defaults among farmers were educational level ( $t= 3.09$ ), monthly expenditure ( $t = 5.05$ ) amount of loan ( $t = 6.11$ ) financial management scale ( $t= 6.26$ ) and time of loan disbursement.

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**Postural analysis of risk of neck and low back pain of adolescents in a high school in Pretoria, South Africa**Useh U<sup>1</sup>, Kotsokoane F<sup>2</sup>, M, Masenya L.P.<sup>2</sup><sup>1</sup> School of Environmental and Health Sciences, North West University, Mafikeng Campus Email: [22839968@nwu.ac.za](mailto:22839968@nwu.ac.za) or [efeuseh@gmail.com](mailto:efeuseh@gmail.com)<sup>2</sup> Physiotherapy Department, University of Limpopo, Medunsa Campus, P.O. 239, Medunsa 204, Pretoria.

**Abstract:** The risk of developing back and neck pain was investigated amongst 84 learners in a high school in Pretoria, South Africa. The design of this study was a cross sectional descriptive study. Ninety percent of the participants reported a high risk of developing neck pain. The findings of the study revealed that there is a high risk of back pain at age 14 (100%), with females (94%) at higher risk than their male (84%) counterparts. There was a significant association between age and risk of back pain ( $p = 0.019$ ). No significant association between neck pain and age, gender, and hand dominance ( $p = 0.670$ ;  $p = 0.286$ ;  $p = 0.542$  respectively), upper back pain and age, gender and hand dominance ( $p = 0.904$ ;  $p = 0.608$ ;  $p = 0.500$  respectively), and lower back pain and age, gender and hand dominance ( $p = 0.176$ ;  $p = 0.473$ ;  $p = 0.675$  respectively). The prevalence of neck pain was found to be 35%. [Life Science Journal. 2011;8(S1):19-23] (03) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Postural analysis; Back pain; Adolescents, Ergonomics, School furniture; Seating designs

**Introduction**

A high rate of musculoskeletal injuries of the spine resulting from poor posture had been documented (Jacobs & Baker 2002; Watson et al, 2002; Oyewole, Haight and Freivald 2010). The position that is mostly implicated in carrying out daily task is the sitting posture. Sitting puts a lot of burden on the ligaments of the back and if sustained for a long time in a poor posture could result in pain. Schoberth (1962), defines sitting as a position in which the weight of the body is transferred to a supporting area, mainly the ischial tuberosities of the pelvis and their surrounding soft tissues. Watson et al (2002), strongly linked sitting to back pain in children and adolescents. According to Jacobs and Baker (2002), correct sitting posture in which the individual is positioned at 90-degree knee flexion, and 90-degree elbow flexion, with an erect back and erect head, is a myth that may have caused some harm. Rapid Upper Limb Assessment (RULA) tool is used to assess the risk of back pain (McAtmney & Corlett, 1993). Evaluation of the risk of injury is important in prevention, therapy and rehabilitation of patient following injuries.

Apart from sitting in incorrect posture at school for prolonged periods of time, school children continue to sit during their free time without taking part in any physical activities, therefore leading sedentary, inactive lifestyles that can predispose learners to back and occasional neck pain. According

to Cardon (2004), prolonged sitting increases disc pressures, resulting in decreased nutrition to the disc. Cardon (2004) also reported that learners spent an average of 97% of the lesson time sitting, from which one-third with the trunk bent over 45°. In a study to evaluate sitting time amongst learners, Hensen (1994) found that in one school, children remained seated between 19 and 90 minutes during a 90-minute double lesson. This puts strain on the neck and back region.

Back pain along gender lines had been documented with no particular trend (Troussier et al, 1994; Grimmer and Williams 2002). Burton (1996), observed that back pain was more common in boys than in girls, especially by age 15 years. Saarni (2007) found that the prevalence of back pain was similar in both sexes, but became higher in males than in females by age 15. Wedderkopp and Anderson (2001); Watson et al (2002), supports the evidence that back pain increases with age and interferes with school work (Salminen, 1992). In some cases, back pain was lead to various forms of disabilities. According to Panayiotopoulos et al (2004) a large portion of adult sufferers reports their first onset of back pain in their early teenage years or in their twenties. The recognition of the symptoms of back pain at an early stage provides the opportunity for remedial action and possible prevention of disablement.

Troussier et al (1994) opines that many of the children experienced back pain while sitting in class for longer than one hour with school furniture that of inappropriate sizes. The pressure exerted on the vertebrae and the vertebral disks is considerably higher than in standing position and this is a dangerous factor that can lead to the development of spinal complaints (Cranz 2000). Until recently, the design of sitting furniture for children has received little or no interest (Oyewole, Haight and Freivald 2010). Most school sitting furniture in use does not meet the ergonomic requirements that would promote the correct sitting posture (Yeats 1997). That is why school children, who for years spend several hours a day sitting, are at risk of back pain. This risk is seldom evaluated. This study therefore sought to analyse the sitting postures of learners in a High School in Pretoria, their risk of developing back pain with the RULA tool and the prevalence of neck pain, upper back pain and lower back pain in this population.

## 2. Material and Methods

This study was a quantitative descriptive cross sectional survey design. The population that was studied was high school learners in grades 8, 9, and 10 in a School in Ga-Rankuwa, Pretoria North, of Gauteng Province of South Africa. The statistical package nQuery Advisor version 4 was used to calculate sample size of 134 learners in this study.

### Data collection tools

#### Back pain

An adapted health and lifestyle questionnaire (Nordic Musculoskeletal Disorders Questionnaire - NMDQ) (Kurionka, 1987), was distributed to the learners. The NMDQ was designed to answer the following question: do musculoskeletal troubles occur in a given population, and if so, in what parts of the body are they localized?

#### Posture

A Rapid Upper Limb Assessment (RULA) was used to analyze the posture of the learners during teaching time. The RULA assessment gives a quick and systematic assessment of the postural risks. This method uses diagram of body postures and three scoring tables to provide evaluation of exposure to risk factors.

### Data collection methods

After consent had been obtained from parents, learners were informed of this study. During this period the Nordic Musculoskeletal Disorders Questionnaire was handed to each learner and completed on the same day.

Posture was analyzed through still camera capturing, by one of the researchers (M.L.P), in the classroom while learners were being taught using the Rapid Upper Limb Assessment.

Ethical approval was obtained by the Medunsa Research and Ethics Committee (MREC), of the University of Limpopo, South Africa to conduct the study. Permission from the Department of Education and the school principal were also requested prior to conducting this study.

Consent was sought from all participants with detailed information about the study explained to the learners. An informed consent form was handed to the parents to sign. Learner assent was obtained once the informed consent from the parents had been returned and the participant information had been explained to the learners.

Confidentiality and anonymity was guaranteed; the names of the participants were not disclosed and the information they gave was used for research purposes only. Freedom not to participate and to withdraw at any time from the study was mentioned.

### Data analysis

The data in this study was analyzed using Statistical Package for the Social Sciences (SPSS) version 17. Descriptive statistics of percentages, mean and graphs were used to describe data. While Chi-square statistics was used to analyze risk of developing back pain with the level of significance was  $p < 0.05$ .

POSTURE: was scored based on the RULA action levels according to McAtamny, and Corlette (1993) and Hignett and McAtamney (2000):

**Action level 1:** RULA score 1-2 means that the person is working in the best possible posture with no risk of injury from their work posture (Acceptable).

**Action level 2:** RULA score 3-4 means that the person is working in a posture that could present some risk of injury from their work posture, and this score most likely is the result of one part of the body

being in deviated and awkward position (investigate and change).

**Action level 3:** RULA score 5-6 means that the person is working in poor posture with a risk of injury from their work posture (investigate further and change soon).

**Action level 4:** RULA score 7-8 means that a person is working in the worst posture with an immediate risk of injury from their work posture. (investigate and change immediately)

### 3. Results

Out of the initial estimate of 134 participants in this study, only 84 learners or 63% provided consent to participated in this study

#### RISK ANALYSIS

The risk analysis score of 84 participants revealed that 76 (90%) scored in the high risk category according to the RULA scale, and only 8 (10%) scored in the moderate risk category.

#### PREVALENCE OF BACK PAIN

Prevalence of neck pain was 35% while, only 23% and 14% of the participants reported back pain in the upper back and lower back respectively

#### HAND DOMINANCE AND NECK PAIN

The results of this study revealed no significant association between neck pain and age, gender, and hand dominance ( $p = 0.670$ ;  $p = 0.286$ ;  $p = 0.542$  respectively), upper back pain and age, gender and hand dominance ( $p = 0.904$ ;  $p = 0.608$ ;  $p = 0.500$  respectively), and lower back pain and age, gender and hand dominance ( $p = 0.176$ ;  $p = 0.473$ ;  $p = 0.675$  respectively).

#### Discussions

##### Risk analysis: RULA scores:

It was found that 90% of the learners were working in the high risk postures for the neck, upper back and lower back, therefore placing them at immediate risk of back injury. This high risk had been reported by Watson et al 2002. According to them, low back pain is common in the UK. Most of the time, parents are not aware of this situation and these children seldom report for treatment. This result was similar to those of Murphy (2004), however,

contradicts those of Hartvigsen (2000) who found no conclusive evidence of increased risk in a review of studies investigating sitting while at work as a risk factor for back pain. This difference in results might be due to the different designs and population investigated. While this study investigated the risk of developing back pain amongst adolescents, Hartvigsen was a systematic review.

##### Prevalence of back pain:

The prevalence rate of neck pain amongst learners was 35%. This rate was higher than higher than the 29% found amongst 8 – 17 years old reported by Brattberg and Wickman (1992) but lower than 51% for age 20 reported by Troussier et al. (1994). The reasons for the differences and high variations in the rates across different age group are not very clear. It is clear that the prevalence increases with age. Further investigation for this is therefore recommended. Wedderkop and Anderson (2001) suggested that the three spinal regions should be investigated as separate entities, and indeed, though lower back pain (14%) was reported, neck pain (35%) and upper back pain (23%) were common complaints in this study.

##### Association between risk and age, gender, hand dominance and school hours

The findings of the study reveal that there was a high risk of back pain at age 14 (100%), with the females (94%) at higher risk than the males (84%). This is in concordance with the findings of Watson et al 2002. A significant association between age and risk of back pain ( $p = 0.019$ ) was also found. This result agrees with the results reported by Grimmer (2000) who found in her study that more girls between the ages of 12 and 14 incurred an elevated risk of back pain after prolonged sitting than the boys in the same group.

##### Association between back pain and age, gender, hand dominance and school hours

This study revealed no significant association between neck pain and age, gender, and hand dominance ( $p = 0.670$ ;  $p = 0.286$ ;  $p = 0.542$  respectively), upper back pain and age, gender and hand dominance ( $p = 0.904$ ;  $p = 0.608$ ;  $p = 0.500$  respectively), and lower back pain and age, gender and hand dominance ( $p = 0.176$ ;  $p = 0.473$ ;  $p = 0.675$  respectively). This is contrary to the findings of Salminen (1984) who reported an increased prevalence of spinal pain among girls (24%)

compared with boys (15%) ( $p < 0.05$ ) between the ages of 11 and 17 years. Similar findings were reported by Troussier (1999) who found lower back pain to be more common in girls than in boys (25% versus 15%;  $p < 0.001$ ). These differences might be because of the different study designs that were used in the respective studies.

Based on the results of this study, it is evident that the prevalence of back pain is higher for the neck area (35%) among the studied High School learners from grade 8 to 10. The results also indicate that learners of this High School are working in the worst postures for the necks, upper backs and lower backs, therefore placing them at immediate risk of back injury. This cannot however be generalized to a larger population because of the relative low sample size. Further study with a larger sample size and covering more than one high school is recommended. The high risk of back pain might be related to the design of school furniture.

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## Socio-Economic Benefits of Urban Sprawl in Mafikeng, South Africa

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**Abstract:** The socio-economic impact of urban sprawl has been a major concern around the world. This paper reports the benefits of urban sprawl in Mafikeng, South Africa. Arc Map software was used to evaluate three spatial images of Mafikeng: 1968, 1996 and 2008. Results indicate extension of the Central Business District to the outskirts and an increase in infrastructure development. Additional benefits include growth in professional services and the migration of the service sector from the city centre. These findings have immediate policy and planning implications for urban development. [Life Science Journal. 2011;8(S1):24-28] (04) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Key words:** Central business district; land use planning; road network; air pollution; traffic congestion

### 1. Introduction

The concept of urban sprawl suffers from difficulties in definition since it depends upon the perspective of who presents the definition. Wilson et al. (2003) have argued that the sprawl phenomenon seeks to describe rather than define. Sprawl typically moves away from existing settlement in a “leap-frog” pattern. Urban sprawl often happens very quickly. Widely spaced developments initially occur several kilometres from the central business district (CBD), which later becomes connected by infill development (Robinson 2005). Such an occurrence has several radical consequences. Another key characteristic is low-density land use, where the amount of land consumed per capita is much higher than in more densely populated city areas. It is not simply the increase of urban lands in a given area, but the rate of its increase relative to population growth. One could also argue that sprawl is a pattern and pace of land development in which the rate of land consumed for urban purposes exceeds the rate of population growth for a given area over a specified period. This results in an inefficient and consumptive use of land and its associated resources.

The impact of urban sprawl is a major concern around the world. In the last one hundred years, human activities have altered the earth's environment mainly through an increase in the global population, which has risen from an estimated

275 million in 1000 to 6.8 billion in 2010 (Worldometers 2010). A significant volume of literature has drawn attention to the negative political, socio-economic and ecological impacts of urban sprawl, such as air pollution, increased traffic congestion, and habitat degradation in areas that are experiencing sprawl. South Africa is no exception to the environmental issues that the world faces concerning urban sprawl. Uncontrolled population growth and increased economic activity are results of the current urban growth problems in South Africa. South Africa is the economic powerhouse of Africa; leading the continent in industrial output, mineral production and generating a large proportion of Africa's electricity. However, in the quest for economic growth, environmental issues are emerging, raising serious concerns. Increased pollution, energy consumption and loss of natural habitat are some of the specific environmental issues pertaining to urban sprawl in South Africa. Major cities such as Johannesburg, Cape Town and Durban have major environmental problems arising from population growth, increased economic activity and intensification of land use practices. Consequently, these activities have led to increased water demand, and degradation of natural resources (Walmsley et al. 2009). Since the late 1960's, Mafikeng has experienced fast urban growth. As an administrative capital of the North West Province, Mafikeng has been attracting people to work mostly in the

government sector. Consequently, there has been generally a greater influx of people into the city leading to the urban areas expanding into the outskirts.

One of the similarities between Mafikeng city and other major cities in South Africa is that the travel patterns are dominated by private automobile use. Mafikeng is a mono-centric type model of a town and it has been shown that when metropolitan areas grow beyond a certain size, a polycentric urban form is more efficient than a compact highly centralized mono-centric form. Centralised cities allow the clustering of land uses to reduce trip lengths and congestion. Environmental concerns in the city often mean more immediate and pressing local issues such as health problems, air pollution, and congestion. Most cities in the world operate in mixed mode. Traditionally the mono-centric city has been the model most widely used to analyse the spatial organization of cities. It has become clear over the years that the structure of many cities depart from the mono-centric model and that many trip-generating activities are spread in clusters over a wide area outside the traditional CBD.

Holcombe (1999) states that urban sprawl nurtures compact commercial development in the form of retail stores, offices and businesses, and this is what a small number of people realize. These newer suburbs provide the society with a whole new set of benefits: comfortable living, flexibility in their area, low door to door travel time, freight-carrying capacity (for businesses/ shopping trips), cheap long-distance travel and the aesthetic benefits of separated land uses. Hence, consumers will have access to shopping malls, which through greater economies of scale, offer lower prices and thus in the long run decreasing the time and energy. Ruddon and Arslanian (2006) stated that transportation increases pollution and congestion in many towns and cities. A common argument about urban sprawl is that it contributes to urban air pollution. However, with new engine technology, motor vehicle emissions have been cut down thus considerably improving the air quality in cities. Since compact cities feature greater congestion and higher commuter time while in sprawled cities there is no congestion, certain global environmental externalities such as greenhouse gas production are likely to be low (Silaban 2002).

Cambridge (2002) summarises these benefits as: transportation investment can improve air quality and energy efficiency, reduce noise pollution,

protect wetlands and safeguard clean water supplies, reduce light pollution, help reclaim brown field and provide a market for recycled material, and provide historic and ecological preservation benefits. Some would view this as an opportunity to lead a better life in larger homes, away from the congested city life. Gordon and Richardson (2001) observed that urban sprawl enables a growing number of people to live according to their desires, as evidently seen in Mafikeng in areas such as Leopard Park and Riviera Park. Opening up ways for the growth of urban sprawl within this city would alleviate congestion of building structures as well as easing traffic. An organised public transportation would help to alleviate the town's crowded network of roads by providing choices.

Ever since the late 1960's, Mafikeng's population growth has been rapid and this has had an impact on the environment and the structuring of the town. The city is located on the 2525 zone on the map grid and between latitude 25°S 40'47" to 25°S 31'32" and longitude 25°E 16'20"; 25°E 51'55". There has been generally a high influx of people into the province leading to the urban areas expanding into the outskirts. Table 1 shows population growth figures for the study area.

Table 1: Population growth in Mafikeng 1993-2010

Years	Mafikeng
<b>1993</b>	158,000
<b>1996</b>	242,193
<b>2001</b>	259,484
<b>2007</b>	290,229
<b>2010</b>	317,248

*Source: Statistics South Africa, 2010*

Urban sprawl in contemporary literature is consistently presented as a negative phenomenon (Downs 1999; Kaur 2008; McElfish 2007; Squires 2002). Hardly any mention is made of its beneficial impacts. It is necessary to enquire into possible benefits as a way of providing new insights on urban sprawl and future urban planning. The purpose of this paper is to investigate urban sprawl in Mafikeng city, identify, and trace specific social and economic benefits. The first is to describe patterns of urban

sprawl in the study area. The second is to quantify the extent of fragmentation of the built up area and lastly to describe changes in population size.

## 2. Materials and Methods

The resource for this study was shapefiles that were downloaded from the internet (Map IT 2009). These shapefiles were exported into ArcMap software. Overlay analysis of spatial data for Mafikeng city since the late 1960's to show spatial extent of growth was done. The overlay analysis involved three stages. Stage 1 dealt with the evaluation of three spatial images of Mafikeng city for 1968, 1996 and 2008. Stages 2 entailed capturing of all patterns of growth using the overlay analysis in Arc Map. In stage three, overall change between the years was detected using the ArcToolBox in ArcMap software. Field observations were carried out to quantify the extent of change in square kilometres and hectares of new land uses while social benefits were derived from observations of shopping patterns at new malls and vehicle traffic density along the Nelson Mandela dual carriage highway.

## 3. Results

The extent of Mafikeng city is determined by the areal distance from the central business district (CBD) to the outskirts. Results show that Mafikeng was 10.33 km<sup>2</sup> in 1968, 47.73 km<sup>2</sup> in 1996 and 75.60 km<sup>2</sup> in 2008 (Figure 1, 2 and 3).

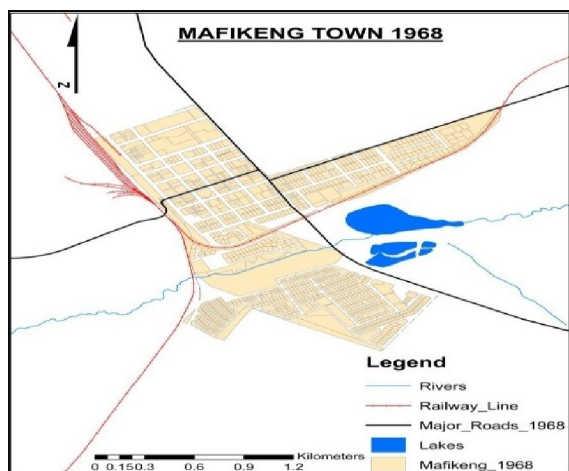


Figure 1: Structure of Mafikeng Town in 1968

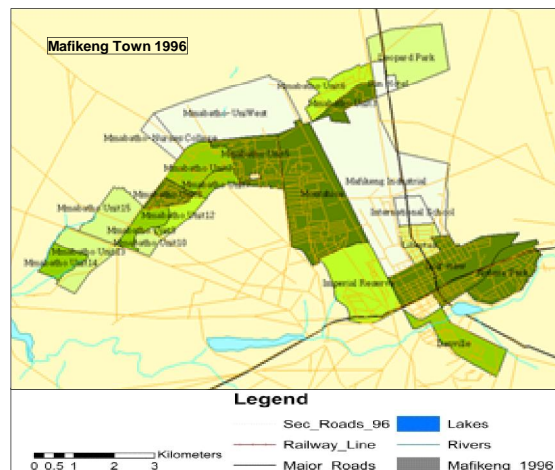


Figure 2: Spatial extent of Mafikeng Town in 1996

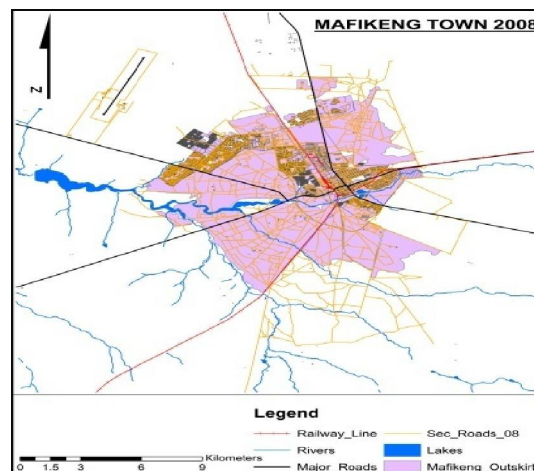


Figure 3: Land Use of Mafikeng City in 2008

The growth of new suburbs- Riviera Park, Lonely Hill, Golf View is a major outcome of urban sprawl. Many of these areas in the outskirts have cheaper land and housing costs compared to urban centres, hence many are lured to settle in this part. Therefore, Mafikeng has experienced increase in public spending for the development of infrastructure such as roads, electricity and water in the emerging suburbs, thus boosting socio-economic development in the respective areas. With the expansion of the Nelson Mandela drive into a two dual carriage highway, this has brought about the connection of inner city with the outer parts, hence bringing the

benefits of urban sprawl. Additional benefits include growth of professional health care services in the suburbs with almost each suburb having a health centre and private clinics with Bophelong Hospital serving as the referral hospital.

Mafikeng has experienced migration of the service sector industry away from the core of the city. Many businesses have been pushed away from the traditional CBD by higher property and business taxes to the suburbs where rent is generally low. The building of the Crossing mall is a response to urban sprawl as well as many other wholesale outlets and motor vehicle dealer. For example, with the emergence of Golf View suburb, a new shopping centre (the Food Zone) has been constructed to serve the residents from this area thereby reducing congestion and pollution in the CBD. Therefore, business locations are more diversified as a result of urban sprawl.

#### 4. Discussions

The expansion of new suburbs has tended to be in those areas with access to the corridor structure of the road network of Mafikeng city. Hence, almost all the new suburbs are situated as residential districts along the road to Zeerust and Ramabantlabama to the north. This has tended to disperse residential districts from the traditional core around the northern edge of the CBD into the outskirts thereby reducing urban housing congestion in the older part of the city. The migration of new middle class housing into the outskirts of the city and the expansion of low income housing to the west and south has meant that urban sprawl is practically encroaching on former farmland and into traditional areas of communal land ownership (Figure 2). This has had a positive effect on land values in the old part of the city and in new areas now settled as a result of urban sprawl- a standpoint that departs from Kaur (2008). Land prices tend to stabilize under these conditions.

The construction of the Nelson Mandela Drive to the north of the city has brought with it immediate benefits. First, it has created a natural link between Mmabatho – the original administrative centre of the former homeland of Bophuthatswana and Mafikeng city allowing the two to merge into a single city. Second, it has created a rapid transit system for the high density low income suburbs to the west and south west of Mafikeng. Third, tribal areas to the north and east of the highway have now a direct access through feeder roads to shopping malls

and chain stores that have been attracted to the former open space between Mafikeng and Mmabatho. Transport developments have lead to the extension of the existing road network and construction of new infrastructure geared to serve a larger urban space due to sprawl has seen immediate benefits in services (Figure 3). Literally all the new suburbs have attracted a wide range of professional and personal services making it possible for residents to save on travel overheads to Mafikeng's CBD. Extension of bulk water and sanitation into these outskirts has seen a general improvement in the health status of households in spite of depressed household incomes since 2007. Access to garbage collection by municipal staff means that such services originally preserved for residential districts round the CBD of the city are now available to a larger segment of the urban population (Mafikeng Local Municipality 2002). These developments are in sharp contrast to the position of McElfish (2007) and Ruddon and Arslanian (2006).

A significant number of businesses in the service and manufacturing sector are migrating to the outskirts where space is in plenty and rent generally low. This has created additional shop flow for the CBD of Mafikeng to concentrate on fast moving consumer goods and specialty stores. This has increased shopping choice and has had an impact on consumer shopping behaviour. In addition, urban sprawl has tended to widen and re-distribute employment opportunities given that formal workplaces are now more diversified than in the past. This has extended benefits in the provision and management of a reliable passenger transport system. This position gets support from the work of Silaban (2002) on sustainable transport development.

In conclusion, urban sprawl has been shown to provide certain benefits that contemporary literature fails to highlight. These benefits have been presented in the results and discussed fully in the discussion section of this paper. While a consistent standpoint of current literature shows urban sprawl as a threat to the environment, people and to the future of the city, this paper has presented an alternative viewpoint that sees it as a more flexible system for land use allocation. Further research is needed to test the findings of this paper in other urban settings and contemporary planning should incorporate the potential benefits of urban sprawl.



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## Experiences of Nurses Caring for People Living with HIV and AIDS in Vhembe district, Limpopo Province.

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**Abstract:** The purpose of this study was to explore and describe the experiences of nurses caring for people living with HIV and AIDS (PLWHA) in Vhembe district, Limpopo Province. A qualitative research design which was exploratory, descriptive and contextual was used, with a purposive and theoretical sample of nurses who provided care in a regional hospital in Vhembe district of Limpopo Province. Data saturation occurred after in-depth interviews with fifteen participants, field notes were also used during data collection. The findings revealed that nurses caring for PLWHA experience physical, emotional and psychological burden of caring, lack of social support by colleagues and managers and the need for education on HIV/AIDS care. Recommendations that are described focused on supporting nurses to cope in caring through provision of work-based support programmes. [Life Science Journal. 2011;8(S1):29-37] (05) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Caregivers, caring, HIV and AIDS; nurses

### 1. Introduction and background

The HIV epidemic along with the growing complexity of medical care, have created major challenges for the health professionals who provide curative and palliative care. As treatment options have expanded, so has the stress experienced by care givers. The prolongation of the disease course, uncertainty about overall prognosis, repeated exacerbations and remission in later stages of HIV disease have intensified the emotional and physical demands of care giving (O'Neill and McKinney, 2003).

The rapid spread of HIV/AIDS has negatively impacted on the inadequate health care system with deteriorating infrastructure, inadequate medical equipments, medications, inefficient ARV programmes and failure to prevent contagion and implement HIV policies in public hospitals. HIV and AIDS have generated fear, anxiety and prejudice amongst health workers. Whilst government gave more attention to patients, caregivers, who in this context are nurses, were left out, leaving a gap to render compassionate care.

Nurses working in South Africa are experiencing tremendous amount of stress as they

struggle with increasing patient workloads, over more complex technology, sicker patients and fewer resources. Hayter (1998) reported that nurses in public hospitals have reported increased rates of burnout, stress and fear of being exposed to HIV. Furthermore Maselesele and Igumbor (2008) reported that caring for people living with HIV and AIDS (PLWHA) was found to be the source of stress and burnout amongst nurses especially because of institutional problems such as poor resources, lack of mentoring and lack of psychological support to care givers.

Limpopo is one of the most rural Provinces in South Africa, faced with tremendous shortages of the health workforce due to attrition of nurses to urban – rural migration, and brain drain to other countries while some die due to the pandemic (WHO, 2006). In addition PLWHA are increasing, with HIV prevalence of ante-natal being 20.8% and that of the general public being 8, 3%. During the HCT national campaign, Limpopo needed to target 1,6million, however 389 163 were tested and 49 629 tested positive in 2010, and presently people on ARV'S is 78 415, which indicates how overburdened are the health services with limited health personnel to render care (Shilumane, 2010). Dorrington, et al

(2006) revealed that PLWHA was 397 000 in 2006, which indicates that PLWHA are increasing.

Coping in the work environment is difficult for nurses because of lack of employer support such as counselling for work-related stress, this was also reported in Uganda where 42,2% of health workers indicated the existence of an official HIV/AIDS policy to guide health workers, a third were not aware that it existed, also in Limpopo nurses lacked in-depth knowledge about HIV/AIDS due to the fast changes taking place, with only a few nurses trained to can deal with the problem (Hall, 2004; Maselesele & Igumbor, 2008).

Thus the study explored and described the experiences of nurses in caring for HIV and AIDS patients and made recommendations which would facilitate support for nurses caring for PLWHA. To remain healthy, nurses need support. World Organisations addressing the AIDS crisis have concluded that nurses need counseling and support (UNAIDS 2005).

## 1. Research design and method

A qualitative, explorative, descriptive and contextual research design was used to explore and describe the experiences of nurses caring for PLWHA (Creswell, 2009). The population of this study comprised of nurse cadres rendering care at a regional hospital in Vhembe district, Limpopo Province. Purposive and theoretical sampling was used (Polit and Hungler, 1999) to select the hospital and convenience sampling was used to select participants since the researcher is knowledgeable about the setting and the staff complements to meet the information needs of the study. Fifteen nurses participated, their ages ranged between 28 and 50years, 12 were females whilst 3 were males, 9 professional nurses, 4 enrolled nurses and 2 enrolled nursing auxiliaries all nurses had a nursing experience of more than 10years. Hence, the size of the sample was determined by the principle of saturation (Streubert & Carpenter, 1999). In-depth individual interviews were used to gather more information on the experiences of nurses caring for PLWHA, with the interviews lasting for 45-60minutes each and the researcher maintained a climate that allowed the participant to express and respond freely (Henning, et al, 2004).

The broad question enabled the researcher to gain a better understanding of the experiences of caregivers/nurses. Follow-up questions were asked to allow for deeper and more thoughtful responses from the participants (Rubin & Rubin, 2005). An audiotape recorder was used to record the interviews and the data was transcribed verbatim for analysis purposes (Van Rensburg & Smit 2004).

Field notes were used to record the non-verbal cues that were observed during the interview in the presence of the participants. An audiotape was used to record the interview and data transcribed verbatim (Neuman, 2000; Henning, et al 2004). Qualitative data was analysed using open coding method according to Tesch's steps in Creswell (1996). The interviews were conducted mainly in Venda and English as some preferred to mix the languages and were more comfortable communicating in their first language, the researcher then translated the interviews in English.

## Limitations of the study

The study was conducted in Vhembe district of Limpopo Province and therefore do not intend to generalize the findings as the study is qualitative.

## Measures to ensure trustworthiness

The researcher was engaged in prolonged interaction with the nurses to build trust and establish rapport. The interview lasted for about 45-60minutes so that participants could be able to express themselves freely. The researcher repeatedly listened to the tapes in order to internalize the content of the interviews. The researcher tentatively observed the nurses behaviour during their working environment in the different units and this enabled her to observe occurrences of phenomenon and the interaction of the nurses. A field journal was kept on all occasions to record the thoughts, feelings, ideas and other circumstances surrounding the study.

## Ethical measures

Permission to conduct the study was granted by the North West University Ethics Committee, Limpopo Provincial Ethical Research Committee, and the respective hospital. Once a letter of permission was received, the researcher informed the participants regarding the purpose, methods and procedure of the study. The participants made an

informed choice, freely and voluntarily and were requested to sign a consent form. Codes instead of names were used to ensure anonymity and raw data was not exposed to anyone except the supervisor of the study. Participants were assured that the information they provide would not be used against them (Burns & Grove, 2003; LoBiondo-Wood & Harber, 2002).

## 2. Results

Three themes were identified during data analysis in which Tesch's descriptive method of analysis (Creswell, 1996) was used. The following themes were identified, namely:

- Nurses experienced different problems as a result of care giving role to PLWHA,
- They experienced lack of support by colleagues and managers in caring for PLWHA and
- The expressed the need to be assisted to cope in rendering care to PLWHA.

## 3. Discussion of the findings

### 3.1 Nurses experienced different problems as a result of caregiving role to PLWHA

A person who is faced with caring role experiences problems associated with care giving, caregiver burden. Care giver burden is described as physical, emotional and social problems associated with caregiving and the act of care giving also leaves an individual with physical, psychological and emotional effects (O'Neill & McKinney, 2003). The following categories emerged from this theme, physical, psychological and emotional burden/stress of caring, and subcategories will be described in detail in the following paragraph as well as literature control.

#### Physical burden of caring due to increased workload

The workload could be compounded by the fact that HIV/AIDS patients need more care than other patients without HIV/AIDS. Nurses explained how the workload has increased by describing their daily chaotic experiences. *"We registered nurses have a lot on our hands, because we have to insert all drips, administer intravenous treatments, attend to*

*the problems and report very ill patients and those who has changed condition, you must run up and down so as to be hasty in helping the patient."* Other participants further explained that, *"one staff nurse has to make sure that all oral medications in the wards as well as ARV's are administered equally to all patients"*. The lower category of staff also shared their concern on how they are burdened, *"the workload is more especially in the mornings, bed making, bed bath, fixing, feeding and dusting, but after 16h00, and the strain is felt by the one who is left behind."* The HIV epidemic has transformed the face of caregivers; the strains on those caring for PLWHA are enormous. Caring for an individual with AIDS-related disease is usually time consuming, burdensome, and unpredictable (Strydom & Wessels, 2006).

#### Physical burden of caring resulting in fatigue

The following statements are ways in which nurse's experienced physical strain or fatigue. A professional nurse working in VCT clinic indicated that, *"we are so overworked due to staff shortage that you knock off being physically strained, you will find that nurses knock-off being tired, and this leave them being stressed"*. Caring for PLWHA is a demanding job that requires physical and emotional reserves that occasionally exceed those of even the healthiest persons. It imposes burdens that may compromise the nurses' health; symptoms of poor physical health are significantly associated with care-related demands and stressors.

#### Physical burden due to lack of human resources

Here is the voice of the participant indicating the scourge of HIV/AIDS on the human resource. *"At the moment, we are having a serious challenge of manpower, it affects the whole multidisciplinary team, we have lack of doctors, lack of nurses especially those allocated specifically in the ARV clinic, people who are supposed to serve them are few..... for instance in our institution our intake is more than 100 per month"*. Human resource challenges manifest not only in shortages of health workers, but also in disparities in their distribution, poor training capacity, skills, skills mix deficits, weak management and supervisory systems. South Africa currently has fewer public health workers, including professional nurses, than it did ten years ago, the

national health system is structurally characterized by public-private sector divide and this is reflected in large inequalities in the distribution of personnel. In 2005, of 99 534 professional nurses registered with South African Nursing Council (SANC) only 43 660 (43.9%) were employed in the public sector despite the fact that this sector caters for more than 80% of the population (Rensburg et al, 2008). According to South African Nursing Council (SANC) verification and transcript statistic for nurses in Limpopo the ratio of registered nurses to patient is 606:1, enrolled nurses 1141:1 and enrolled nursing auxiliary 649:1 which is a reflection of how nurses are overburdened.

#### **Physical burden due to lack of material resources**

Shortages of resources contribute to waste of time and also retard nursing care, the situation negatively affect the ability of nursing personnel to deliver a quality service to their patients. One participant said *"There is gross shortages of resources, you have to wait for the other persons when you need to use the item, like when you want to take vital signs, or you can borrow from another ward, and it retards the routine, moreover they are not enough and are of low quality, and don't last and not long you will realise that they are no longer in good condition"*. King and McNerney (2006) also reported shortages of basic equipment and a tendency by hospital management to sanction the ordering of cheap and inferior quality of surgical supplies that has negatively impacted on the everyday work routines. Furthermore nurses felt irresponsible, guilty and emotional pain about not rendering the necessary care to patients, like omitting to administer medication to the critically ill patients. *"You will find an HIV patient has being ordered to be given treatments and you find that antibiotics are out of stock, and this gives us stress because maybe if he had antibiotics he would be better"*. Nurses felt that shortages of medications retards the progress of the patient's prognosis, resulting in prolonged stay and increases the burden of caring resulting in stress and burnout. Similar findings were reported by Vhurumi and Maselesele (2009) at selected clinics in Limpopo, that the clinics ran out of pharmaceuticals and vaccines which made it impossible to render IMC services.

#### **Psychological burden of caring due to fear of contagion**

The participants expressed feelings of fear related to becoming infected at work. The following statements are ways of expressing their fears. *"We are at risk of contracting diseases, like when a patient has TB, or has defaulted treatment and developed multi-drug resistance..., it means we can also get the disease and it make us to be fearful that we can contract the disease"*. Furthermore they felt that they were at risk of being infected due to intentional exposure by some patients. *" Sometimes giving care is not a pleasing as some patients are uncooperative and not listening to instructions you will find them messing the whole place, taking out drips and so on, like he or she want all of you contaminated by his/her secretions and wanting to touch everyone around"*. Ehlers (2006) also indicated that some HIV+ persons are believed to spread the disease on purpose so as not to die alone, the so-called "vengeance belief/theory" since nurses are easy targets for such purposeful infections. Awusabo-Asare and Marfo (1997) also reported the inability to identify infected persons due to lack of facilities, and the fact that the risk of contracting the disease might be very low if nurses adhere to basic safety measures applicable to other diseases, such as the use of gloves for invasive procedures, disinfecting, proper handling of specimens and adequate disposal of used items.

#### **Psychological burden of caring due to loss of hope, helplessness and frustration**

Most participants lost morale and felt depressed when they could not provide further help when death was inevitable. One remarked *"We are badly affected psychologically, because you also place yourself in their position, that you will also be packed due to these things, because I am also exposed to these things on daily basis, therefore there is no guarantee, to tell the honest truth it is really giving us a bad feeling at times"*. Another nurse said *"sometimes you care for the person of your own age group, when s/he is still well and not yet become emaciated and so on, but maybe s/he failed to cope with the diagnosis and dies, it also makes you think that tomorrow you might find yourself facing a similar situation"*. Dageid et al (2000) also reported similar findings among home-based carers that sometimes seeing symptoms



of their patients made them cry, caring for the terminally ill or dying patients, who literally died in their hands was traumatizing.

#### **Psychological burden of caring due to feelings of insecurity**

The nurses felt that the work situation was unpredictable and frustrating as you could not anticipate how your day will turn out to be. *"This very week when coming on duty at 19h00, we found a patient with an uncontrollable and unexplainable behaviour, sometimes you find that you are even forced to run away as the patient will be threatening, ee..... (loud voice and agitated look) as you are running for help, when he hurts you, you are just hurt, nothing happens, when you are not hurt nothing is said and I haven't seen them taking any actions whatsoever".* Another nurse had to say *"some abuse us verbally, they use abusive language"*. King and McInerney (2006) also reported that nurses in the Durban metropolitan area experienced violence in the workplace. Kgosimore (2004) as cited by King et al (2006) also reported that in the South African context, workplace violence has become a daily occupational hazard, and that the Democratic Nursing Organisation of South Africa (DENOSA) has noted an increase number of complaints from nurses who have suffered abuse in the workplace from both medical and nursing colleagues, patients and the public.

#### **Psychological burden of caring due to feelings of guilt and self blame**

Nurses experienced guilt and self blame when they failed to advocate for the formal healthcare when faced with conflicts with the informal health care system that contributed to poor prognosis of PLWHA. One had to say *"There are so many things that they encounter when they are discharged from here, most come back being in a critically ill condition as they don't adhere to treatment, they use traditional medication, and it causes a lot of drawback, as they listen to the hearsays that such a person (traditional healer) is efficient in curing the disease, then the person stop taking treatments"*. Ehlers (2006) reported that nurse's form bridges between the traditional and formal (western) health care systems in African countries, however referral from one to the other health care system might cause conflicts for nurses should the patient's condition deteriorate. Thus the

nurses need to teach the patient not to take any medication in addition to ARV's.

#### **Emotional burden of caring as a result of isolation and dissociation due to stigma**

One participant responded that the mere fact that you work at the VCT centre, other health workers dissociate themselves in rendering care to patients that are infected. *"We are experiencing problems as nurses don't want to involve themselves in the care of contributing something to a colleague or patient, it is meant for a specific set of people (VCT trained), the others are just observers....., they are not involving themselves at all"*. Furthermore the nurse reported that *"VCT nurses and the patient are attached an identifying label linking them to a sign or negative term to PLWHA and this isolates them. 'like when a patient is in need of assistance that does not require an HIV trained somebody, but because s/he is known to be HIV+ it means that his care and support should come from the HIV unit. Zelnick and O'Donnell (2005) also reported that nurses felt undervalued, the social value of their jobs was not recognized or reflected in pay or benefits.*

#### **Emotional burden of caring as a result of emotional stress**

Most of the health workers are emotional drained and overwhelmed and were unable to deal with their own emotional reactions. *"I also feel very stressed, especially after counseling, and the client is failing to accept and start crying, when the patient denies and undergo those stages, even yourself as a nurse you do experience the emotional pain and end up placing yourself in her situation, it really affects us."* Some nurses identified themselves with the clients and experienced loss and emptiness after death of their clients. *"It is emotionally painful when a patient dies just because he could not come to terms with the diagnosis and failed to accept the condition"*. Repeated exposure to death and dying, fear relating to attachment and loss, profound feelings of loss and grief can lead to loss of professional objectivity (Bellani et al, 1996).

#### **Emotional burden of caring as a result of fear of disclosure**

Some participants indicated that it is better to remain silent than of being stigmatized. Moreover professional nurses also contravened their ethical responsibility of professional secrecy as one reported,

*“ (Laughing) There is no professional secrecy, we start hearing it from the chief professional nurses, deputy managers, we hear about it from the teams of calls, there is a lot of gossip going on during weekend calls.”* The risks of disclosure are greater in situations when employment, reputation, and community acceptance are placed in jeopardy (WHO, 2006). Suzanne and von Zinkernagel (2008) also indicated that it is difficult for nurses to practice what they teach and to take basic steps toward health that they counsel for their patients. The stigma attached to the disease impacted on behavior of health workers as they could not talk openly leading to gossips and the use of coded languages when PLWHA were referred to.

- **Emotional burden of caring as a result of stigma and discrimination**

Nurses reported negative consequences in caring for PLWHA of perceived stigma and internalized shame. *“The situation sometimes is unbearable because of the gossips and it make the person to feel uncomfortable emotionally, and is this gossips and hearsays that does not stop that are the major problems, they attach a label to say that one has passed the test (tested+ve)”*. Due to stigma associated with the disease the patients as well as the carers are always discriminated against and these results in feelings of discomfort and uncertainty for the caregiver as he is not able to maintain the situation. Cloete (2008) revealed that a negative organizational context can influence job performances of HIV and AIDS infected individuals, including a decreased self concept, violated psychological contract and reduced commitment.

### 3.2 Lack of social support from managers

A need for a supportive practice environment was expressed by most participants. *“Ever since I started working in the department of HIV/AIDS there is no single support that I have seen coming from management. You just work and work January to December without ever seeing management coming to understand if you are encountering any problems, or what can be done in order for us to be assisted, You work without ever having a single day that management can arrange a meeting with nurses working in the HIV unit, to hear them out and support them”*. A health care environment where one spent long hours giving care has numerous stressful incidents, and support system

is required. Moola et al. (2008) also indicated that there's a need to integrate professional and peer interventions as it improves identification and clarifications of emotions and that debriefing and defusing support systems should be accessible to help to resolve cumulative prolonged stress reactions. Furthermore it was apparent that they perceived lack of emotional support and counseling in the workplace. *“Ee....e there is nowhere to relieve stress, you only can relieve stress while discussing with colleagues, talking about the problems that we encounter, otherwise you can take leave”*. Mkhabela et al (2008) also reported that feelings of isolation and dissatisfaction was expressed by nurses working at VCT centers, they indicated that there's no structure in place to assist them, one has to shoulder all the problems for clients and self, sort them out, at the end of the day go home with that burden. Others complained that their efforts and concerns go unnoticed by management and lack of support from management *“When management come to the ward, she is not there for nurses, she is there for the patients, to see if the patients are well cared for....., are they receiving adequate care?, failing to know if nurses are operating with adequate staff and if ever they are coping with the situation.....?(Looking depressed and pressing fingers)”*. Lephalala, et al (2008) reported that nurses needed more recognition to satisfy their needs for reputation, prestige and respect from others, which could lead to increased self-esteem and job satisfaction.

### 3.3 Nurses expressed their needs in assisting them to render care to PLWHA

- **The need for educational support to assist nurses in their care giving role**

One VCT trained nurse reported that some nurses lacked skills in rendering care to PLWHA.

*“Staff members do not have the necessary knowledge, really...., they lack knowledge...., because when you visit the wards from HIV side, you will find that a patient has been mismanaged with regard to his medications and his complaints were not attended to accurately because nurses have not been trained for that.”* Bond (1990) as cited by Effa-Heap (1997) indicated that 70% of nurses felt that they should receive specialized training in order to safely carry out the nursing care of HIV/AIDS patients regardless of where they work. The nursing of HIV/AIDS patients requires special skills. They



include the identification and management of specific clinical problems, counseling techniques, the administration of patient care and the ability to communicate effectively with individual patients, families and communities.

One of the participant reported that *“In-service training are not regular, haa..., is long that it has been scheduled”* Swansburg (1995), states that the acquired knowledge should enable the registered nurses to be more receptive and adaptable to changes in their roles and contribute to employee satisfaction and improve morale. It is in this light that managers should have a policy in place of educational programmes and induction courses that are supposed to be attended by nurses, and should be made compulsory or nurses should receive credits on the skills and job-content knowledge acquired.

### Recommendations

The institution needs to think of new ways of providing HIV/AIDS care and support to its health workers by increasing the number of staff, with more assistants or semi-skilled labourers to deal with non-nursing duties, improving on the provision of equipments, improving the work relationships between nurses and managers, with provision of more training on stress management and HIV/AIDS to provide emotional support through regular professional debriefing and counselling. Nurses are the backbone of the health care system and as providers of care, it is imperative that they be offered staff development programmes that promote quality care, including in-service training, continuing education as well as work-based counselling to cope with the caring challenges related to HIV/AIDS care.

### Conclusions

Research has shown that caring for PLWHA is time-consuming, burdensome and unpredictable. The stress that nurses experienced in their course of duty made them vulnerable to varying degrees of physical, psychological and emotional distress. Nurses also experienced constraints as a result of caregiving role that lead to poor physical health. Lack of knowledge on managing HIV/AIDS was also indicated as one of the challenges in rendering quality care to patients

with HIV/AIDS. The findings also revealed that there was no effective support system for nurses; nurses were unable to vent their views and ideas and find productive solutions to their problems, leading to stress and burnout. The HIV/AIDS pandemic continue to negatively impact the health service; however employers must be able to support their employees to lead productive lives.

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## **An investigation into the prevalence of *Toxoplasma gondii* among indigenous, communally reared goats in the Mafikeng area of the North West Province of South Africa.**

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**Abstract:** An enzyme-linked immunosorbent assay (ELISA) based study was conducted to determine the seroprevalance of the zoonotic infection *Toxoplasma gondii* in indigenous, communally reared goats around Mafikeng. Sera from 172 goats from 5 areas around Mafikeng in the North West Province were tested. The seroprevalance ranged between 11.1 and 14.8% ( = 6.4%). Sixty percent of the sampled areas tested positive, so were 50% of the herds. Only 25% of the farmers had prior knowledge of toxoplasmosis. Sixty three percent of the farmers consumed goat milk, while 87.5% slaughtered goats for own consumption. The prevalence of the infection among goats raises public health concerns due to the zoonotic nature of the parasite. Health officials are encouraged to review policies that involve human exposure to the parasite as well as mount awareness campaigns about the infection. [Life Science Journal. 2011;8(S1):38-41] (06) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** enzyme-linked immunosorbent assay (ELISA); infection; *Toxoplasma gondii*; toxoplasmosis; parasite

### **1. Introduction**

Toxoplasmosis is caused by the protozoan parasite *Toxoplasma gondii* that infects most warm-blooded animals including humans (Abu Samra et al. 2007; Buxton, 1998). It is a widespread zoonosis and humans acquire the infection by ingestion of raw or partly cooked meat containing *Toxoplasma* cysts, unpasteurised milk and ingestion of contaminated cat feces during gardening (Clementino et al. 2007, Dubey et al. 1995; Lopez et al. 2000; Tenter et al. 2000). Worldwide, ocular toxoplasmosis is considered the principal cause of retinal infections (Holland, 2003) in humans and a long term follow up of patients recently showed that 24% of the affected eyes become blind (Bosch-Driessen et al. 2002). Persons with compromised immune systems (Acquired immune deficiency syndrome (AIDS) or receiving immunosuppressive) are more vulnerable, experiencing severe symptoms which include confusion, headache, seizures, nausea, poor coordination and coma. In the above situations, the outcome may be fatal (Bisson et al. 2000). Whereas in pregnant women the infection may lead to miscarriages/ spontaneous abortion, stillbirth and congenital toxoplasmosis (children born with abnormal head size) that lead to mental retardation (Dubey, 2004; Thiebaut et al. 2007). Small ruminants, including goats are an important source of protein for humans. Furthermore, goats play an important role in the socio-cultural lives of communities around

Mafikeng where they serve during rituals. The epidemiology of toxoplasma has been studied most closely in western countries, but in Sub-Saharan Africa, where the prevalence of the human immunodeficiency virus (HIV) is among the highest in the world, data are limited. The aim of this study was therefore to determine the seroprevalance of *Toxoplasma gondii* among indigenous, communal reared goats around Mafikeng.

### **2. Materials and methods**

A total of 172 goats over the age of 6 months were randomly sampled from 3 herds in small holder and 5 rural areas around Mafikeng (25° 52'S and 25° 38 E) in the North West province of South Africa. Mafikeng is 1278m above sea level, and has a semi-arid environment with Savanna type vegetation and summer annual rainfall of 540 mm year<sup>-1</sup>. It has one long dry season (winter) extending from May to October and a relatively short wet season (summer) extending from November to February. The sampling areas included Ramatlabama, Top village, Molelwane, Moshawane, Signal Hill and Lokaleng (table 1). Jugular blood samples were drawn into vacuum tubes and left at room temperature overnight. The sera were separated after centrifugation at 2500rpm for 10 minutes and then stored at -20 °C until analysis. The enzyme-linked immunosorbent assay (ELISA) method was used for sample analysis following instructions on the Checkit\*Toxotest ELISA test kit (lot number is

192-T941) from IDEXX Switzerland AG. During sample collection, observations were on the cat population in the respective areas, while structured

interviews were used to gather other relevant information.

**Table 1: The sample areas and the number of samples.**

Sampling area	No. of herds	Purpose for farming	No. of animals per herd
Molelwane	1	Research	27
Top village	1	Sustenance	18
Ramatlabana	1	Sustenance	45
Lokaleng village	1	Sustenance	41
Moshawane village	3	Sustenance	27
Signal Hill village	1	Sustenance	14

### 3. Results

A total of 172 goats over the age of 6 months were tested for the prevalence of *T. gondii* antibodies. Seropositivity ranged from 11.1 to 14.8% (u=6.4%), with Moshawane village having the highest prevalence (table 2). Sixty percent of the sampled areas tested positive while 50% of the herds were positive. Stray cats were observed in most of the villages. Only 25% of the farmers who also happened to be Animal Health professionals had prior knowledge of toxoplasmosis. Sixty three percent of the farmers also used their goats' milk for consumption, while 87.5% occasionally slaughtered their goats for consumption for various reasons.

**Table 2: Prevalence of *T. gondii* around Mafikeng in the North West province.**

Areas	Animals sampled	No. of seropositive samples	% sero positive
Lokaleng	41	0	0
Molelwane	27	3	11.1
Top village	18	2	11.1
Ramatlabana	45	0	0
Moshawane village	27	4	14.8
Signal hill village	14	2	14.2
<b>Total</b>	<b>172</b>	<b>11</b>	<b>6.4</b>

#### 4. Discussion

To the best of our knowledge this is the first study of the seroprevalence of *T. gondii* in goats in the North West Province. Goats were chosen because they are commonly kept by communal farmers in this province as they are inexpensive to rear, are disease resistant, and have a special role in traditional ritual purposes. According to the country pasture/forage resource profile of South Africa, in 2006, 66.6% of the estimated 6.4 million goats were in communal areas.

The 6.4% overall prevalence in this study compares well with the 4.3 % noted in sheep in South Africa (Abu Samra et al. 2007). On the contrary, a 67.7% prevalence was documented for adult sheep and goats in Zimbabwe (Hove et al. 2005), while a 10% prevalence was noted in goats in Botswana 10 % (Binta et al., 1998). The seroprevalence of *T. gondii* in goats is an evidence of environmental contamination with infective oocysts, either by wild felids or domestic ones. Variant ecological factors and breeding systems could be responsible for the different prevalence rates between localities (Malik et al. 1990). The semi arid climate of Mafikeng and much of Botswana could have been responsible for the lower prevalence in these two localities since previous epidemiological studies have found infections in sheep to be more prevalent in cool, moist areas than in hot, dry ones (Hove et al. 2005). The prevalence of the infection in the current study may have significant public health implications. The consumption of raw or undercooked goat meat contaminated with cysts, or unpasteurised goat milk containing *T. gondii* tachyzoites (Pepin et al. 1997) may expose community members to infection. In this study, 63% of the farmers consumed goat milk, 87.5% slaughtered their own animals for consumption, while 75% had no knowledge of the infection. These factors may greatly expose the populace to infection. Some of the practices that should be emphasized to residents include thorough cooking of meat, vigorous hand washing before meals or after doing outdoor activities such as gardening, having a healthy person dispose of cat litter boxes rather than pregnant women, the use of gloves in cat box disposal, and the pasteurization of milk before consumption by humans (Lopez et al. 2000). Toxoplasmosis is one of the fatal opportunistic infection in humans infected with the

AIDS virus, resulting in severe toxoplasmosis which causes damage to the brain, eyes, or other organs after an acute infection or reactivation of an earlier infection (Hill and Dubey, 2002). This is further compounded by the statistics that Sub-Saharan Africa remains the most affected region in the AIDS pandemic with more than two thirds (68%) of all people who are HIV-positive living in this region (DoH, 2007). Serological evaluation of food animals therefore becomes central in the control of the disease.

In conclusion, the current study has revealed the presence of the toxoplasma parasite in 60% of the sampled areas, together with a low awareness among residents. Control measures and awareness campaigns need to be prioritized if the infection is to be stopped from increasing.

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## Risk assessment for *Salmonella* contamination of pig carcasses in abattoirs in the North West Province, South Africa.

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**Abstract:** One hundred and eighty blood samples were run using the ELISA method to determine the seroprevalence of *Salmonella* in slaughter pigs at various abattoirs in the North West Province of South Africa. Seroprevalence ranged from 18.8-47.4% (= 28.3%), while 100% of the abattoirs tested positive. Indications were that infections were occurring at farm level. Further farm level qualitative investigations are recommended in order to identify the actual factors associated with the infections. Consideration should be made for the introduction of *Salmonella* monitoring programs at farm level to assist in the prevention of contamination. [Life Science Journal. 2011;8(S1):42-45] (07) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Abattoirs, ELISA; North West Province, pig, *Salmonella*, Seroprevalence.

### 1. Introduction

*Salmonella* is a leading food borne pathogen in the world, with pork being regarded as contributing to 20% of human infections (Frenzen et al. 1999; McDowell et al. 2007). *Salmonella* genus are members of the *Enterobacteriaceae* family which inhabits the intestinal tract of animals (Cortez et al. 2006) and is the cause of human salmonellosis that causes a gastroenteritis (Voetsch et al. 2004). Outbreaks of salmonellosis are mainly related to the consumption of contaminated raw meat, eggs, and egg products that have not been properly cooked (Parry et al. 2002). *Salmonella* infections which occur in persons with AIDS can be particularly difficult to treat and are more likely to lead to serious complications (Mead et al. 2001). The actual prevalence of salmonellosis could be higher because of an under reporting associated with difficulty in diagnosis of mild cases (Angellilo et al. 2001; Atkas 2001). In South Africa, sporadic cases and outbreaks continue to occur. The major risk for the spread of *Salmonella* is carrier animals like pigs that are latently contaminated, but under normal conditions do not shed *Salmonella* (Nowak et al. 2007; Shimshony 2008). Data on the prevalence of salmonella in pigs in South Africa is scant, this despite the economic and public health significance of the infection. The purpose of the present study was to therefore determine the seroprevalence of *Salmonella* in slaughter pigs at

some abattoirs in the North West province of South Africa.

### 2. Materials and methods

The investigation was carried out at five red meat abattoirs involving 24 farms in the North West Province of South Africa. The abattoirs were situated one at Ventersdorp, Brits (142km from Venterdorp), Swartruggens (87km from Venterdorp, and 2 at Zeerust (132km Venterdorp). The abattoirs generally sourced pigs from various farms, while one small abattoir at Zeerust slaughtered pigs from a single farm. Blood samples were randomly collected in to vacutainer tubes from slaughter pigs during the bleeding process. Blood samples were coagulated for 24 hours at room temperature and centrifuged for 10 minutes at 2500 rpm. Serum was then extracted and stored at -20°C until analysis. The ELISA methods was used to analyse sera for the presence of antibodies against salmonella using the commercial kit Salmotype®Pig screen, obtained from Labor Diagnostik Leipzig (Germany), Lot no 1200587. The assay was performed according to the producer's instruction supplied with the kit.

### 3. Results

A total of 180 pigs from 24 farms were sampled and had their blood samples analysed. Seroprevalence ranged from 15.8 to 47.4% (=28.3%). All the 5 abattoirs had seropositive pigs at each slaughter. The abattoir with the highest seroprevalence was mainly serving a single farm.

**Table 1, Seroprevalence of *Salmonella* in pigs in the North West abattoirs.**

Abattoir	Number of samples	Number of positives	% Seroprevalence
1	90	17	18.8
2	19	3	15.8
3	18	7	38.9
4	19	9	47.4
5	34	15	44.1
Total	180	51	28.3

### 4. Discussion

To the best of our knowledge, this study is the first study on the seroprevalence of *Salmonella* infections in pigs in South Africa. Few of the studies on the prevalence of *Salmonella* infections in pigs are microbiology based (Kidanemariam et al. 2010). The ELISA test used in this study is highly sensitive. However, a general shortcoming of antibody-based tests is a low specificity related to the fact that sick and immunocompromised animals may test negative (Nowak et al. 2007). The study revealed an overall seroprevalence of 28.3%, which could be an underestimation of the actual prevalence based on the limitations of antibody based tests as alluded to above. However, the prevalence was higher than results from other countries like Germany (6.8- 7.7%), Denmark (3- 6.1%), Great Britain (15%) and Netherlands (23%) (Davies and Wray 1997; Mousing et al. 1997; Ludewig and Fehlhaber 2000; Von Altrock et al. 2000; Hald and Andersen 2001; Van der Wolf et al. 2001; Czerny et al. 2001; Ehlers 2002) where serologic methods were also used. The difference in prevalence

rates could be related to factors that include pig population differences and management practices (Nowark et al. 2007). That the prevalence between abattoirs ranged from 15.8 to 47.4%, being highest at the abattoir serving a single farm suggests management factors having a huge influence on infection rates. Although farm level investigations were beyond the scope of this study, future quantitative studies at farm level are highly recommended in order to clearly identify the factors associated with the high prevalence of infections. This would also facilitate the formulation of policies aimed at controlling the infections.

Healthy pigs need approximately five to seven days after oral uptake of *Salmonella* to build up an appropriate antibody titre which can be identified by ELISA (Nielsen et al., 1995; Proux et al. 2000). This further supports the finding that exposure to *Salmonella* revealed in this study was at the farms of origin since the animals did not spend that much time at the abattoir prior to slaughter. Contamination could then spread during the chain of procedures from slaughter to retail. This then calls for the introduction of monitoring programs at farm level to control carcass contamination. In other countries, serology testing is performed at farm level, leading to the classification of farms into different categories according to the test results (Rajic et al. 2005). Control measures to minimize carcass contaminations would then include ensuring that pigs from positive farms are slaughtered last.

### Conclusion

Current results show a high prevalence of farm associated salmonella infections in pigs, indicating the need for the implementation of farm level control measures. Further, quantitative studies at farm level are highly recommended in order to clearly identify the factors associated with the high prevalence of infections.

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#7



## Settlement structure and energy access in rural Sub-Saharan Africa

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**ABSTRACT:** The purpose of this paper is to report the results of an investigation on energy access in rural Sub-Saharan Africa. Three objectives were advanced for this study: to review literature on rural energy access, comment on energy policy and planning, identify constraints to increasing rural access and finally, develop an alternative intervention for the energy sector. The methodology was based on adaptation of the shortest path model (SPM), the maximum flow (MFM) model and the minimum cost flow (MCF) model in network design. Statistics from international organisations on the energy sector, population, land use and road networks were handled using correlation analysis to identify key relationships. The results highlight serious shortfalls in energy provision, infrastructure, and policy, planning and capital investments in the energy sector. The absence of a correlation between power generation, rural energy access, population density and road density point to the inadequacy of current planning practices. Current settlement patterns appear to impose constraints on the optimization of rural energy provision in spite of immense untapped potential for renewable energy sources. An alternative integrated energy platform (EAP) based on restructuring settlement is suggested that could allow for a radical increase in energy access at national level by exploiting opportunities provided through rural settlement densification. [Life Science Journal. 2011;8(S1):46-58] (08) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Installed capacity; grid network; generation; transmission; distribution; renewable energy; biomass energy

### 1. Introduction

Sub-Saharan Africa (SSA) remains one of the least developed in the world in terms of the percentage of the population with access to electricity. Shah (2010) reveals that South Asia with 706 million topped the list followed by Sub-Saharan Africa at 547 million people living without electricity. On a global scale, at least 1.6 billion people have no electricity (Mondal and Denich 2008). Yet, the dominance of a centralized grid system of electricity means that only industrial nodes and urban areas get priority access. Average rural energy access rates are consistently less than 10% (UPI 2010; Adenikinju 2008) with few exceptions: Mauritius, Ghana, Namibia, Zimbabwe, Zambia, Swaziland, Botswana,

and South Africa. Apart from inter-country disparities, there is a striking inequality from country to country in access between urban and rural areas and in the reliability of supply. Mean country access data computed through aggregation often fail to capture the reality in rural areas where access often drops to less than 1% as in Uganda and Kenya (Karekezi and Kimani 2004). This is in spite of SSA having immense untapped energy resources. Hydropower potential is highest in DRC, Ethiopia and Cameroon while South Africa alone accounts for 90% of the continent's coal reserves but per capita consumption in SSA is very low at a mere 150kWh (Niyimbona 2006). (Table 1. Electrification Rates by Region)

Table 1. Electrification rates by Region

	1970	1990	2000	2015	2030
North. Africa	34	61	94	98	99
<b>Sub Saharan Africa</b>	<b>9</b>	<b>16</b>	<b>23</b>	<b>33</b>	<b>49</b>
Africa	14	25	34	43	56
South Asia	17	32	41	53	66
Latin America	45	70	87	94	96
EAsia/China	30	56	87	94	96
Middle East	36	64	91	97	99
Dev Countries	25	46	64	72	78
World	49	60	73	78	83

Source: IEA (2002)

Energy access plays a major role in transforming the livelihoods of the people (Adenikinju, 2008; ICSU 2007) and in addressing the poverty crisis. The problem that needs to be addressed therefore is how to increase energy access in rural SSA in spite of financial, technical, institutional and policy limitations. To address this problem, the objectives of this paper are to survey the state of literature on the energy sector in SSA, to comment on energy policy and planning, to identify particular constraints to energy access and, finally to develop an alternative intervention that could offer a feasible vehicle for improving energy access. It is hypothesized that an efficient settlement structure lowers the cost of extending rural electrification. The rest of this section addresses the energy sector and constraints to energy access while the second part covers materials and methods. In part three results are presented followed by a discussion of findings in part four.

Current demand for energy in all countries except Ethiopia, exceed installed capacity (ICSU

2007) leading to inadequate provision (Adenikinju 2008; Deichmann et al. 2010) power outages and unreliable supply (Subair and Oke 2008). As a result, current supply in SSA faces a serious financing gap for infrastructure (IMF 2009). Outside South Africa and Zimbabwe, energy sources in the rest of SSA are dominated by hydroelectric power, thermal and biomass. Available regional statistics (ECA 2007) show variations in the growth of the generation capacity of countries and the relative contribution of both hydro and thermal power output. A group of countries notably-Angola, Ethiopia, Gambia, Kenya, Mauritania, Mozambique, Nigeria, Sudan, Tanzania and Zambia- registered major increases in output and some even doubled generation capacity in the period 2000-2007. Large parts of the region lack appropriate sites for energy generating capacity forcing a reliance on high carbon fossil fuels at a time when global energy trends show a preference for renewable clean energy. Karekezi (2006) reports that almost 80% of the population in SSA still depend on biomass resources for cooking. Only South Africa is the exception with a 16% score in this respect. The ICSU

(2007) paints a bleak picture of the energy sector in SSA. The use of firewood and charcoal is ineffective, registers energy losses of up to 15% and is believed to be a major source of indoor pollution. There are significant geothermal reserves in the Rift Valley with an estimated potential of 2.5-6.5GW- but only Kenya today has developed an installed capacity of 129MW. Energy pricing systems have not been geared to cost recovery-given the sensitivity to the low income levels of the population. State power utilities face serious problems of non-payment, illegal connections (Mwangi 2006) and out-dated technology cumulatively leading to power losses to as high in some cases as 33-40% for Nigeria (Subair and Oke 2008). One view is that one way out of this crisis is to promote regional organisations in SSA (Adenikinju 2008; Hollard and Mayer-Tasch 2008) to supplement national efforts. Zhou(2003) reports that NEPAD set itself a target of providing electricity to at least 35% of the population by 2015 while the Forum for Energy Ministers (FEMA)'s target was to provide improved energy sources for cooking to at least 50% of the population by 2020 (FEMA 2006). In the meantime, methodologies for optimizing energy access (Deichmann et al. 2010) indicate an apportionment of a county's regional space in terms of suitability for decentralized and or centralized energy generation, transmission and distribution. It is not disputed that with increasing distance from generating sites and decreasing rural population density, the costs of provision increase to a point where it will not be possible to break even. Empirical evidence also indicates that flexible combinations of centralized HEP generation and off-grid renewable energy sources can be instituted to guarantee a reliable energy supply (Adenikinju 2008; Mondal and Denich 2010). But Deichman et al. (2010) conclude that decentralized power supply is unlikely to be cheaper than grid supplies any time soon- a position echoed by Wamukonya (2005). This means that the economics of grid-supplied electricity in more densely populated areas remain compelling, especially as population concentration patterns are likely to increase rather than diminish (World Bank 2008a). Energy policy and planning should therefore target the expansion of renewable power now rather than thinking of this as a future option.

Energy policy and planning is reported in a significant volume of work by international organisations-the (IMF 2008, 2009; World Bank

2008a, 2008b; OECD 2004; ICSU 2007; WHO 2006; IEA 2008; WEC 2005;) - through essentially a compilation of data at country and regional scales together with policy and planning. Policy documents on energy sector by individual states provide an idea about the overall thrust of policy positions and strategic planning for the sector. Institutions within SSA (NEPAD 2002; AFREPREN 2004) have also done significant research in analyzing the energy sector and in advising on how best to intervene to improve access to energy. The international energy agency (IEA 2008:18) believes that at the nation state level, policy should focus on securing the supply of reliable and affordable energy, effect a rapid transformation to a low-carbon, efficient and environmentally benign system of supply. The EU for example has pledged to provide 100 million Africans with clean and sustainable energy by 2020 through the Africa-EU Energy Partnership, and with an initial funding of \$6.5million, it intends to build 10 000megawatts of hydropower, at least 5 000MW of wind turbines, 5 000MW of solar power facilities and raise energy efficiency (UPI, 2010). The World Bank's new energy strategy proposes direct support to the poor through finance and technical assistance to facilitate access to modern fuels and electricity, supporting energy needs for education, communications and public health. It also encourages private investment, improvement of regulation of the energy industry, the removal of market barriers to renewable energy and ultimately a focus on community-driven development (CDD) in both Africa and South Asia (World Bank 2009).

The World Bank estimates that 21 countries are unable to generate the minimum threshold of 200MW of electricity (World Bank 2008b). In the majority of countries, energy generation, transmission and distribution have remained a vertically integrated state monopoly (Deichmann et al. 2010). Where attempts at reforming the sector (Karekezi and Kimani, 2004) have been initiated as in Eastern Africa- results are mixed. Instead, the focus has shifted to facilitating the entry of independent power producers (IPP's) as in Kenya and Uganda. Privatisation of the energy sector has not attracted a massive response (Bayliss and McKinley 2008). International organisations supported privatization in the belief that it would lead to the unbundling of state power monopolies. This did not occur and there is empirical evidence that many

countries offered expensive incentives that killed potential competition in the industry simultaneously driving up consumer prices (Adenikinju 2008) and lowering power consumption (Subair and Oke 2008). They have since reviewed their approaches and started encouraging countries to focus on capacity building to improve performance (ICSU, 2007). Once again, large scale capital investments have remained low since 2000 leading to serious backlogs. Today, the energy sector needs to be reformed to improve its performance, to minimize losses and increase efficiencies and the realisation that state monopolies will remain the dominant players in the industry (Deichmann et al. 2010). State energy policy in the region has shown a low priority for rural areas (IEA 2004; KMOE 2008), limited infrastructure investments (Karekezi 2006; Karekezi and Kimani 2004) and a reliance on centralized grid networks (Deichmann et al. 2008). There has been a failure to integrate energy planning into the overall growth and development strategy (ICSU 2007) of these countries. Davidson and Mwakasonda (2008) recommend that a diverse set of technical and institutional approaches are needed for rural electrification together with smaller scale distributed energy systems. In addition there has been a failure-save for some few countries-to develop information management systems at the national level for tracking the actual extension of access outside of urban areas and building a reliable data base (Karekezi and Kimani 2004).

At a planning level, rural electrification targets are often so low as to be literally of no consequence. Yet data from some countries

(Davidson and Wrinkler 2003; Gboney 2001; Kayo 2002; Eremu 2003; Kayizzi 2003; Dube 2002; Okumu 2003) indicate that even in a shorter period of time, it is possible to achieve higher electrification levels. In some countries, rural electrification levels were higher than the national level: in South Africa, it was raised from 21% to 50% in the period 1995-2002 (NERSA 2002) an increase of 29%- see table 2. Far more reaching reforms of the energy sector in order to encourage private investment and raise competition-Subair and Oke (2008) are suggested in a study of Nigeria where privatisation will in actual sense reduce electricity consumption. Regional cooperation in energy policy and planning has seen the setting up of power pools in recent years. The West African Power Pool (WPP) system has formulated a master plan to boost inter-connections between Nigeria, Togo, Benin, Ghana, Cote d'Ivoire, Niger, Burkina Faso and Mali across 5600km and raise generation by 4 times by 2020. The resulting facility should equip the region with an installed capacity of 17 000MW (ECOWAS 2005). A thermal gas pipeline will link Nigeria to Ghana, Benin and Togo to supply gas to thermal power stations and yield a capacity of 3000MW. These efforts are commendable and are slowly beginning to show benefits on the ground but the problem of how to increase access remains a challenge. Similar regional power pools, the EAPP for Eastern Africa (Mburu, 2010) and the South African Power Pool (SAPP) for southern Africa are also engaged in long term interconnections of grid networks across national borders. (Table 2. Rural electrification in southern Africa)

Table 2. Rural electrification in the Southern Africa power pool (SAPP)

Country	1999	2007
Angola	8	15
Botswana	15	22
Democratic Rep. Congo	4	6.7
Lesotho	3	5
Malawi	3	5

Mozambique	6	7.2
Namibia	26	34
South Africa	65	70
Swaziland	21	28
Tanzania	5	10.5
Zambia	20	39.7

Source: Geni Global Energy Institute, 2010. <http://www.geni.org/globalenergy/library> (Retrieved 22/09/2010)

Several constraints can be identified from the literature. Low income levels (UNDP 2009) due to poverty create problems of affordability for over 80 percent of rural populations. Simultaneously, energy state monopolies are unable to benefit from economies of scale in supplying energy to dispersed low-density settlements (ICSU 2007). There is wastage of natural gas resources through flaring- for example in Nigeria where in 2004, 18.5Gcu.m. was lost (Niyimbona, 2006). The low levels of road density- for example in the Sahel zone and in much of central Africa- mean that there are serious problems of physical accessibility. Extending grid networks which commonly follow existing road networks-save for high capacity transmission lines- is expensive. In some countries, Adenikinju (2008) argues that existing old laws, policies and regulations inhibit the development of competition and an enabling environment. Centralized grid distribution networks exert a heavy toll on infrastructure platforms and increase transmission losses. This is made worse by problems of management efficiency in many of the power utilities in SSA. Apart from a few countries, state policy hardly mentions rural areas as a priority for electrification. An added constraint has been the failure of most countries to develop decentralized energy stand-alone units that use a flexible combination of renewable and non-renewable sources and target particular settlements depending on total population of households. Little effort has been shown in adapting hybrid systems for power generation (Mondal and Denich, 2010) which is widespread in parts of Asia. The failure (ICSU 2007) to mobilize domestic funds to finance energy development is noted. This has been made worse by reluctance to allow private power producers to set up

generation facilities and connect into national grids. The limited capacity for power consumption in rural areas raises concerns about the viability of rural electrification. Finally, responses to participation in regional power pools often indicate the reluctance of some countries to join and participate in the extension of power grid connections across international borders (Mburu 2010). Given that practically none of the sources in current literature relate to limitations imposed on access to energy by settlement patterns, it is possible to design an integrated energy platform using settlement structure as a starting point.

## 2. Materials and Methods

The design of a transmission and distribution grid is basically a network optimization problem (Bergey et al. 2003; Parshall 2009) in which the target is to minimize the total length and cost of transmission links. For purposes of this study, we look at a shortest path model (SPM), a maximum flow model (MFM) and a minimum cost flow model (MCF) all of which are critical tools in network design and optimization. The SPM is used in dealing with the problem of handling materials between points in a fast, cheap and reliable way. The MFM is commonly used in dealing with system capacities for transmitting information and power while the MCF handles flows in the most cost efficient manner. In Figure 1, after Gen et al. (2008:53) a diagraph on the nodes set  $N = \{1, 2, \dots, n\}$  is specified by (1) its number of nodes  $n$ ; (2). The list of its arcs, given as a sequence of ordered  $m$  pairs  $A = \{(i, j), (k, l), \dots\}$ ,



$(s, t)$ . The digraph may then be given as follows: 1. Its number of nodes  $n = 10$ ; 2. The list of its arcs  $A = \{(1, 2), (1, 3), (2, 4), (2, 5), (3, 2), (3, 5), (3, 6), (4, 7), (4, 8), (5, 4), (5, 6), (5, 7), (6, 7), (6, 9), (7, 8), (7, 9), (8, 9), (8, 10), (9, 10)\}$ . [Figure 1. Network directed diagram (diagraph)]

When adapted to optimizing energy access in rural areas, the arcs in Figure 1 represent the shortest connections and the nodes marked 1 to 10 become settlements. It is possible to locate settlements at nodes and along all the arcs in order to maximize supply without extending total network length. The maximum flow component covers the capacity of the power lines for transmitting power between consumption points and the number of sub-stations required along these arcs. Reducing the distances along each of the arcs, lowers the number of step down transformers. Simultaneously, increasing housing units at each node and along arcs reduces the unit cost of energy per household. Densification in settlement and housing at nodes should increase energy consumption potential per unit area thereby reducing costs of supply. An efficient road network improves accessibility and connectivity of the greatest part of the rural population and facilitates fast movement of people and goods between nodes and along arcs. An efficient power grid network brings energy to the greatest number of households at the lowest unit cost of supply. The extent of power grid line optimization is partly controlled by the existing road network but for the EAP, an additional component is introduced. Relying only on SPM, MFM and MCF will produce in theory a graphically efficient distribution of settlements and power grid connections. We need to cater for spatial efficiency in the settlement system if energy access is to facilitate an increase in production. This calls for stretching the arcs  $A = \{(1, 2), (1, 3), n, \dots\}$  in distance such that each node in the network concentrates population, resources, production and circular markets into a system of dense settlements. For large countries with a sparse rural population, the nodes can be located at 50 kilometres from each allowing for a circular or quadratic market shape with an outer perimeter of 25 kilometres from the centre. For already densely populated countries, the nodes can be reduced to intervals of 30 kilometres with a market area demarcated by an outer perimeter of 15 kilometres. The bulk of the population will be concentrated at these nodes, close to these nodes or

along the arcs making every home accessible by road. Settlements should be located at pre-determined nodal points to optimize efficiencies in connectivity, cost of energy, movement and trade. In the second phase, we design a theoretical base platform – an energy access platform (EAP) on which to stage an alternative intervention aimed at increasing the rates of access to rural electrification in SSA. The first step involves mapping the existing road networks, detailed population density and distribution, the existing grid-power supply networks and dominant land-uses in the entire space of each country. These are the four critical inputs on top of the model in Figure 2. Step two involves identifying areas that score high in terms of density and just-positioning map layers of the four inputs. In step three, we rank order these areas into those with the best opportunities for settlement densification and electricity grid power extension on a scale from the best to the worst. Using recent statistics from various sources (IMF 2009) on power production in SSA, on road density, rural energy access and population, correlation analysis is applied to test relationships, if any. [Figure 2. Rural energy access platform (EAP)].

### 3. Results

Rural energy access at household level varies between countries and regions. Some countries have improved rural access tremendously but the majority of countries have not put in places policies and investments for rural electrification. The rate of energy extension from the main urban centres remains low, erratic and often unrecorded. For most countries, energy provision is not a national priority. While some countries show a radical increase in energy generation capacity, there has been extremely limited capital investments in extending rural energy access since the late 1980's. Correlation analysis revealed the absence of a link between power generation, rural energy access, population density and road density. The slow pace of technology adoption partly an outcome of the absence of a green revolution in agriculture means that across much of SSA, energy demand beyond cooking and heating remains low. The dominance of biomass energy means that increasing population leads to large scale deforestation. Few countries have initiated programmes aimed at adapting energy technologies

for the masses of the rural poor. The road network expressed in road density per square kilometre remains, with the exception of South Africa and Zimbabwe, extremely low. The result is that large parts of rural SSA suffer from lack of accessibility. Rural settlements and land use are not planned resulting in a situation where settlement structure is an impediment to land use restructuring. Finally, energy policy and planning are not integrated in the broad rural development strategies of individual

countries. Countries with the greatest increase in energy generation are not the ones with the greatest investment in extension of energy to rural areas. Most countries with great HEP potential have hardly exploited these reserves to increase output. There is no correlation between power generation and percentage of rural access. There is no correlation between road density and length of power grid lines at country level.

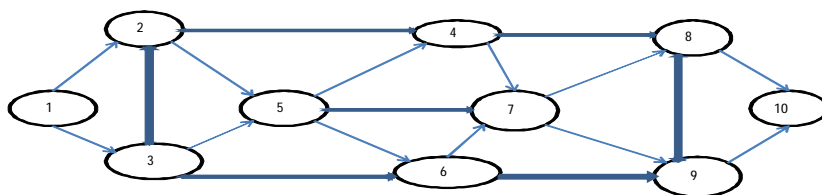


Figure 1 . Network diagram

Source: Gen M, Cheng R, Lin,L 2008. *Network Models and Optimization: Multiobjective Genetic Algorithm Approach*. London: Springer

Reduce to 50% to fit double column format

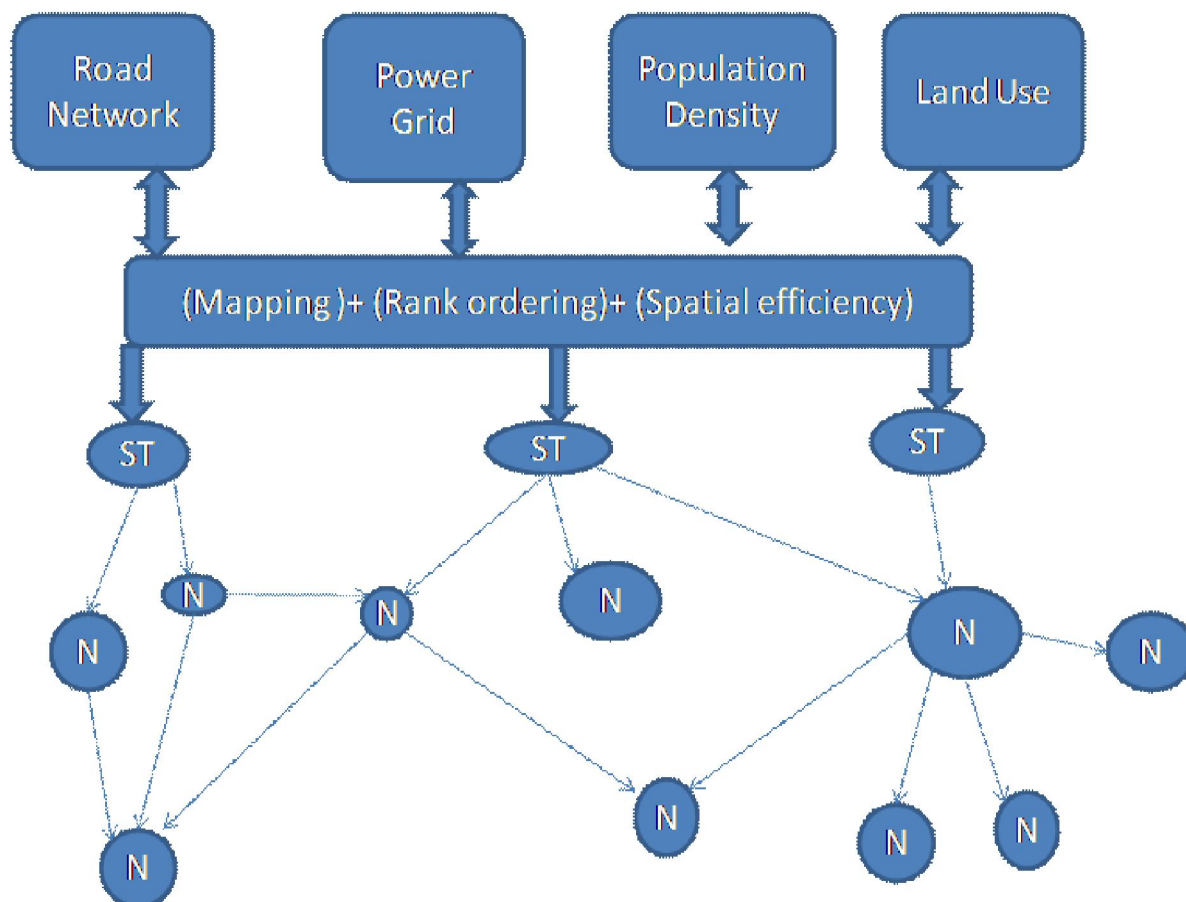


Figure 2. Rural energy access platform (EAP)

where ST= power sub-station, N=settlement nodes,      Arcs=  $\longrightarrow$

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#### 4. Discussion

The results are dealt with in the context of the objectives and implications for energy policy and planning. The model is discussed in terms of the extent to which it offers an alternative and potentially radical planning intervention. Finally, the limitations of the model are briefly presented. Variations in rural energy access between countries often mask internal regional differences. Some countries have improved rural access tremendously but the majority have not

put in place policies and investments for rural electrification. A juxtaposition of road networks, population, economic activities and electricity grids do not show any definite convergence. This implies that policy and planning misses a critical and harsh fact. Settlement patterns in time and space should not be ignored in any rural development effort; a fact that does not appear to feature in any of the development strategies pursued by SSA countries and international organisations today.

The lack of a long term consistent policy of capital investments in the energy sector (IEA 2004)

has adverse effects on rates of energy extension from the main urban centres into the rural countryside. Rural electrification has to be in the context of a far more comprehensive package of interventions (ICSU 2007) aimed at raising standards of living, diversifying rural production systems, accelerating technology adoption and lowering poverty levels. But the findings of this study indicate that the required interventions need to include restructuring settlement patterns since improving energy access alone is not enough to transform the rural social landscape. This position deviates from contemporary literature on how to improve energy access (Davidson and Mwakasonda 2008; Karekezi 2006; ICSU 2007; ECOWAS 2005).

Designing energy programmes for rural areas should address household cooking and water-heating to reduce dependence on fuel wood. Davidson and Sokona (2002) assert that the use of off grid solar home systems should be reviewed urgently as they focus on lighting, which is not the highest priority of the poor. This position however does not highlight issues of affordability and sustainability of such energy supply schemes for rural areas. The slow pace of technology adoption means that across much of SSA, energy demand beyond cooking and heating remains low. This situation has not been helped by policies that initially projected these countries into exporters of natural resources without diversifying the structure of their exports. This is made worse by a consistent policy position that fails to appreciate the multiplier effects of energy access if built into a long term infrastructure programme. The resulting disconnect between settlement location and the potential for generating inter-linked growth multipliers (Ruhiga 2009) is not widely appreciated in land use planning. The EAP addresses this disconnect between settlement, infrastructure and services by proposing a mechanism for targeted settlement densification through which development efforts in the form of rural growth strategies are integrated into a single multi-purpose strategy. Rural electrification then becomes a critical cog in this overall framework.

It is argued that the focus of energy planning should be raised so that energy access is seen as a potentially critical input in the development equation. In the meantime, for most countries, energy provision is not a national priority (IEA 2004). The

actual extension of energy into rural areas remains low, erratic and is often unrecorded (Karekezi and Kimani 2004). Indeed, the lack of national data bases on electricity extension for many countries is a measure of the low priority accorded (Deichman et al. 2010). While some countries show a radical increase in energy generation capacity, there has been extremely limited capital investments in extending rural energy access since the late 1980's. Based on the latest statistics on the energy sector road networks, population density and economic activity, computations through correlation analysis revealed a consistent absence of any significant correlations.

The dominance of biomass energy means that large scale deforestation is a real problem today. A reduction in biomass usage as the main source of energy requires an accelerated rural electrification programme for the entire SSA. But such a programme must be sensitive to issues of affordability and sustainability. These presuppose a form of planning for infrastructure, settlement and energy which is integrated and aims at achieving efficiencies in resource deployment. Empirical evidence in those countries where radical extension of electricity has occurred in the last 15 years indicate no parallel restructuring of production systems. This finding departs from the hype commonly associated with the impact of energy in rural areas. In the meantime, few countries have initiated programmes aimed at adapting energy technologies for the masses of the rural poor. At the same time, the road network registers low density scores except South Africa, Nigeria and Zimbabwe. The result is that large parts of rural SSA suffer from lack of accessibility. Through linking existing road networks to distribution of electricity, telephone lines, schools, health facilities and water, there will be a natural tendency for a shift in the location of settlement. This should translate into a movement towards the nearest road generating a nodal, linear- corridor arrangement of settlements following the road network. This should allow for optimizing energy access (ECA 2007) by these new structures because they inevitably decay distance.

Rural settlements and land use are not planned resulting in a situation where settlement structure is an impediment to land use restructuring. Settlement patterns in SSA were not intended to be points for generating economic activities in space.

Apart a few countries, no major settlement restructuring programmes have occurred in SSA. In individual countries, internal population re-distribution has occurred in Kenya, Uganda, Rwanda, DRC and to some extent in parts of Sudan but this has not radically transformed rural areas as such. Traditional settlement patterns often pose severe limitations on the extension of feeder roads and on the supply of essential services because the configuration of individual and communal holdings is not linked to the road network. The growth of dense settlement nodes would eventually evolve as a natural process. Finally, energy policy and planning are not integrated in the broad rural development strategies of individual countries (ICSU 2007). The attractiveness of the model therefore lies in the ultimate opportunities it offers not just through accelerating access to rural energy but in creating a radical growth platform for re-engineering the rural space for development. There is empirical evidence throughout SSA and in other developing regions of this taking place whenever roads are built into formerly un-accessible areas. To change the status quo, there is a need to review policy positions and strategic integration of resources in the development equation at various scales.

The EAP provides a radical but integrated system of planning for infrastructure, energy, transport and settlement as a base for providing services and mobilizing rural development. Accordingly, the platform built on a network design base offers possibilities for re-organising the entire rural landscape into an efficient production system making it possible to supply energy on an affordable and sustainable way. For this to occur, rural planning should aim at restructuring settlement structure to facilitate access to infrastructure and services. Note that the position of this paper is an alternative standpoint from that of the World Bank (2009) whose strategy calls for direct support for the poor through finance and technical assistance. A paradigm shift in planning is implied in this model which presents human settlement as a critical platform in the configuration and allocation of resources. Infrastructure policy, planning and provision should be tied to a long-term strategy of integrated planning. This position departs from Adenikinju (2008) who instead calls for private public partnerships in fighting rural poverty.

Several assumptions of the model are

provided. The first is that there exists in each country the necessary political will to support, sustain and drive a radical policy shift in integrating energy planning into a long term consolidated national development plan. That each country commits a significant annual expenditure on energy infrastructure. That restructuring rural settlement patterns requires as a starting point some form of land tenure reform to create a stronger regime of property rights. That once certain settlements are seen to be the priority target of energy access, services and development, as a result of a deliberate policy of differential resource allocation and infrastructure investments- these will exert an attraction on the settlement and resettlement behaviour of people outside of these localities. That population re-distribution should free resources currently either not optimally deployed to better uses and these developments will see the growth of large nodal and linear villages.

Several limitations are worth noting here. It has not been possible to undertake actual computations to determine variations in the shape of the EAP at the level of individual countries. The model is a development from network theory; however, the geography of the present road network and surface topography may disrupt the attempt at spatial efficiency. Because no major re-structuring of these networks occurred after the 1960's, they remain often poorly configured in addressing accessibility and connectivity needs of these countries. Restructuring the road network in each of these countries may carry with it a heavy capital overhead that poor countries may not be willing to consider. The EAP requires a level of state political, policy and planning support on a radical, sustained long term basis, something that most SSA countries may not be capable of given the doubtful stability of the planning policy environment. The EAP calls for a level of development coordination and land-use re-engineering that may alarm the political elite in individual countries for fear of the possible adverse reactions of the masses of the people. The EAP requires a paradigm shift in the way development is viewed for it proposes a deliberate system of selective resource allocation towards few nodes in order to cause a gradual shift in population, settlement structure and production systems through agglomeration forces. In addition, the EAP requires a form of land tenure reform that may see the eventual



disappearance of communal tenure and its replacement by a private ownership system that separates residence from farm production.

In conclusion key issues around the energy sector have been raised and a set of critical constraints discussed in the context of increasing energy access. By integrating power grids with population, road networks, dominant land use activity, it has been possible to design an integrated energy access platform through settlement re-engineering. The resulting platform is a radical but feasible departure from conventional energy policy and planning. The EAP is discussed in terms of assumptions, opportunities and limitations. The EAP proposed here opens an alternative but exciting line of thinking on rural energy access and may provide a cheap and efficient method of increasing access to energy in rural SSA. There is an urgent need to review and transform conventional planning approaches in order to make settlement a key element in development interventions and energy policy and planning should be integrated into a comprehensive regional and national rural development strategy if it is to achieve efficiencies and develop growth multipliers.

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## Applications of Remote Sensing and GIS Techniques in Analyzing the Effects of Rainfall Variability on Crop Acreage

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**Abstract:** Climate change is a global concern and has a major impact on overall economic development. This is even more prominent in developing countries, especially in Sub-Saharan Africa. As one of the major elements of climatic change, rainfall variability is one the most unpredictable factor and a common cause of failure in agricultural production. The impact and the pattern of the variation in crop acreage changes in this region are investigated with particular reference to the semi-arid parts of Southern Africa. Satellite images of Mafikeng municipal area, North West Province, South Africa, are used to detect changes since 1988 with an image processing tool (ERDAS-Imagine). The resulting output allows for change detection and image classification for different land cover classes. The GIS package (Arc Map9.3) was used for mapping and visualizing the results on the screen and paper. The findings indicate that the periodic variation and irregularity of rainfall in the region does not have a particular negative effect on the size of crop land in the study area. The insights have direct policy and planning implications for dry land agriculture in the face of current climatic variations. [Life Science Journal. 2011;8(S1):59-67] (09) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

Key words: Climate change; satellite images; land cover change; Mafikeng

### 1. Introduction

In the past the Mafikeng municipal area in the North West Province of South Africa was highly dependent on agricultural products (Mason et al. 1997). Since late 1980s most agricultural fields are lying fallow and the total output is declining at a remarkable rate (ICRA 2003). Since variation of agricultural crop output to a large extent depends on rainfall amounts and seasonality, investigating the variability and the trend of these phenomena at a local scale is highly imperative. As the major element of climatic change, rainfall variability can adversely affect social, economic, political, cultural and other functions of a region during extreme climatic regimes. Accurate prediction of this variability may prevent large scale consequences at a higher level. In order to meet such objective, it is important to develop a method of compatible prediction by considering the realities of the local climatic patterns based on the available past experiences and present environmental, socio-economic and cultural situations. This phenomenon at a local scale can play a very prominent role because it is the base for regional and global scales. Although the small scale features have little direct effect on the planetary scale simply

because they are treated as rather unnecessary, nevertheless they tend to modify the state of the planetary at a significant scale (Kabanda and Munyati 2010). Rainfall variability is a complex phenomenon which mostly depends on various interactions of meteorological elements. Of the many natural hazards facing the Mafikeng Local Municipality in South Africa today, the extent and variability of rainfall remains the most difficult to quantify, delineate, visualize and quickly interpret in maps (ICRA 2003). the variability of rainfall emerge evolve and migrate most of the time without considering major physical barriers in the landscape and in most cases farmers many hundreds of kilometers away from the actual phenomena can be impacted (Wilhite and Glantz 1987). This paper presents a systematic analysis of how the characteristics of rainfall variability can affect changes in crop acreage in the study area.

### 2. Materials and Methods

The study was carried out for Mafikeng Municipal area located in North West Province of South Africa between 25.266°E and 26.157°E latitude and -25.508°S and -26.380S longitude lies

immediately south of Botswana. Climatic data and satellite images were used in this study. The climatic data of the study area was acquired from South African weather bureau and the satellite images of the study sites were downloaded from land-sat home page for the years 1990 and 2000. An aggregated average rainfall is presented separately as a standardized departure 'Xi' from the long term (30 years) mean i.e. the mean over the entire length of records, (Sirdas and Sen, 2004) to evaluate the overall distribution of the rainfall in the study area.

$$Xi = (r - \mu) / \delta, \quad (\text{Equation-1})$$

Xi – Standardized departure of rainfall, r – Rainfall total of the year,  $\mu$  – Mean annual rainfall,  $\delta$  –

Standard deviation of rainfall totals from the mean. Station rainfall have been treated differently i.e. only the major three summer months (January, February and March) have been considered since the growing summer season fall under these particular months, mainly to be compared with the potential evapotranspiration rate (equation-2) of the same months (Vörösmarty et al. 1996) and (Papadopoulos et al. 2003) to determine agricultural potential of the study area in terms of actual rainfall efficiency.

$$E = 16 C (10T_m/I)^a \quad (\text{Equation-2}).$$

Where, E – Potential Evapotranspiration Rate, C – Day light coefficient,  $T_m$  – Average monthly temperature, – Exponent derived from the heat index, I – Heat index [ $I = (T_m/5)^{1.51}$ ].

GIS software (Arc-Map-9.3) for mapping and visualizing the area of interest and ERDAS-Imagine for processing satellite images have been used to create interactive maps of temporal changes in agricultural fields for the study area. Hence, this process involved the creation of base layers like municipal and ward boundaries with drainage network and mapping of water bodies from the existing top sheets on a scale 1:25 000 and 1:50 000. Extraction of bands with resolution of 30 meters from the Land-Sat data and identification of ground control points (GCP's) and geo-correction of bands through nearest neighbour resampling method. Cropping and mosaicing of data corresponding to the study area was followed by generation of FCC (False Color Composite) and identification of training sites. Collection of attribute information from field was undertaken corresponding to the chosen training sites

using GPS. Classification of remote sensing data (1990 and 2000) was through the use of a maximum likelihood classification method (Kulf et al. 1995). Change detection analysis was made by using a temporal image ratioing and image differencing methods to quantify the changes that took place over time, (Lillesand and Kiefer 1987).

### 3. Results

In terms of annual rainfall, the rainfall variability indices in Mafikeng North West, South Africa for 1980-2009 are averaged for all four stations used in this study (Figure 1). In general, 7 major periods have been observed since 1980. It began with wet period (1980-1982) followed by relatively longer periods of drought which lasted for 5 years (1983-1987). Even though, this period has been interrupted by 1988 and 1989 positive indices, the drought has continued again from 1990-to 1994. The area was experiencing relatively wetter episodes from 1995-2001 with the exception of 1999 being relatively drier year. The period 2002-2007 with the exception of 2005 relatively wetter year, was characterized by drier condition which was followed by 2008 and 2009 near normal wet period. [(Figure 1. Normalized annual rainfall departure)

For summer rainfall variability, Rainfall-Station-1 from Figure 2, five years-running means show summer rainfall below the long term mean from the beginning of period up to 1984. After 1984 to early 1990s the rainfall was well above the mean. From 1990-1995, the rainfall was once again below the long term mean. It was only 1994 to 1999 when the summer rainfall was above the mean. While 2000 up to the end of 2007 the rainfall was below the mean. The rainfall started increasing from 2008 to the end of the period. Even though the five years running means of rainfall of Station-1 were fluctuating around the mean of the three summer months, it has never approached the potential evapotranspiration rate (equation 2) of the three summer months of the study area. [Figure 3 Summer rainfall and Summer Potential Evapotranspiration Rate (Station-1)]

For Rainfall-Station-2, 5 years-running means show summer three month rainfall below the long term running means from the beginning of the period to the end of 1985 (Figure 3). From 1986 up to 1988 the rainfall was above the long term mean until it was interrupted by relatively below average rainfall from 1989 up to 1992. The period from 1993 to 1997

depicts above rainfall pattern in the area. The rainfall was below the average from 1998 up to 2002, and finally, from 2003 up to the end the rainfall near parallel above the mean. However, the total summer rainfall in this area is well below the potential evapotranspiration rate even though, the total amount of rainfall deviates extremely from the long term mean. [Figure 3 Summer rainfall and Summer Potential Evapotranspiration Rate (Station- 2)]

Station-3 in Figure 4, 5 years running means show summer rainfall below the long term mean from the beginning up to the early 1990s with the exception of 1985 when the rainfall was slightly above the mean. Interrupted by a negative deviation from the mean between the years 1995 up to 2002, the rainfall was well above average between the years 1992 to the end of the period. Potential evapotranspiration rate is well above the average rainfall and the fluctuating rainfall over the mean. [Figure 4 Summer rainfall and Summer Potential Evapotranspiration Rate (Station-3)]

Station-4 in Figure 5, 5 years running means shows from the early 1980s up to mid 1980s the rainfall was below the average. The rainfall was well above the mean from 1985 up to 1989. From early 1990s up to the early 2000s, the rainfall was below the mean with the exception of 1995 and 1996. From 2003 the rainfall remained nearly the same as the long term mean. The five year running mean and the average summer rainfall remained well below the potential evapotranspiration rate up to the end of the period. [Figure 6 Summer rainfall and Summer Potential Evapotranspiration Rate (Station-4)]

With reference to changes in crop acreage, for the period 1980 to 2003, major changes are noted. Around 1980s and 1990s large parts of the study area was under cultivation, that is approximately ~148633 ha in 1980 and ~135761 ha in 1990. Even though, during these periods agricultural activity was dominated by large scale farming system that covered most parts of the study area, there was considerable amount of farm land under small scale agriculturalists. The large scale farms during these periods were confined to south western and north eastern portion of the area between the Mogosane and Ramatlabama rivers which are relatively far away from the major town, Mafikeng. The south western portion of the large scale agricultural site is found between the

intermittent river systems of Matlonyane. Small scale agricultural farm sites were concentrated along the Upper Molopo river catchment in the north western portion of the Mafikeng Local Municipality. In the early 2000s the small scale agricultural activity declined to unrecognizable size while the large scale farming also faced a huge set back in terms of size at both south western and north eastern portion of the municipality. During this period the total amount of land under cultivation was ~22353 ha for large scale farmers and there was no visible agricultural activity under small scale farming system.

The rate of annual rainfall variability was compared with the rate of changes in the size of agricultural fields. The normalized departure of annual rainfall and the normalized departure of agricultural fields have been computed to determine the impact of rainfall variability on the declining size of agricultural fields (Figure 7). Contrary to most sub Saharan African countries, more particularly semi arid southern African region where rainfall variability is the major cause of decline in terms of productivity in agricultural output and size of agricultural fields, the study area is not influenced strongly by this phenomena. The correlation between rainfall variability and changes in agricultural fields is weak with a value of  $r = -0.2641$  at  $p < .05000$  significant level (Figure 7). Figure 7. Normalized departure of Agricultural Fields and Normalized departure of precipitation]

The weak correlation between these two phenomena can be attributed to changes in the political system and agricultural policy of the country. Generally, the results show poor correlation between rainfall variability and changes in the size of agricultural fields. The moderately declining size of agricultural fields with average rate of decline of 1287.2ha per annum between the year 1980 and 1990 has been overtaken by a drastic decline 11340.4ha per annum between the year 1990 and 2000.

#### 4. Discussion

The results show that there is no well defined temporal trend for the 30 years rainfall data from the study area, Mafikeng Local Municipality [Figure 8, Annual rainfall Trend (Station-1), Figure 9. Annual rainfall Trend (Station-2), Figure 10. Annual rainfall Trend (Station-3), Figure 11 Annual rainfall Trend (Station-4)]

These findings are consistent with Nash et al. (2007). There is evidence of rainfall variability in the

study area associated with above and below average pattern both annually and seasonally. Moreover, the potential evapotranspiration rate is far higher than the actual rainfall and the long term mean even during the wettest period (Vogel 2000). The scarcity of water for arable agriculture in Mafikeng is reflected in the low and highly variable annual rainfall received and the high evaporative demands (Chipanshi et al. 2006). Monthly rainfall for the study area over the last 30 years is generally drier, especially during the months of January, February and March (Figure 2), the normalized annual departure of rainfall indicates unclear fluctuating trends for the study area (Table 1).

With slight differences in overall trends, all the stations across the study area have similar characteristics. The spatial extent of cultivated area shows significant decline in terms of size between the year 1980 and 2000. Both large scale farms and small scale farms have been reduced in extents from ~92536 ha in 1980 and ~77507 ha in 1990 to ~22270 ha in 2000 in which the small scale farming was almost undetectable on 2000. ICRA (2003) indicated that about 95% of semi commercial farmers and more than 52% of commercial farmers in Mafikeng Local Municipality let their agricultural land lie fallow. In addition, accelerated movement of working adult population to urban centers, land degradation and the rainfall variability and its erratic nature which is hardly predictable from year to year and other environmental factors are the major reasons for the

decline of agricultural activity in the study area, (ICRA, 2003). Moreover, the opportunities which are associated with the transitional 1994 democratically elected government are also among the pull factor of the working classes to different urban centers in the country. A change in the distribution and magnitude of extreme rainfall events (associated with changing variability), such as droughts or flooding, have significant psychological impact on human and natural phenomena than a changing amount of rainfall distribution over time (Williams et al. 2009), as the region is considered vulnerable to and ill-equipped (in terms of adaptation) for extreme events (Thomas et al. 2005).

In conclusion, the fluctuating extreme environmental cases and the opportunities which were associated with the 1994 transitional government have played a major role in the decline of agricultural fields especially among small scale agriculturalists where rain fed farming was very common. Agricultural activity in the study area is very difficult if it is not impossible in the absence of further water supply from other sources, more specifically in the absence of irrigable river and underground water. It is recommended that more organized research

Integrating environmental, cultural, social and political factors have particular importance to come up with long lasting solution in terms of developing effective and consistent agricultural activity in the study area.

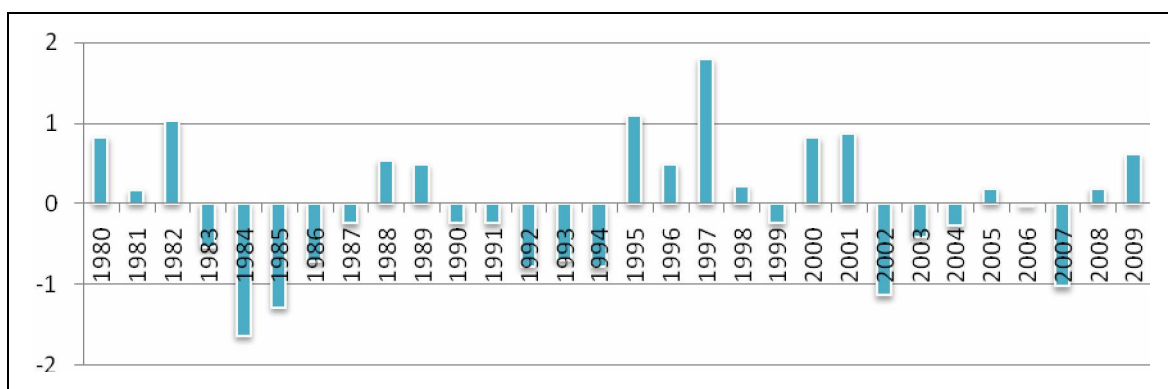


Figure 4: Normalised annual rainfall departure



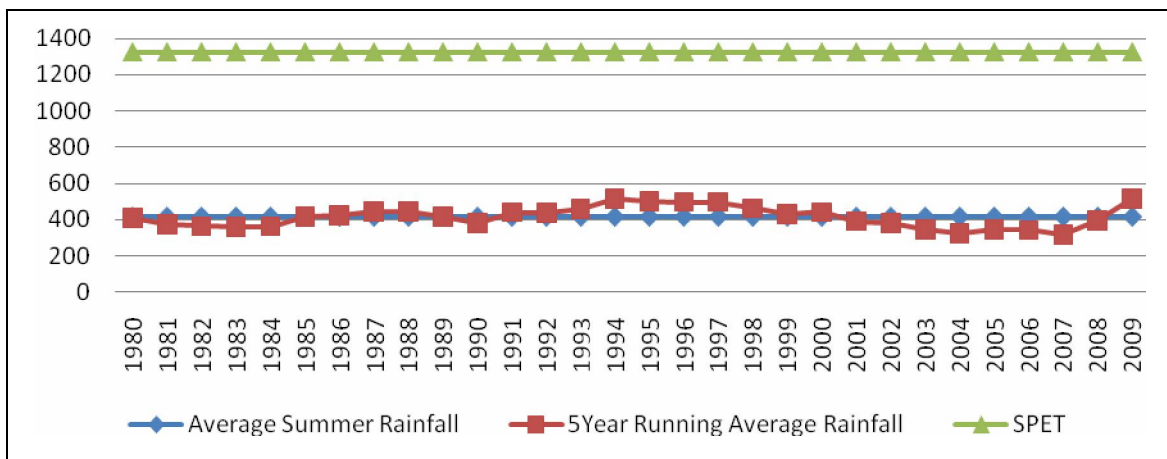


Figure 5: Summer rainfall and Summer Potential Evapotranspiration Rate (Station-1)

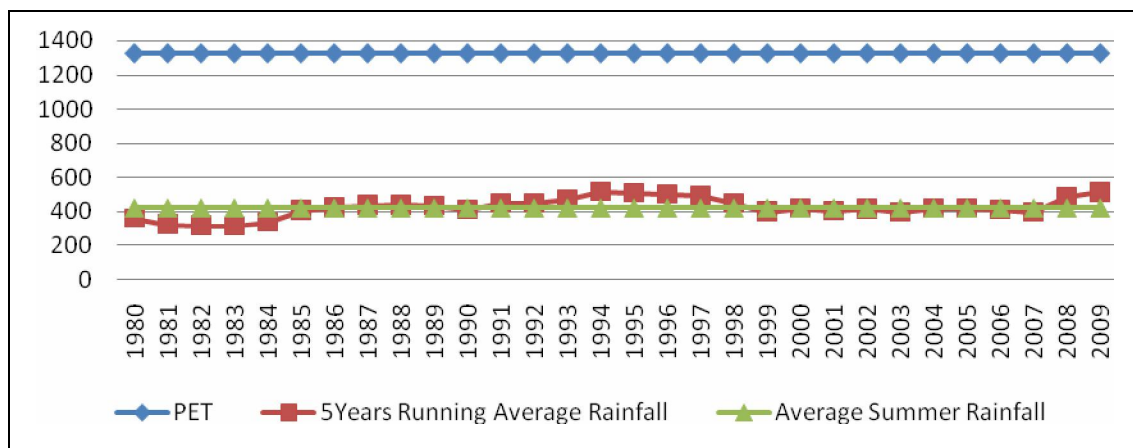


Figure 6: Summer rainfall and Summer Potential Evapotranspiration Rate (Station- 2)

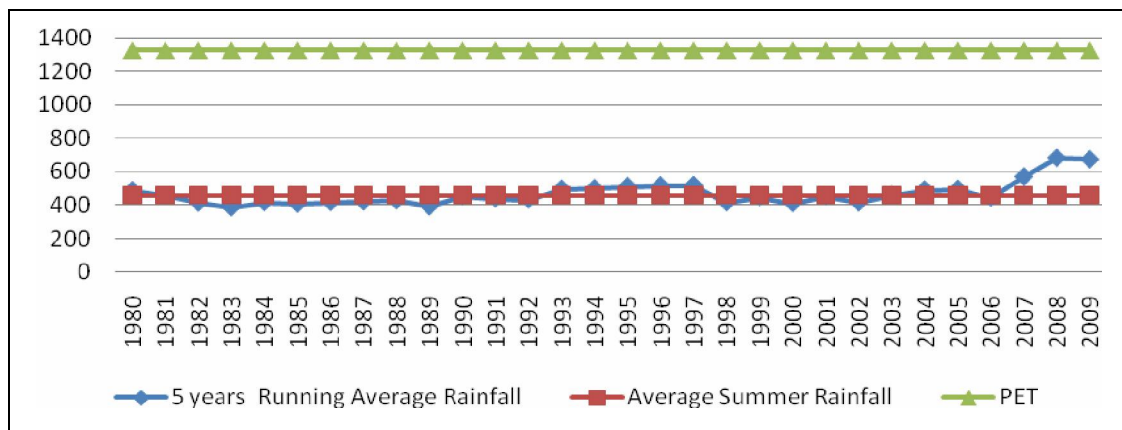


Figure 7: Summer rainfall and Summer Potential Evapotranspiration Rate (Station-3)

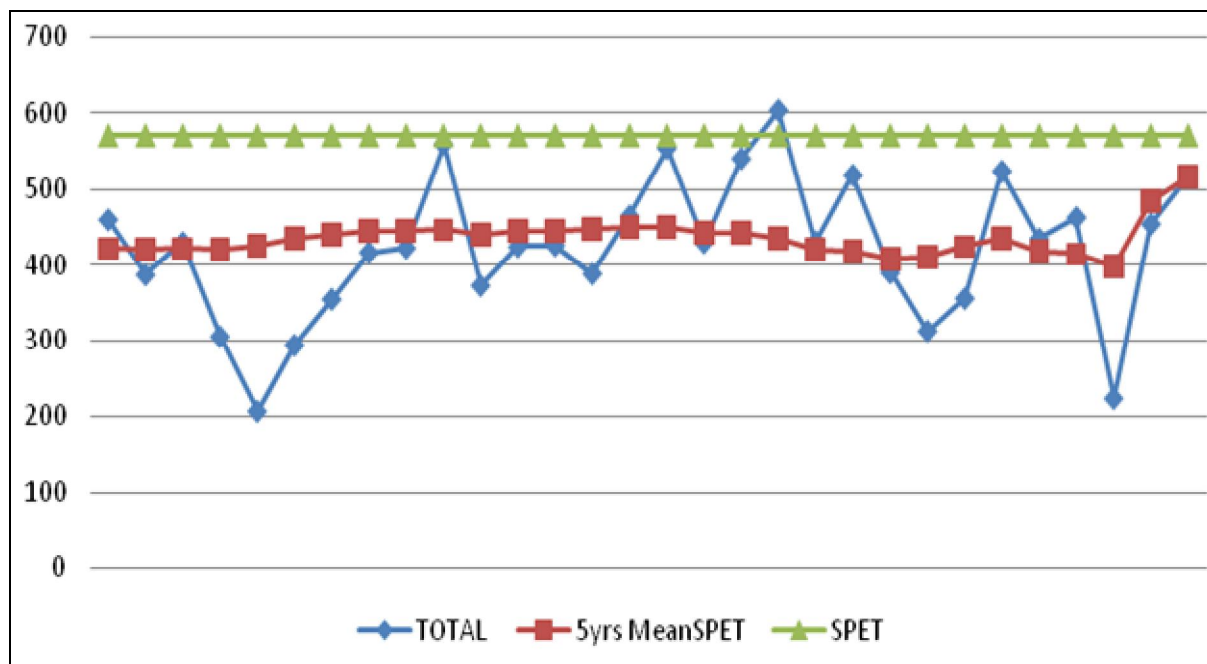


Figure 8: Summer rainfall and Summer Potential Evapotranspiration Rate (Station-4)

Table.1 Average summer actual rainfall and the potential evapotranspiration rate of the same period.

Station	SMRF	SPET	SPET-SSMRF
Station-1	270.2	571	300.8
Station-2	259.6	573	313.4
Station-3	292	571	279
Station-4	276	572	296

N.B SMRF-Summer Mean Rainfall, SPET-Summer (January, February, March) Potential Evapotranspiration Rate

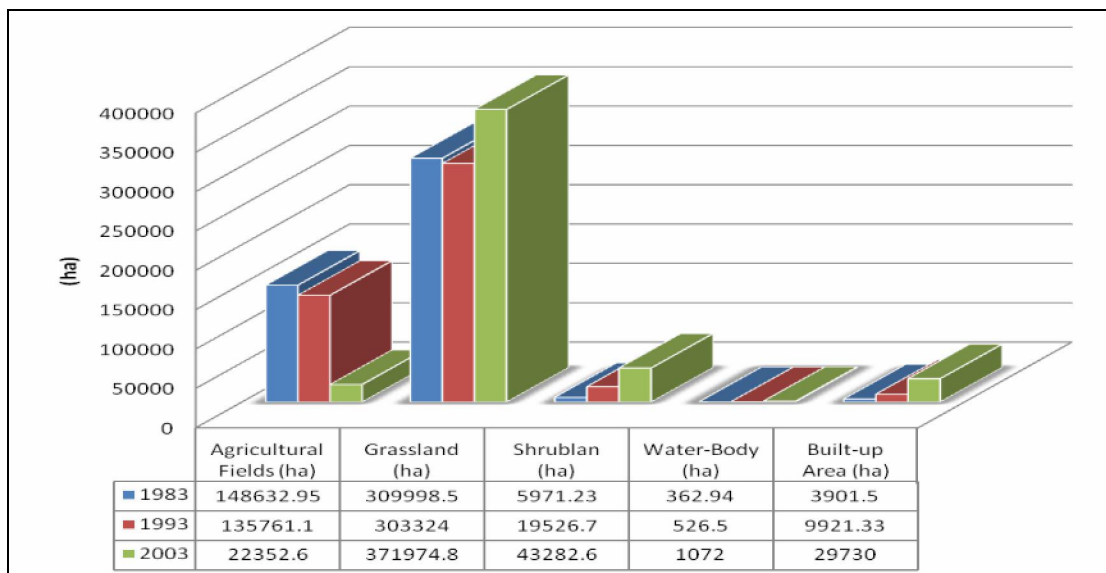


Figure 9: Land Cover Distribution (1983, 1993, 2003)

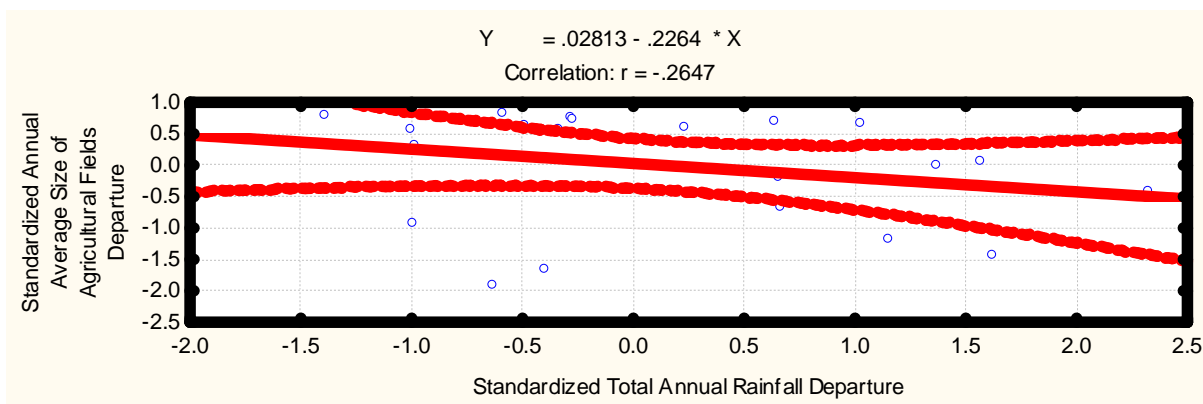


Figure 10: Normalized departure of Agricultural Fields and Normalized departure of precipitation

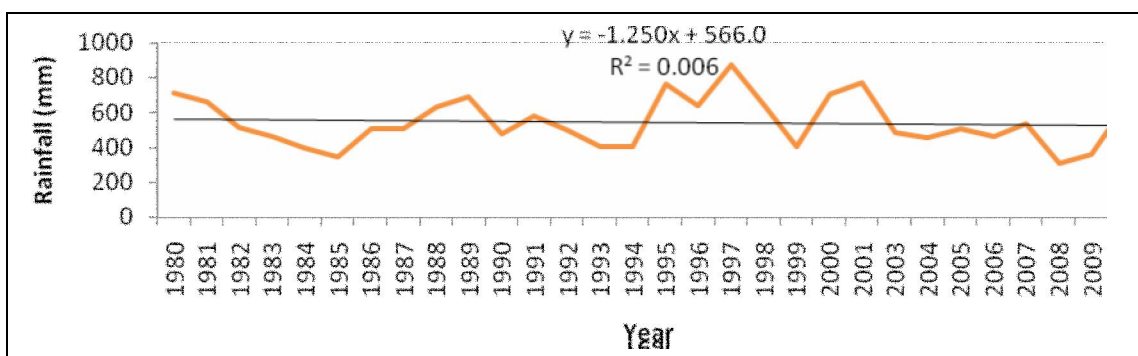


Figure 11: Annual rainfall Trend (Station-1)

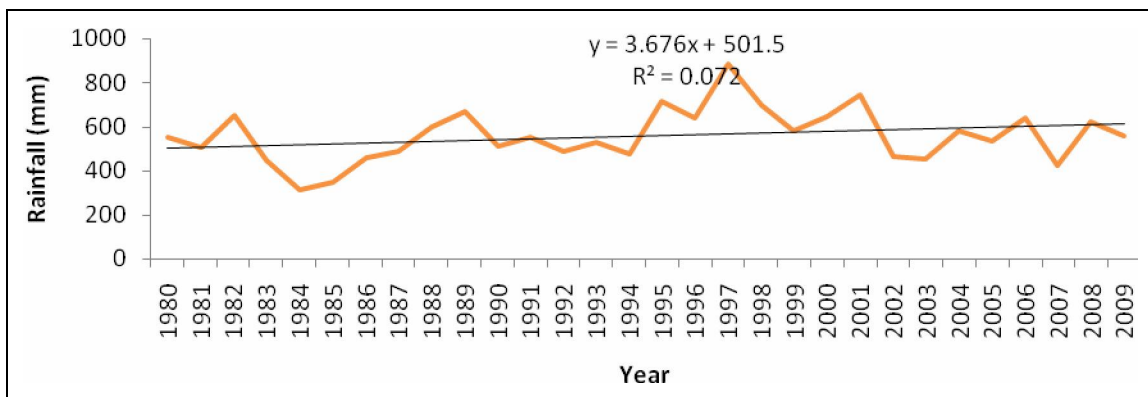


Figure 12: Annual rainfall Trend (Station-2)

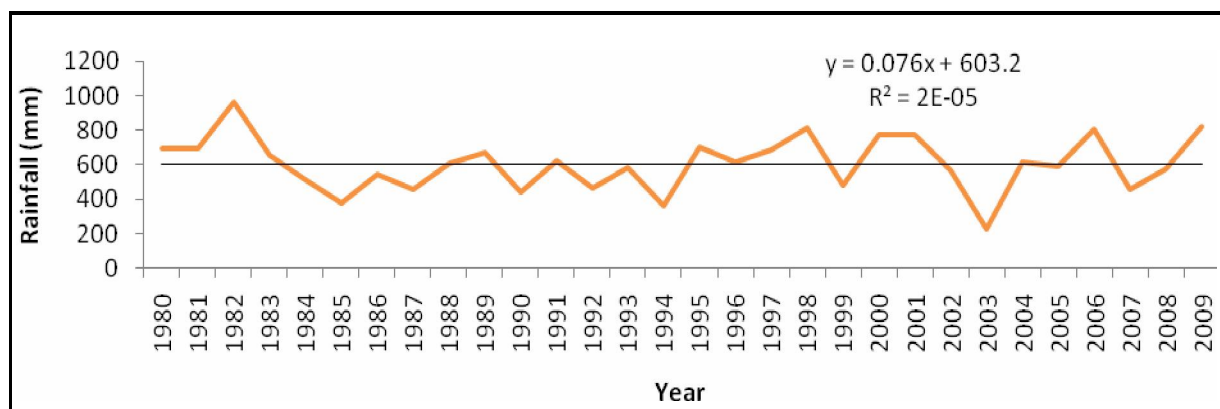


Figure 13: Annual rainfall Trend (Station-3)

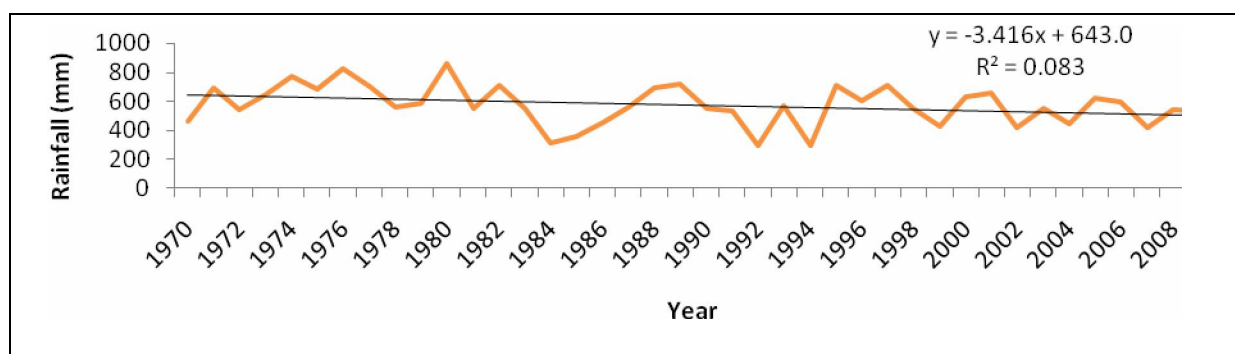


Figure 14: Annual rainfall Trend (Station-4)

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## Seasonal weather events and their impact on buildings around Mafikeng, North West Province, South Africa

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**Abstract:** The study used time series analysis of climatic data (1978 to 2009) of rainfall, temperature and wind to investigate the impact of extreme weather events on buildings and their surroundings in Mafikeng, South Africa. Questionnaires were administered on 100 households in order to establish residents' experiences on seasonal weather events. Mafikeng and its environs, belong to arid climate regions; it features a long term mean seasonal rainfall of approximately 76mm and it receives a unimodal rain season which starts in October and end in April of the following year. In this study, the results reveals that Mafikeng experienced the highest rainfall during the 1997 with a seasonal rainfall mean of 117 mm and the lowest rainfall was experienced during the 1991 season (32 mm). The 1997 rainfall resulted into waterlogging and leaking of roofs in the homes. Extreme temperatures were experienced in the area during 1992 summer season where the highest mean maximum temperature of 37<sup>0</sup>C was recorded. Usually the maximum temperature in Mafikeng range between 25<sup>0</sup>C and 32<sup>0</sup>C. The lowest minimum temperature (-7.5<sup>0</sup>C) was observed in 1994 during the cold season. The study identified that the extreme weather events in Mafikeng are associated with building fatigue, which resulted into structural damages such as cracked walls, windblown roofs, dust accumulating indoors from dust storms and noise pollution. The study highlights the need for maintaining appropriate building standards, designs and regular review of standards in Mafikeng and its surroundings in order to address climate extreme and the climate change issues. [Life Science Journal. 2011;8(S1):68-73] (10) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Seasonal weather events, Climate change, Mafikeng.

### 1. Introduction

Climatic impact from precipitation, wind, temperature and exposure to the sun causes extensive degradation and damage to the built environment every year. It is important to understand how and why degradation and damage occur and how a reversal of this scenario is of considerable importance in the design and construction of building structures (Nielsen et al. 2007). Observations at various sites worldwide point to changes in climate system due to global warming. Warmer climates with intensified weather events will require new conditions for the construction industry. Knowledge about potential impacts on the built environment will be of utmost importance in the years to come (Building Research Establishment and Norwegian Building Research Institute 2002).

The future of cities as desirable places for human settlements remains questionable as climate change has an impact on infrastructure and in human settlements such as buildings, transportation networks and wastewater systems (Intergovernmental Panel on

Climate Change 2009). It is then important for government to provide a policy, to develop and update construction designs that can withstand most external influences, whether cold, heat or heavy rainfall. However, with governments facing tighter budgets and higher demands for progress and quality in housing (Sexwale 2009) and increased urbanization, an immediate problem encountered in urban areas is the shortage of adequate housing accommodation.

Seasonal weather events are highly variable and at times become extreme. These impacts may have significant consequences for Mafikeng society in a number of areas. For example in January 2010, Taung near Vryburg in the North West Province experienced floods that affected access to roads and many houses at other inaccessible areas were destroyed (South Africa Broadcasting Cooperation News, 2010). This is a clear example of how vulnerable an area can be to fluctuations in climate and extreme weather. However, Mafikeng Municipality residents are not prepared for such



adverse weather changes yet few studies have focused on the possible impacts of seasonal weather events on the built environment (Building Research Establishment and Norwegian Building Research Institute 2002). The importance of considering effects of climate changes on the type and design of dwellings for an informed decision on proper building planning, construction and geographical localization cannot be underestimated. The current study seeks to evaluate the impacts associated with seasonal weather and climate events on building structures, types and on the surrounding land in Mafikeng in the North West Province, South Africa.

## 2. Materials and Methods

Mafikeng, upon which the study is based, is situated in the Ngaka Modiri Molema District Municipality, the second largest district in the North West Province by population and size (Setsetse et al. 2007). Mafikeng is on the far northern part of North West Province of South Africa, bordering on Botswana (Figure 1).

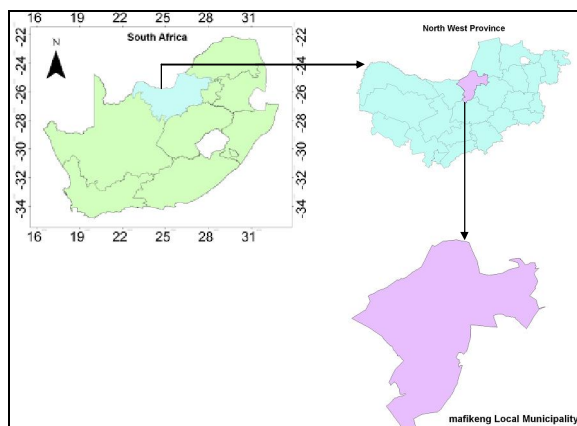


Figure 1: Study area: Mafikeng Local Municipality (Kabanda 2010)

Mafikeng Municipality has experienced population increase from 259502 in 2001 to approximately 290229 in 2007 (Statistics South Africa Community Survey 2009), representing an average annual growth of 1.9 %. The population in Mafikeng is characterized by middle – income residents as the proportion of households living in formal dwellings decreased from 87.2% in 2001 to 80.8% in 2007 while the proportion of households living in informal

housing increased from 8.8% in 2001 to 15.1% in 2007 (Statistics South Africa Community Survey 2009). Urbanization has notably improved the economic prospects and life of people. However, it has also caused many problems including housing. The Provincial Department of Local Government and Housing, acknowledges that the municipality has a housing backlog of 43 736 houses. This means that approximately 40 000 families live in informal houses (Vilakazi 2004).

Characterisation of extreme weather events utilises climatic data (temperature, rainfall and wind) from 1978 to 2009 obtained from South African Weather Services. Statistical analysis of climatic data (temperature and rainfall) through standardisation and normalisation yielded anomalies above and below the normal values (Makarau 1995; McPhee et al. 1994). This helped in identifying wet and dry spells within the period 1978 – 2009 for the Mafikeng Local Municipality. In addition, pentad analysis was done in order to explain the most effective period of average annual rainfall and temperature, and to define intra-seasonal climate variability (Singo 2008). Questionnaires were administered on 100 households sampled from four regions (Dibate and Montshia Extension 38–informal settlements; and Unit 13 and Leopard Park – formal settlements) within the study area. Purposive sampling technique was used to capture residents who have occupied the same house/dwelling place for more than ten years. Responses from questionnaires formed the bulk of primary data on building materials and residents' experiences of extreme weather events such as years of extreme heavy rains, gusty winds and high temperatures. In addition, observations in terms of durability of building materials, availability of ceiling and thickness of walls formed part of the research design.

Statistical analyses (means and standard deviations) on climatic data were done to determine the extremities in climate in the study area. Information from questionnaires and interviews was gathered, transformed and analyzed using Statistical Package for Social Scientists (SPSS) package. Frequencies were drawn to describe the relationships between the extreme weather events and respondents experiences during corresponding years of extreme events.

### 3. Results

The results of standardised anomalies of seasonal rainfall showed that Mafikeng Local Municipality experienced normal, near normal, above normal and below normal values from 1978 to 2009 with 1981 and 1997 as the wettest seasons (Figure 2). The results revealed that Mafikeng experienced the highest rainfall during the 1997 season with a seasonal rainfall mean of 117 mm (long-term mean = 48.2 mm) and the lowest rainfall was experienced during the 1991 season (32 mm).

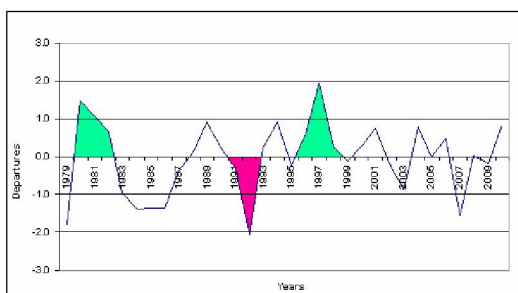


Figure 2: Time series of standardised seasonal rainfall

In terms of intra-seasonal rainfall variability, the mean pentad rainfall for 1997 wet season, shows greater variability from pentad 31 to pentad 41 when the rainfall was concentrated in days with pentad rainfall totals > 20 mm, the highest rainfall reached was 87 mm (Figure 3). The 1997 season recorded a longest continuous wet period of 12 pentads (approximately 60 days) with 342mm falling in this period.

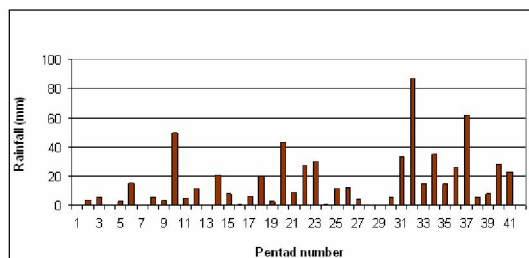


Figure 3: 1997 Rainfall pentads for wet season

Analysis of seasonal rainfall departures for all the rainy months in a dry season (May to

September) indicated a long-term mean of 9.5mm and the standard deviation was 8.5 mm. The dry season anomalies presented in Figure 4 shows evidence of a gradual decrease of rainfall from 1979 to 1996; that signified a continuous drying that lasted for about 17 years.

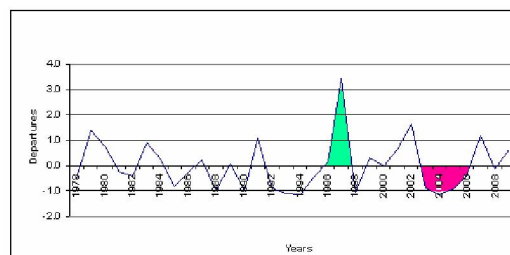


Figure 4: Time series of standardised dry seasonal rainfall

Temperature was divided into two seasons, summer (October to April) and winter (May to September) based on the monthly temperature time series. Figure 5a shows the seasonal mean maximum temperature in summer for Mafikeng. Temperature data for that season was standardised with respect to the long-term mean (28.8°C) and the standard deviation (1.2°C). The trend pattern of the temperature in the 31-year period remains unchanged. The 1992 season had the highest departure of 2.0 above normal. Figure 5b shows the seasonal mean minimum temperature that was standardised with respect to the long-term mean (6.6°C) and the standard deviation (0.7°C). The 1994 season had the lowest departure of 2.0 below normal temperature. Extreme temperatures were experienced in the area with 1992 summer season having the highest maximum temperature of 37°C (mean range = 25.6°C to 30.9°C), while two seasons later 1994 cold season had the lowest minimum temperature of -7.5°C (mean = 7.9°C to 5.3°C).

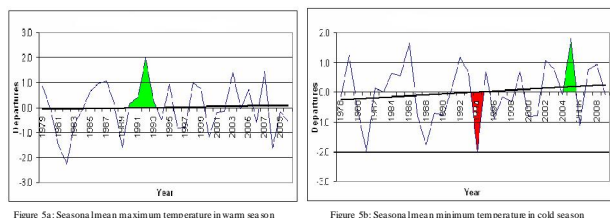


Figure 5a and 5b. Seasonal mean maximum temperature in warm season

Wind roses were used to summarise the occurrences of winds in the study area to show their speed, direction and frequency. Figure 6 shows the winds in Mafikeng during the year, blow from the north northeast much of the time. The 3 spokes around the northeast direction (N, NE and NNE) comprise 47% of all hourly wind directions and approximately 5% of the time in the year in Mafikeng the wind blows from the north northeast at speeds between 2.5 and 3.5 m/s.

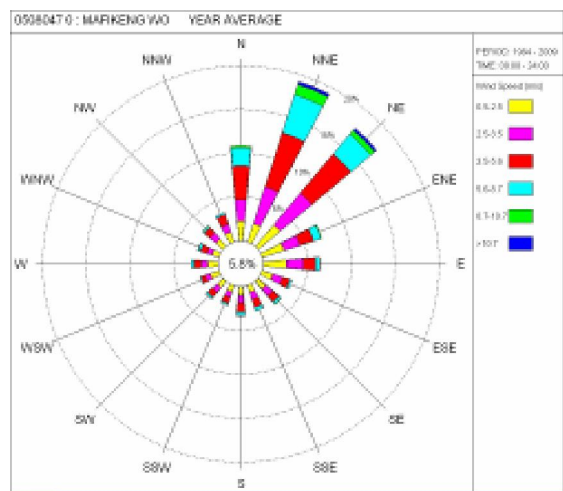


Figure 6: Wind direction, speed and frequency in Mafikeng

#### 4. Discussion

Mafikeng Local Municipality receives a unimodal rainy season centered on January, where rainfall start in October and end in April of the following year. The unimodal characteristics of summer rainfall have been observed in various studies of southern Africa rainfall (Kabanda 2004; Makarau 1995). Potential changes in both the amounts and timing of rainfall events are important aspects of local climate change, which can alter the distribution and dynamics of water content with significant ecosystem-level consequences (Chambers 2003). Results by Harper et al. 2005 indicate that both the size and timing of rainfall events are important in arid to semi-arid ecosystems. Large events may result in deeper penetration of moisture in a façade, affecting (combined thermal) hygric expansion with accompanying stresses (Sabbioni et al. 2010). Observations revealed that the thin walled houses in Dibate and Montshioa are not strong enough to withstand heavy downpours such as the ones experienced in 1997 (Figure 3). The climatic analysis reported here indicates that deeper penetration resulted in water seepage through walls in Dibate and Montshia Extension 38. In Dibate and Montshia Extension 38, 70% of the respondents complained of roof leakages in wet season with 60% indicating water seepage through the walls. On the contrary, houses in Leopard Park and Unit 13 have thick walls and added polystyrene that inhibit the effects of driving rain.

A further complication of large rainfall events in Mafikeng is waterlogging. The overall topography in Mafikeng is classified as flat with the underlying geology consisting of limestone, dacte and granite that result in impermeable surfaces causing water logging. In Dibate village and Montshia Extension 38, 90% of respondents complained of water logging in the surrounding land even after a small rainfall event. Similar complaints were reported by 60% and 80% of the respondents from Leopard Park and Unit 13 respectively. Hence, it becomes difficult to get from the road to their house, to go to work or school as the surrounding land turn into quagmires in the rainy season and residents have to erect wooden gangplanks. Residents reported that waterlogged areas could stay for 1 to 3 days. Although these flooded surroundings have little impact in terms of destroying the house, if left on the ground for a prolonged period or if the rains continue, the stagnant

water may become contaminated e.g. perfect breeding grounds for mosquitoes.

Temperature changes between day, night and seasons bring about volume changes such as expansion and shrinking (Yaldiz 2010). In Montshia Extension 38 and Dibate, 80% and 70% of the respondents respectively attributed the cracks in their homes to temperature variations. Continuous temperature changes as observed in the 1992 and 1994 season caused cracks and breaks on stones because of material fatigue. This is common in informal dwellings and government housing because they are often 'single skin' buildings i.e. – one wall, rather than 'double skin' – two walls. Homes are built with poor foundations, usually fitted with sub-standard components and unplastered walls often coated with non-waterproof paint ([www.claybrick.org.za](http://www.claybrick.org.za)). With exposure to alternate temperature extremes, there is building material fatigue, which results into structural damages such as cracked walls beneath windowsills and around doorframes. In addition, higher temperature and precipitation will cause faster development of micro-organisms (e.g. higher germination power rates), and affect the species of micro-organisms occurring (Chambers 2003). Through observations, buildings in Mafikeng depict worn out exteriors, corroded metal fittings and rust.

An increase in wind load would have implications for the anchoring of cladding materials (Steenbergen et al. 2009). As a flat area, Mafikeng is vulnerable to stronger winds, which blows dust into homes. This situation is exacerbated by poor building orientation and poorly constructed tiled roofs. Houses in Montshia Extension 38 generally have a linear orientation with a north east direction thus all houses are affected by wind and the lack of surrounding trees intensifies the impact. Unit 13 residents (50%) complained least about dust conditions, due to a dense tarred road network. Besides, the area is medium residential hence the surrounding buildings usually weaken wind speeds around individual building group (Kuismanen 2005).

Two general impacts can be expected from climate change: increased intensity of extreme weather events and changes to regional weather patterns (Freeman and Warner 2001). The combined effect of higher temperature and higher precipitation during summer months in Mafikeng is likely to speed

up biocolonization and increase effects of biodeterioration and biodegradation, for stony materials, (organic) coatings and roofing tiles. The study identified a strong positive seasonality in the influence of climate on buildings and surrounding land through the analysis of seasonal rainfall, temperature and wind data. Conclusively, the deteriorations related to climate conditions on the buildings in Mafikeng Local Municipality occur due to temperature differences between seasons and day-night. The capillary movement of water within the structural members of the building, the weathering effects of rainwater, salts and various chemicals existing in water and particles carried by winds affects the durability and aesthetics of buildings in Mafikeng. The study recommends the need for maintaining appropriate building standards, designs and regular review of those standards in Mafikeng area and its surroundings in order to address climate extreme and the climate change issues.

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## General knowledge and utilization of Indigenous Leafy Vegetables by villagers in the Mafikeng area of South Africa.

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**Abstract:** The role of wild indigenous leafy vegetables (ILVs) for nutritional and medicinal purposes, and in food security is recognized in African countries; however, their use and consumption in South Africa is diminished since they can be associated with poverty and low self-esteem among rural people. This study was conducted to investigate villagers' general knowledge and utilisation of ILVs through a survey conducted among thirty randomly selected households in each of three villages (Lokaleng, Moshawane and Tsetse) in the Mafikeng area of South Africa. Data was collected using a structured questionnaire administered face to face (personal interview) with the researcher completing the questionnaire as each villager responded. The results show that all villagers have knowledge of the most common ILVs. The most common ILVs recognized and used were *Amaranth*, *V. uinguiculata*, *C. maxima*, *C. gynandra* and *C. album*. However, *Amaranth*, *C. gynandra* and *C. album* were identified as the three most commonly used ILVs as sources of food. Most participants (67%) cited that in the presence of both ILVs and exotic vegetables, they would prefer ILVs for food. This preference of ILVs versus exotic vegetables was age specific but not gender specific. The youngest age group of <20 years was the only group which preferred exotic vegetables (63%). Additionally, it was determined that ILVs were simply used as found in the wild and were not domesticated. [Life Science Journal. 2011;8(S1):74-79] (11) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

Keywords: knowledge; indigenous leafy vegetables (ILVs); rural villagers; utilisation

### 1. Introduction

There is a wide variety of indigenous leafy vegetables in Africa that are mainly used for nutritional and medicinal purposes. The diversity in traditional vegetables offers variety in family diets and helps to ensure household food security (Luchen and Mingochi, 1995). However, there are some barriers that limit the utilisation of ILVs and hence may encourage their potential extinction.

First, Hendricks, Modi & Modi (2006) emphasized that although the role of wild indigenous leafy vegetables in food security is recognized in other African countries, their use in South Africa has diminished and consumption is associated with poverty and low self-esteem among rural people. As people modernize they may turn away from old lifestyle practices. Today, young people mostly associate the use of ILVs with being inferior, old fashioned and poor (Stevens, Steyn & Vorster, 2008). This shows that ILVs are viewed negatively by young people. The latter statement is also supported by Kabuye *et al.* (1999) who argued that the 21<sup>st</sup> century generation has adopted western culture which introduced new food habits and new crops, hence they neglect African foods. Thus, it is very challenging to educate and encourage people to

change their negative attitudes towards ILVs and thereby increase their utilisation.

Second, Dovie *et al.* (2007) highlighted that although edible herbs (some of which are ILVs) have high levels of important nutrients, some may have toxic effects if intake exceeds certain limits. Thus, due to lack of knowledge, some people do not believe it is safe to use ILVs at all since they do not know where to draw the line.

These barriers that limit utilisation and increase potential extinction of ILVs may be overcome. Abukutsa-Onyango (2007) emphasized that promoting the production and utilisation of ILVs will ensure conservation by utilisation, and that as long as there is consumer demand for ILVs then production will be sustained to meet the demand and thereby avoid the threat of their extinction. For this study it has been hypothesized that peoples' knowledge on indigenous leafy vegetables influences utilisation of such plant species. The survey study will act as tool to compile villagers' knowledge and utilisation of indigenous leafy vegetables.

### 2. Materials and Methods

The study was conducted in three Mafikeng rural villages: Lokaleng, Moshawane and Tsetse. A survey was conducted among thirty



randomly selected households per village, allowing only one person per household to participate in an interview. Data was collected using a structured questionnaire administered face to face (personal interview). Personal interviews yield good responses since the interviewer can persuade respondents to participate. Problems such as misplacing questionnaires and the respondents taking too long to complete the questionnaire can be avoided. In personal interviews, the interviewer can note specific reactions and eliminate misunderstandings by further simplifying or clarifying questions. Closed questions were used to collect information from the respondents. The researcher completed the questionnaire form as the respondents answered. The language better known to respondents (this was Setswana in all cases) was used. It was assumed that respondents were not familiar with soil texture descriptions such as sand, clay, and loam. Therefore, the interviewer explained these terms. Sandy soils were explained as soils that felt gritty and allow water to drain easily. Clay soils were explained as soils which feel sticky when wet and do not allow water to easily drain, and may show cracks when dry. Loam soils were explained as an intermediary between sand and clay soils. The data collected was analyzed by Statistical Analysis System (SAS).

### 3. Results

Most participants were from the 21-40 year age group (43%), followed by the >60 year age group (24%), 41-60 year age group (23%), and the least being the <20 year age group (9%). The largest number of respondents (76%) were females. The majority of participants were single (69%) with a smaller percentage being either married or widowed persons (31%). The majority of respondents (62%) have no formal education while only 38% have secondary education. In this survey, no formal education refers to all participants who either completed primary education or never attended school, while the secondary education refers to all respondents who have completed secondary or tertiary education. The unemployment rate was very high (89%) among participants. The majority of participants (92%) have resided in the study areas for more than 10 years.

Participants from all villages cited that they have knowledge pertaining to ILVs (Table 1). In the communities respondents recognised 11 out of 16 ILVs presented in the survey. Respondents also had

knowledge of an additional 11 ILVs. The responses of participants' recognition of ILVs pictorially is given in (Table 2). The results show that Amaranth was the most recognized ILV (59%), followed by *C. gynandra* (46%), *V. unguiculata* (27%) and *C. maxima* (32%). Although the participants had knowledge of many plants, they had difficulty in recognizing them in pictures. Some participants complained that the pictures were not clearly visible. This complaint was with the age group of > 60 years and was most likely due to their poor vision. Pictorial recognition of ILVs was lower for respondents at Tsetse village as compared to the other two villages (Table 2). Tsetse villagers identified only 4 of the additional 11 ILVs which were recognized by respondents in Lokaleng and Moshawane. Two Tsetse respondents were familiar with *B. pilosa*, while the plant was unknown as a vegetable to both Lokaleng and Moshawane villagers. Furthermore, Tsetse respondents had more difficulty identifying ILVs by pictures.

However, knowing about ILVs does not necessarily mean that participants utilise such vegetables since participants have their preferences. Table 3 presents participants ILV preference. Amaranth was cited as the most preferred vegetable (89%), followed by *C. album* (31.1%), *V. unguiculata* (30%) and *C. gynandra* (25.6%). Participants indicated that Amaranth grows more abundantly than other ILVs. Although results indicated *C. gynandra* as one of most preferred ILVs, it was established that the majority of respondents with a preference for this vegetable are from Tsetse followed by Lokaleng with only three respondents from Moshawane. A vast majority (94%) of villagers indicated that ILVs are used only for consumption purposes. Although villagers use ILVs, only 6% of the respondents indicated that they cultivate them, with 80% of these being from Tsetse village. It was observed that villagers in Tsetse have home gardens and mainly cultivate *V. unguiculata* along with exotic vegetables.

Approximately 77% of participants indicated that they transfer ILV knowledge to their children through their usage of ILVs. This transfer of knowledge through usage was higher in Lokaleng than in the other villages. A vast majority (82%) in all villages indicated that utilisation of ILVs in their village is high. Most participants (67%) in all villages indicated a preference of ILVs in the presence of both ILVs and exotic vegetables (Table

4). Most participants mentioned that although they prefer ILVs they still use exotic vegetables a lot because ILVs have a very short growth duration period and that low rainfall reduces their availability (personal communication). In addition, the results of this study established that vegetable preference is not gender dependent but age dependent (Table 4). The majority of participants < 20 year age group indicated a 63% preference of exotic vegetables over ILVs. Vegetable preference as influenced by age is indicated by Chi-Square  $p=0.0139$ ,  $df=3$  at 0.05 and Fisher tests  $p \leq 0.0103$  at 0.05.

Harvesting methods were grouped into three categories, namely: leaf picking (leaf blade without stalk), leaf+branches (where leaf blade is cut together with stalk or the whole branch) and uprooting. The majority of respondents (70%) reported leaf picking as a commonly used harvesting method. The villagers indicated that this method increases the production of new leaves (personal communication). Although these results were common throughout the three villages, villagers in Tsetse utilized leaf picking at a 90% level. The results indicated that a vast majority of the Tsetse respondents used only one method of harvesting (leaf picking), while participants from other villages combined this method with other methods. It was also established that the method of uprooting was used only at Moshawane, where it is practised by a few people.

Results show that villagers do not have knowledge pertaining to soil conditions associated with ILV growth. Respondents cited “any” or “don’t know” when asked to give any observation or knowledge on soil colour (79%) and soil type (78%) where ILVs are found. Generally, a majority of Lokaleng respondents cited “don’t know” while at Tsetse and Moshawane the respondents mainly cited “any”. If respondents cited a colour selection, “red” was their choice over ‘black.’

#### 4. Discussion

Villagers had knowledge on given ILVs and beyond, as respondents additionally added to the list given in the survey. The results of this study clearly show that ILVs are used as part of food culture to villagers. Villagers acknowledged passing their knowledge of ILVs to the young generation as a contribution of imparting African food culture. Villagers listed ILVs they know using their local names which at times made it difficult to identify

plants. Respondents identified *Amaranth*, *V.inguiculata*, *C.maxima* *C.gynandra* and *C.album* as the most commonly known ILVs. It was realized that although there are common ILVs, there are some plant species that are known to specific persons. Plants cited to be known by respondents are in line with those known to be among the ILVs of South Africa (Faber et al, (2007).

The preference of ILVs was higher than of exotic vegetables. Villagers mentioned that they use ILVs mainly because of their low economic status (personal communication). Thus, their lower economic status forces them to utilize the plant species in their environment as an available source of food. Akula *et al.*, (2001) pointed out that ILVs represent an inexpensive food source to the poorer segment of the population. Faber *et al.* (2007) confirmed this when stating that poor households tend to use ILVs because they lack finances to buy exotic vegetables and the inputs for vegetable production. It was also evident that the preference for ILVs is age dependent with a majority of the younger age group preferring exotic vegetables. The young people also felt that since exotic vegetables can be easily accessed from shops there is no need to go to the bush for vegetable gathering (personal communication). Stevens *et al.* (2008) observed that a barrier to ILV utilisation is that the youth have a negative view of ILVs. This may be attributed to the change in food culture which has now influenced people to leave their old and traditional food culture and adopt a modern food culture.

The use of ILVs in Tsetse was much lower than in Lokaleng and Moshawane. This may be attributed to the fact that Tsetse is growing into a town where settlement allocation is similar to that done in urban areas. Plots are joined together and not scattered as observed in other villages like Lokaleng. However, Tsetse villagers have gardens, where they grow exotic vegetables. Generally, in all villages, it was observed that apart from the commonly preferred ILVs, preference for other known ILVs is low. Some respondents attributed this to a lack of knowledge on ILV toxicity and safety for consumption. Although *C. Gynandra* was a preferred ILV in Lokaleng and Tsetse, only one respondent from Moshawane had a preference for it. The respondents claimed that they did not prefer it because it is too bitter and requires a long cooking time. This study has shown that although villagers use some ILVs, they do not domesticate them. Many villagers still think that it is

not necessary to grow ILVs as they grow naturally thus it will be wasting energy and resources. Only a few of the respondents at Tsetse domesticated ILVs.

The study established that villagers use the leaf picking harvesting method as the best method to enhance re-growth of ILVs. They understand that this method increases new leaf development through re-growth and ultimately increases production and yield of ILVs. Villagers who use the leaf+branches method mainly use it to give more weight to the harvest, since cooking only leaves requires harvesting an abundant amount of leaves (personal communication).

**Table 1.** Rural villagers' knowledge of ILVs verbally based on 30 respondents surveyed in each village (common names are given in parentheses).

Villagers do not use the uprooting method to avoid lowering future ILV production and possible extinction of plant species because the plants are uprooted before they produce seed.

It is evident that the respondents do not have knowledge of soil aspects influencing growth of ILVs. A majority of them cited "any" or "don't know" on each case, when asked to give any observation or knowledge on soil type and colour where ILVs are found. Respondents outlined that as long as it rains well, ILVs will grow regardless of soil colour or type (personal communication).

ILVS	Response (# of people)			Total	
	Lokaleng	Moshawane	Tsetse	#	%
<i>ILVs included in the survey</i>					
1. <i>Amaranth</i> (amaranth)	30	30	30	90	<b>100</b>
2. <i>Cochorus Olitorious</i> (jute)	4	15	7	26	<b>29</b>
3. <i>Cleome gynandra</i> (spider flower)	19	20	25	64	<b>71</b>
4. <i>Cleome monophylla</i> (single-leaved cleome)	0	0	0	0	<b>0</b>
5. <i>Vigna unguiculata</i> (cowpea)	23	24	26	73	<b>81</b>
6. <i>Curcubita maxima</i> (pumpkin)	21	25	27	73	<b>81</b>
7. <i>Citrullus lanatus</i> (wild watermelon)	1	10	1	12	<b>13</b>
8. <i>Bidens pilosa</i> (common blackjack)	0	0	2	2	<b>2</b>
9. <i>Chenopodium carinatum</i> (green goosefoot)	0	0	0	0	<b>0</b>
10. <i>Chenopodium album</i> (white goosefoot, fat hen)	13	17	16	46	<b>51</b>
11. <i>Chenopodium murale</i> (nettle-leaved goosefoot)	0	0	0	0	<b>0</b>
12. <i>Hypochaeris radicata</i> (hairy wild lettuce)	0	0	0	0	<b>0</b>
13. <i>Portulaca oleracea</i> (purslane)	6	1	1	8	<b>9</b>
14. <i>Urtica Urens</i> (annual nettle)	0	0	0	0	<b>0</b>
15. <i>Emex australis</i> (spiny emex)	4	3	0	7	<b>8</b>
16. <i>Lactuca serriola</i> (prickly lettuce)	1	1	0	2	<b>2</b>
<i>Others ILVs cited by respondents (common names)</i>					
17. Seropolane	1	7	0	8	<b>9</b>
18. Thoma	6	2	1	9	<b>10</b>
19. Phate ya ngaka	1	0	0	1	<b>1</b>
20. Motetenyanane	8	5	0	13	<b>14</b>
21. Monoto wa koko	6	3	0	9	<b>10</b>
22. Monyaku	12	8	6	26	<b>29</b>
23. Leshe	7	16	3	26	<b>29</b>
24. Shepashepe	2	11	0	13	<b>15</b>
25. Seruane	0	5	1	6	<b>7</b>
26. Moonyane	1	2	0	3	<b>4</b>
27. Ramogola	0	2	0	2	<b>2</b>

**Table 2.** Rural villager's vegetable knowledge verified by pictures.

ILV	Response (# of people)			Total	
	Lokaleng	Moshawane	Tsetse	#	%
<i>Amaranth</i>	21	21	11	53	59
<i>Cleome gynandra</i>	12	13	16	41	46
<i>Curcubita maxima</i>	10	17	2	29	32
<i>Vigna unguiculata</i>	10	14	0	24	27
<i>Cochorus olitorious</i>	2	9	1	12	13
<i>Citrullus lanatus</i>	0	7	0	7	8
<i>Portulaca oleracea</i>	0	1	1	2	2
<i>Bidens pilosa</i>	0	0	1	1	1
<i>Emex australis</i>	0	1	0	1	1

**Table 3.** Rural villagers' ILV preference.

ILV	Response (# of people)									Total	
	Lokaleng			Moshawane			Tsetse			#	%
	1	2	3	1	2	3	1	2	3		
<i>Amaranth</i>	27	0	0	26	0	0	27	0	0	80	89
<i>Chenopodium album</i>	0	4	4	0	11	6	0	1	2	28	31
<i>Vigna unguiculata</i>	0	2	2	0	2	0	0	7	14	27	30
<i>Cleome gynandra</i>	0	5	2	0	0	1	0	13	2	23	26
<i>Leshe</i>	0	1	1	0	3	6	0	0	0	11	12
<i>Cochorus olitorious</i>	0	0	1	0	0	0	0	0	0	1	1
<i>Monyaku</i>	0	6	1	0	0	3	0	0	0	10	11
<i>Curcubita maxima</i>	0	0	0	0	1	2	0	2	4	9	10
<i>Thoma</i>	0	2	1	0	0	0	0	0	0	3	3
<i>Motetejane</i>	0	1	2	0	0	0	0	0	0	3	3
<i>Shepashepe</i>	0	0	0	0	0	1	0	0	0	0	1
<i>Monoto</i>	0	0	2	0	0	0	0	0	0	2	2
<i>Seruane</i>	0	0	0	0	0	1	0	0	0	1	1
<i>Seropolane</i>	0	0	0	0	0	2	0	0	0	2	2
<i>Phate</i>	0	0	1	0	0	0	0	0	0	1	1

1 = first preference; 2 = second preference; 3 = third preference

**Table 4.** Rural villagers' vegetable preference based on age.

Preference	Response (# of people)				Total for all villages	
	<20 yrs.	21- 40 yrs.	41- 60 yrs.	>60 yrs.	#	%

<b>Exotic</b>	5	17	2	6	30	33
<b>ILVs</b>	3	22	19	16	60	67
					90	100

(Chi-Square  $p=0.0139$ ,  $df=3$  at  $0.05$  and Fisher test  $p \leq 0.79$  at  $0.05$ )

## 5. Conclusions

In conclusion, this study has shown that there is a wide range of plant species used as indigenous leafy vegetables around Mafikeng area. The study has also shown that knowledge of various ILVs by villagers does not necessarily mean that villagers use them, but villagers have variant preferences. Evidence from this study show that although many ILVs are known only a few are used. *Amaranth*, *C. gynandra* and *C. album* are the three most commonly used ILVs as sources of food in all three villages. However, despite much knowledge and utilisation of ILVs, domestication of ILVs is negligible.

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## The effects of cattle manure and harvesting frequency on the growth and yield of *Cleome gynandra*

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**Abstract:** A study was conducted to determine the effects of cattle manure and harvesting frequency on the growth and yield of *C. gynandra*. The experimental design was a RCB with four replicates. A factorial experiment of 4 x 3 combinations was used. Treatment combinations consisted of four manure application rates (0 ton ha<sup>-1</sup>, 15 tons ha<sup>-1</sup>, 30 tons ha<sup>-1</sup> and 45 tons ha<sup>-1</sup>) and three harvesting frequencies (weekly, bi-weekly and at termination). Results indicated that cattle manure application had a significant effect on growth and yield parameters (dry weight, leaf number, plant height). The highest yield (1.73 g/pot) was obtained with a 45 tons ha<sup>-1</sup> application rate which was not significantly different from the 30 tons ha<sup>-1</sup> (1.51 g/pot). The highest leaf number (180) was obtained with a rate of 45 tons ha<sup>-1</sup>, which was not significantly different from 30 tons ha<sup>-1</sup> (173). The greatest plant height (55.1cm) was recorded for 45 tons ha<sup>-1</sup>. There was no significant difference in plant height for 0, 15 and 30 tons ha<sup>-1</sup> (43cm, 49cm and 51.2cm, respectively). Harvesting frequency had a significant effect only on dry weight. There was no significant difference for yield recorded for weekly or bi-weekly harvests. In conclusion, the study recommends that farmers use cattle manure at a 30 tons ha<sup>-1</sup> application rate and harvest bi-weekly. Results established that soil properties (pH, organic carbon, organic matter, and available phosphorus) increased with an increase in manure application and may be a cause of the observed increased yield and growth of *C. gynandra*. [Life Science Journal. 2011;8(S1):80-88] (12) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** cattle manure; *Cleome gynandra*; harvesting frequency; indigenous leafy vegetables.

### 1. Introduction

*Cleome gynandra* (Spider flower) is one of the most significant indigenous wild leafy vegetables in Africa. The plant belongs to the Capparaceae family. It is an erect herbaceous plant with a height ranging from 0.5 m to 1.5 m depending on the environment in which it is cultivated (Faber *et al.*, 2007). The plant grows for a short period, hence the cutting of leaves is usually done once. The leaves of *C. gynandra* are mainly boiled and consumed as a green vegetable or dried to be used for future consumption as a relish with starchy food such as sorghum or maize meal porridge. The boiled sap is drunk by some people as it is assumed to possess medicinal properties. The leaves are bitter, thus at times they are cooked together with other leafy vegetables such as *Amaranth* or cowpea. The youngest leaves are usually gathered due to their ease of harvest, tenderness and high nutrition. They are

also more appealing since they lack the insect damage of older leaves. Older leaves accumulate more dust and require more washing during preparation than younger leaves. Harvesting is usually done by women. Some communities sell dried leaves of *C. gynandra*, thus it also plays an important role in such communities by improving the economic status of villagers.

Groeneveld H *et al.* (2009) indicated that ILVs have a high potential for domestication since they are adapted to harsh environments and generally require simpler technologies and inputs to grow than exotic vegetables. Stevens *et al.* (2008) also supported the latter by indicating that ILVs are easy to cultivate with minimal management. The documentation of ILVs, especially on agronomic aspects is scant (Hendricks, 2006); therefore, this motivates for research in such areas. Studying agronomic or husbandry practices of ILVs is crucial



in determining methods to increase the yields of these plant species. For this study, cattle manure fertilization and harvesting frequency were studied as husbandry practices that influence the growth and yield of ILVs.

Cattle manure fertilization is a widely used husbandry practice among small scale farmers in South Africa. Chen *et al.* (2009) emphasized that cattle manure is a valuable fertilizer and contains a variety of plant nutrients that are recycled in agronomic systems for the production of food and fibre for humans and feed for livestock. Inorganic fertilizers are expensive for small scale farmers in South Africa; therefore, the use of manure will continue to play a very significant role in the maintenance of soil fertility (Materechera & Mkhabela, 2003).

Harvesting frequency is one of the agronomic properties that can be manipulated to increase the growth and yield of leafy crops. This is because pruning encourages new leaf production. Chiveu & Opile (2005) observed that pruning as a method of harvesting led to higher productivity of *Amaranthus*. They attributed higher productivity with the reduced apical dominance following cutting. This promoted the production of lateral branches resulting in the production of higher harvestable shoots. The quality of leaf is of great importance in leafy vegetables (Materechera & Medupe, 2006). Therefore, harvesting at the end of plant life may yield coarse leaves. This implies that frequent harvesting may improve leaf quality as it allows new growth and palatable leaves. The objective of this study was to determine the effects of cattle manure and harvesting frequency on the growth and yield of *C.gynandra*.

## 2. Materials and Methods

The study was conducted at Molelwane farm, School of Agriculture at North-West University (Mafikeng campus). The farm is located along the Ramatlabama main road to Botswana, 8 Km from Mafikeng City, which lies approximately 25° 48'S and 25° 38'E. According to Materechera & Medupe (2006), Mafikeng is a typical semi-arid area, characterized by unreliable rainfall, with an annual

mean of 550 mm (Materechera & Modiakgotla, 2006). Vegetation in the area is composed of grasses with scattered shrubs and bushes which are mostly acacia species. The area has dry cool winters with a minimum temperature range of 7°-11.4°C and hot summers with a maximum temperature range from 26.9°C in June to 37°C in January (Materechera & Modiakgotla, 2006). The soil in the area is described as a Hutton soil. Hutton soils are among the most important agricultural soils due to the deep, well-drained nature of these soils which provide excellent to moderate cultivation opportunities. Hutton soils are identified based on the presence of an apedal (structureless) "red" B-horizon (Soil Classification, 1991).

Hutton soil was collected from an uncultivated area along the outskirts of the Molelwane farm. The soil was allowed to air-dry for one week prior to sieving (2-mm). Composted cattle manure was collected from the Molelwane farm and allowed to air-dry for one week. The manure was also sieved through a 2mm sieve. Subsequently, soil (6.2 kg) and cattle manure were thoroughly mixed and placed in 25 cm diameter PVC pots. Four cattle manure application rates were used: C1 (0 ton ha<sup>-1</sup>), C2 (15 tons ha<sup>-1</sup>), C3 (30 tons ha<sup>-1</sup>) and C4 (45 tons ha<sup>-1</sup>). Three methods of harvesting based on frequency were as follows; W1 (weekly), W2 (bi-weekly) and W3 (harvesting at the termination of experiment). A factorial experiment of 4 x 3 combinations was arranged in a randomized complete block design (RCB) with four replications. Seeds of *C. gynandra* were sown directly in seedling trays using Hygrotech<sup>+</sup> growing media and watered daily. Seeds emerged within four days of sowing. Two seedlings were transplanted per pot.

Data collection commenced two weeks after transplanting and was conducted weekly thereafter. The parameters measured were dry weight, number of leaves, plant height, and root length. The soil was analyzed at the beginning and at the completion of the study. The distribution of soil particle sizes (soil textural class) was measured using the hydrometer method (Bouyoucos, 1951). Soil pH was determined on a saturated soil paste (Miller, 1992). Organic carbon and organic matter percentages were determined using the Walkley-Black method (1935). Available phosphorus was determined using the Bray-1 method with subsequent spectrometer

analysis (Olsen & Sommers, 1982). Total nitrogen was determined by a micro-Kjeldahl procedure (Anderson & Ingram, 1993). Extractable potassium was determined using an ammonium acetate extractant with subsequent analysis utilizing atomic absorption spectroscopy (Barnard *et al.*, 1990). Cattle manure was analyzed for total nitrogen, available phosphorus, and extractable potassium utilizing the same procedures as for soil analysis. Organic matter was determined by the ignition method (Gathua *et al.*, 1993).

Data was analyzed by Statistical Analysis System (SAS) and all data collected was subjected to ANOVA. The differences between means were compared using the Tukeys method. The linear model for factorial treatment design is:

$$Y_{ijk} = \mu + r_i + a_k + b_l + (ab)_{kl} + e_{ijk}$$

where,  $Y_{ijk}$  is the observation from the  $j^{\text{th}}$  block, cattle manure and harvesting frequency treatment combination,  $\mu$  is the general mean,  $r_j$  is the  $j^{\text{th}}$  level of block effect,  $a_k$  is the  $k^{\text{th}}$  level of cattle manure effect,  $b_l$  is the  $l^{\text{th}}$  level of harvesting frequency effect,  $(ab)_k$  is the treatment cattle manure with harvesting frequency interaction effect,  $e_{ijk}$  is the experimental error.

### 3. Results

Manure application rates had a significant effect on yield and growth parameters, while harvesting frequency had a significant effect only on dry weight (yield). Data recorded from this experiment showed that the interaction effect of manure application rate and harvesting frequency was not significant.

Data recorded from this experiment showed that manure application rates significantly improved yield/dry weight (Table 1). The highest yield (1.74 g/pot) was obtained with a manure application rate of 45 tons  $\text{ha}^{-1}$ ; however, this was not significantly greater than the yield obtained at 30 tons  $\text{ha}^{-1}$  (1.51 g/pot). The lowest yield (0.69 g/pot) was obtained when no manure was applied.

Manure application rates had a significant effect on leaf number (Table 1). The highest leaf numbers were obtained when 45 tons  $\text{ha}^{-1}$  and 30 tons  $\text{ha}^{-1}$  manure was applied (1780 and 173 respectively).

The lowest leaf number was recorded when 0 tons  $\text{ha}^{-1}$  and 30 tons  $\text{ha}^{-1}$  manure were applied (115 and 143 respectively).

There was no significant difference in average plant height (Table 1) for manure application rates of 0, 15 and 30 tons  $\text{ha}^{-1}$  (43 cm, 49 cm and 51.2cm respectively). The greatest plant height (55.1cm) was recorded for 45 tons  $\text{ha}^{-1}$ ; however, it was not significantly different from that of 15 and 30 tons  $\text{ha}^{-1}$ . The effect of manure application rate on root length was not significant

The effect of harvesting frequency was significant on dry weight only and not on leaf number, plant height and root length (Table 2). The highest yields were recorded for weekly (1.69 g/pot) and bi-weekly (1.62 g/pot) harvesting, which were approximately three times greater than with a single harvest at the termination of experiment (0.53 g/pot).

The results also indicated that manure application rates had a significant effect on soil pH, organic carbon, organic matter, and available phosphorus but not on total nitrogen and potassium. Harvesting frequency did not have a significant effect on any of the above soil properties. The interaction effect of manure application rate and harvesting frequency was not significant on soil properties. The soil properties before and after planting are shown in Tables 3 and 4, respectively.

The original soil pH was 7.14 (Table 3). The lowest soil pH level (7.46) was recorded when no manure was applied. Soil pH increased with increasing manure application rates (Table 4). The highest soil pH levels were recorded at 30 tons  $\text{ha}^{-1}$  (7.83) and 45 tons  $\text{ha}^{-1}$  (7.89) which were statistically equivalent.

Manure application effect on soil carbon is given in Table 4. The original soil carbon was 0.53% (Table 3). There was no change in soil carbon at the 0 tons/ha manure application rate. Soil carbon increased with increasing manure application rates; however, the increase was not significantly different for the 30 tons  $\text{ha}^{-1}$  and 45 tons  $\text{ha}^{-1}$  application rates.

Soil organic matter content also increased with increasing manure application rates (Table 4). The original soil organic matter content was 0.91% (Table 3). There was no change in soil organic matter

at both 0 ton ha<sup>-1</sup> (0.9%) and 15 tons ha<sup>-1</sup> (1.04%) application rates. However, soil organic matter significantly increased at the 30 tons ha<sup>-1</sup> (1.25%) and 45 tons ha<sup>-1</sup> (1.25%) rates.

The original available soil phosphorus level was 17.5 ppm (Table 3). Available soil phosphorus increased with increasing manure application rates (Table 4). The lowest available phosphorus levels were observed at manure application rates of 0 ton ha<sup>-1</sup> (41.73ppm) and at 15 tons ha<sup>-1</sup> (58.8ppm). The highest soil phosphorus levels were observed at

manure application rates of 30 tons ha<sup>-1</sup> (84.9ppm) and 45 tons ha<sup>-1</sup> (96.9ppm) which were statistically equivalent.

The results established that all treatments did not have a significant effect on total soil nitrogen. Extractable K remained statistically the same with increasing manure application rates and with harvesting frequency (Table 4).

**Table 1** Effect of cattle manure application level on yield and growth parameters.

Parameter				
Manure	Dry weight	Leaf number	Plant height	Root length
	(g)	#	(cm)	(cm)
0 ton ha <sup>-1</sup>	0.69 <sup>a</sup>	115 <sup>a</sup>	43.3 <sup>a</sup>	17.4 <sup>a</sup>
15 ton ha <sup>-1</sup>	1.19 <sup>b</sup>	143 <sup>a</sup>	49.0 <sup>ab</sup>	23.7 <sup>a</sup>
30 ton ha <sup>-1</sup>	1.51 <sup>bc</sup>	173 <sup>b</sup>	51.2 <sup>ab</sup>	21.5 <sup>a</sup>
45 ton ha <sup>-1</sup>	1.73 <sup>c</sup>	180 <sup>b</sup>	55.1 <sup>b</sup>	20.6 <sup>a</sup>
SE	0.11	8	2.5	1.8
HSD ( 0.05)	0.41	29	9.6	6.7

Values are means ± S.E (n=48); Values in the same column bearing the same letter are not significantly different according to Tukey's Test.

**Table 2.** Effect of cattle manure application level on yield and growth parameters.

Parameter				
Harvesting	Dry weight	Leaf number	Plant height	Root length
	(g)	#	(cm)	(cm)
Weekly	1.69 <sup>a</sup>	144.1 <sup>a</sup>	48.0 <sup>a</sup>	17.4 <sup>a</sup>

<b>Bi-weekly</b>	1.62 <sup>a</sup>	148.8 <sup>a</sup>	48.0 <sup>a</sup>	23.7 <sup>a</sup>
<b>At termination</b>	0.53 <sup>b</sup>	165.5 <sup>a</sup>	53.0 <sup>a</sup>	21.5 <sup>a</sup>
<b>SE</b>	0.09	6.6	2.2	1.5
<b>HSD ( 0.05)</b>	0.33	22.7	7.6	5.3

Values are means  $\pm$  S.E (n=48); Values in the same column bearing the same letter are not significantly different according to Tukey's Test.

**Table 3.** Properties of soil and manure used at the beginning of the study.

Analysis	Soil	Manure
Particle size distribution		
Sand 2 mm-0.053	74.4%	na
Silt 0.053- 0.002	11.8%	na
Clay <0.002	14.8%	na
Textural class	Sandy loam	na
pH (saturation)	7.14	na
Organic carbon (%)	0.53	na
Organic matter (%)	0.91	33
Ash	na	67
Phosphorus (ppm)	17.5	1027
Nitrogen (%)	0.14	0.84
Extractable Potassium (ppm)	314	
Extractable Potassium (%)		0.05

na= not applicable

**Table 4** Effect of cattle manure application level on soil parameters.

Parameter						
Manure	Soil pH	OC	OM	Available phosphorus	Total nitrogen	Extractable potassium
		(%)	(%)	(ppm)	(%)	(ppm)
0 ton ha <sup>-1</sup>	7.46 <sup>a</sup>	0.53 <sup>a</sup>	0.99 <sup>a</sup>	41.7 <sup>a</sup>	0.09 <sup>a</sup>	377 <sup>a</sup>
15 ton ha <sup>-1</sup>	7.65 <sup>b</sup>	0.64 <sup>a</sup>	1.04 <sup>ab</sup>	58.9 <sup>a</sup>	0.1 <sup>a</sup>	361 <sup>a</sup>
30 ton ha <sup>-1</sup>	7.83 <sup>bc</sup>	0.73 <sup>b</sup>	1.25 <sup>ab</sup>	84.9 <sup>b</sup>	0.1 <sup>a</sup>	361 <sup>a</sup>
45 ton ha <sup>-1</sup>	7.89 <sup>c</sup>	0.73 <sup>b</sup>	1.25 <sup>b</sup>	96.9 <sup>b</sup>	0.16 <sup>a</sup>	377 <sup>a</sup>
SE	0.05	0.03	0.05	4.82	0.03	5
HSD ( 0.05)	0.18	0.12	0.2	1.84	0.12	20

Values are means  $\pm$  S.E (n=48); Values in the same column bearing the same letter are not significantly different according to Tukey's Test.

#### 4. Discussion

The results indicate an optimum cattle manure application rate of either 30 tons ha<sup>-1</sup> or 45 tons ha<sup>-1</sup> since both rates give significantly the same yields, leaf numbers and plant heights. Apart from the effective increase on growth and yield of *C. gynandra*, the use of cattle manure is of great importance to villagers since it is cheap and locally available. Therefore, this can help rural villagers who cannot afford the cost of inorganic fertilizers. These results suggest that rural villagers can cultivate *C. gynandra* using cattle manure as a source of fertilizer.

Yield of *C. gynandra* improved when harvesting was done either weekly or bi-weekly. This was three times higher than the yield when harvested only at the termination of the study. Plants which were harvested at the termination of the experiment showed some yellowing of older leaves which eventually fell off while more frequent harvesting yielded green coloured leaves. The recommended harvesting frequency is bi-weekly since 1) it results in high yield, 2) it results in high quality leaves, and 3) it is more practical than weekly harvesting. The

results of this study are in line with the findings of Materchera & Medupe (2006), who observed that frequent (weekly) cutting encourages production of many leaves; however, does not allow new leaves sufficient time to re-grow resulting in low fresh weights and low dry weights of edible leaves. The latter also highlighted that harvesting frequency influenced leaf quality with a single harvest at the end of termination of the study resulting in coarse leaves. This quality is undesirable to consumers; therefore the latter recommended bi-weekly harvesting. Chiveu & Opile (2005) reported an increase in the total shoot number and length, leaf number and area (as some components of yield of the vegetable *Amaranth*) when harvesting was done by pruning (frequent harvestings) as compared to when harvesting was done by uprooting. The latter therefore suggested that it would be more economical to grow and harvest *Amaranth* under pruning. Additionally, Agbo *et al.* (2006) indicated that among the urban and peri-urban areas of Cote d'Ivoire, most farmers harvest leafy vegetables by pruning so as to allow multiple harvests.

Manure application rates resulted in significant increases of soil pH, organic carbon, organic matter, and available phosphorus, while harvesting frequency did not have a significant effect on any soil property. The observed growth and yield increase of *C. gynandra* in this study as a result of cattle manure addition to soil may be attributed to the concurrent increased levels of soil organic matter and available soil phosphorus. Materechera and Medupe (2006) highlighted that apart from supplying crops with nutrients, manure helps increase the organic matter content of the soil, as was observed in this study. This increased organic matter improves soil structure and water holding capacity, thereby providing a good environment for plant growth. Similar results of soil properties improvement were also reported by Babatunde (2008), who found out that use of cattle manure significantly increased organic carbon, pH, phosphorus, potassium, calcium and sodium. Kimbi *et al.*, 2001 also found that soil available N and P significantly ( $P < 0.05$ ) increased with increasing rate of manure application for each manure type (cattle manure inclusive).

Unexpectedly, there was no observed increase in total soil nitrogen with increased manure application rates. A similar observation was made by Alleh, Okwuagwu & Osemwota (2003) where cattle manure application rates did not increase total soil nitrogen levels. They attributed low soil nitrogen levels to crop N uptake, immobilisation by microorganisms and nitrogen loss through volatilisation in conjunction with decreasing soil organic matter levels. However, this cannot be the cause of the unexpected soil N results in this study since soil organic matter increased with increased manure application rates and we would thus expect to observe a concurrent increase in total soil nitrogen. The lack of differences in total soil N results for the various manure application rates creates suspicion in the accuracy of N analysis, either with the age of chemicals or error by the researcher.

There was no significant change in extractable K with increasing manure application rates. A comparison of the control and manure treated soils indicates that the added manure did not provide much K to the soils. Lower extractable K might have been caused by the fact that the manure used in this study was exposed in the open prior to collection. This would have led to K loss from the manure since

K is immediately and completely made available once mineralization begins (Fulhage, 2000).

An increase in soil pH was observed in this study. The same observation of an increase in soil pH with an increase in manure application rates was also made by Azeez, *et al.* (2009). Similarly, Christo, Madikwe & Onuh (2008) observed that manure (both poultry and cattle) application increased the pH of the soil after harvest. The effect of manure on soil pH is variable. Repeated applications of fertilizer N may lead to soil acidification while organic matter added as manure can act to help buffer the soil against a decrease in pH. This scenario therefore implies that addition of manure may lead to either pH increases or decreases depending on the rate of application and its chemical composition.

## 5. Conclusions

The study recommends an application rate of 30 tons ha<sup>-1</sup> with a bi-weekly harvesting and also concludes that, manure is a valuable resource to use as way of soil management for improved crop growth hence improved yields.

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## Do chemical structures of flavonoids have potential in predicting intake and relative palatability indices?

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**Abstract:** The main aim of this study was to test the potential of chemical structures of flavonoids in predicting intake and relative palatability indices. Six pedi male goats were used in a completely randomized design to determine intake and relative palatability indices of *Acacia karroo*, *Acacia nilotica*, *Acacia sieberiana*, *Acacia tortilis*, *Acacia rhemniana* and hay. Chemical structures were also isolated from *Acacia* species using nuclear magnetic resonance. Correlation analyses were done to establish the relationship between chemical structure, intake and relative palatability indices. The null hypothesis for the study was chemical structures of flavonoids will have a potential in predicting intake and relative palatability indices. *Acacia sieberiana* had the highest intake and relative palatability indices as compared to *A. rhemniana*. Leaves from acacia contained carbohydrates, flavan-3-ols, flavanols and glycosilated flavones. Methyl gallate, epigallocatechin and catechin gallate had highest correlations with intake and palatability whilst sucrose and glucose were weakly negatively correlated to both intake and relative palatability indices. Luteolin -7-glucoside, rutin and catechin gallate were not correlated to intake and relative palatability indices. The results indicated that chemical structures of flavonoids have potential in predicting intake and relative palatability indices. [Life Science Journal. 2011;8(S1):89-97] (13) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Flavonoids, intake, relative palatability indices, nutritive value

### 1. Introduction

Tree fodders are important in providing nutrients to grazing ruminants in arid and semi-arid environments where inadequate feeds are major constraint for livestock production. Tree fodders maintain higher protein and mineral contents during growth than do grasses, which decline rapidly in quality with progress to maturity (Aganga and Tshwenyane 2003). Tree fodders are important sources of high quality feed for grazing ruminants and as supplements to improve the productivity of herbivores fed on low quality feed. Leguminous trees and shrubs often have thorns, fibrous foliage and growth habits which protect the crown of the tree from defoliation. Secondary chemical compounds exist in a wide variety of plant species. Bate – Smith and Metcalf (1957) have reported that 80% of woody perennial dicots and 15% of annual and

herbaceous perennial dicots contains tannins. Secondary chemical compounds especially tannins play a very important role in affecting forage preference and quality. In fact, plants contain thousands of compounds which, depending upon their situations, can have beneficial or deleterious effect on organisms consuming them. They diminish animal productivity but may also cause toxicity during periods of scarcity or confinement when the feed rich in these substances is consumed by animals in large quantities. The plant contains variety of bioactive components such as phenolic acids (Singh et al. 2009), alkaloids (Clement et al. 1997), terpenes (Mujoo et al. 2001), tannins (Readel et al. 2001) and flavonoids (Fourie et al. 1974) which are responsible for numerous biological and pharmacological properties like hypoglycaemic, anti-inflammatory, anti-bacterial, anti-platelet aggregatory,

anti-hypertensive, analgesic, anti-cancer, and antiatherosclerotic due to their strong antioxidant and free radical scavenging activities (Chopra et al. 1999; Singh et al. 2009). Efforts to predict nutritive value of tannin – containing feeds based on wet chemistry tannin assays have failed. It has been proposed that methods based on chemical structures of flavonoids could better relate to nutritional value of feeds than wet chemistry methods (Mueller – Harvey 2001). This study is therefore aimed at testing the potential of chemical structures in predicting intake and relative palatability index of *Acacia* species harvested in Limpopo Province, South Africa.

## 2. Material and Methods

### *Study site*

Five *Acacia* species (*Acacia karroo*, *Acacia nilotica*, *Acacia rhemniana*, *Acacia tortilis* and *Acacia sieberiana*) were harvested at University of Limpopo, Mankweng, South Africa. The soil is a litholutanic with lots of stone and a sandy loam texture underlying an orthic A. horizon. The climate is semi-arid. For feeding experiments, the study was carried out at the University of Limpopo Experimental Farm. The longitude and latitude of the farm was 23° 53" S and 29° 44" E of South Africa. Mean annual rainfall is 446.8 mm with the dry season occurring between April and October and the rainy season occurring between November and March. The temperatures are above 32°C during summer and 25°C or lower in winter season.

### *Feed collection*

Leaves from five different trees of *A. karroo*, *A. nilotica*, *A. tortilis*, *A. sieberiana*, and *A. rhemniana* were collected around Mankweng, Limpopo Province. The leaves were air dried at room temperature, ground to pass a 0.2 mm screen and stored in plastic bottles to await analysis for total phenolics, condensed tannins and radial diffusion.

### *Intake and relative palatability indice*

Six pedi male goats whose weights ranged from 20 to 41.3 kgs were each offered six feeds simultaneously in a cafeteria – style feeding regime (Kaitho et al. 1997) in order to measure intake and relative palatability indice. The feeds used were *A. Karroo*, *A. nilotica*, *A. rhemniana*, *A. sieberiana*, *A. tortilis* and hay.

### *Chemical structures of flavonoids*

Chlorophyll from the pulverized leaves of the *Acacia* species was exhaustively extracted with chloroform. The chlorophyll free leaves were subsequently extracted with methanol and acetone/water (70:30) to yield dark brown solids. Due to the complexity of the extracts, acetylation (pyridine/acetic anhydride) was done prior to purification by Thin Layer Chromatography so as to afford an acceptable level of purity. Dry weighed extracts were dissolved in a minimum volume of pyridine and twice the amount of acetic anhydride was added. After 8-12 hours at ambient temperatures, crushed ice was added to precipitate the acetylated material which was filtered, and excess pyridine washed out with cold water.

In order to establish the presence of different compounds in the plant extracts, two-dimensional paper chromatograms on Whatman no. 1 paper (28.5 × 46 cm) were conducted prior to any separation. The papers were developed in two directions, namely with water saturated butan-2-ol in the first direction and a 2% (v/v) acetic acid solution in the second direction. After the chromatograms were dried in a strong air current, they were investigated by UV-light and sprayed.

**Qualitative thin-layer chromatography (TLC), a method employed to determine the best suited solvents, (based on polarity) which can be employed in preparative scale thin-layer chromatography (PLC), was conducted on Merck TLC aluminium sheets: Silica Gel F254 (0.2 mm layer) divided into strips of ca. 3 × 5 cm.**

Following TLC, preparative scale thin-layer chromatography (PLC) was conducted on glass plates (20 × 20 cm) coated with a layer (1.0 mm) of unactivated Merck Kieselgel 60 PF254 and dried overnight at room temperature. After development in the appropriate eluant, the plates were dried in a strong stream of air and the bands identified by either UV-light (254 nm) or by the appropriate spraying reagents. The bands were eluted with acetone and the acetone removed under reduced pressure in a water bath at ca 30 °C. The plates were charged with 10-15 mg of crude product. Small-scale separations were conducted on Merck Pre-coated (0.25) TLC plates, Silica Gel 60 F254 with each plate charged with 3-5 mg of the impure product.

The pure compounds were analyzed by Nuclear Magnetic Resonance spectroscopy (NMR). NMR spectra were recorded on a Bruker AVANCE DPX<sub>300</sub> spectrometer with tetramethylsilane as internal standard. The solvents used were deuteriochloroform (CDCl<sub>3</sub>,  $\delta$  7.24), deuteriobenzene (C<sub>6</sub>D<sub>6</sub>,  $\delta$  7.15) and deuterioacetone [(CD<sub>3</sub>)<sub>2</sub>CO/acetone-d<sub>6</sub>,  $\delta$  2.04]. Chemical shifts are reported in parts per million (ppm) on the  $\delta$ -scale and coupling constants were measured in Hz.

#### Statistical analysis

Analyses of variance was used to test the effect of species on intake and relative palatability indices using general linear model procedure of SAS (2003) for completely randomized design. If significant P value occurred separation of means was done using least square means. Correlation analyses were done to test the relationship between chemical structures, intake and relative palatability indices.

### 3. Results

There were significant species effects on intake and relative palatability indices (Table 1). *A. sieberiana* had the highest relative palatability indices of approximately 65.4 and 79.2 percentage points more than values for *A. rhemniana* in goats (Table 1). *A. karroo* had medium relative palatability indices.

*A. nilotica* contained many flavonoids except glucose, sucrose, Luteolin-7- glucoside and Kaempferol-6-C-3-O- diglucoside as compared to *Acacia rhemniana* with less flavonoids (Table 2). *A. tortilis*, *A. karroo* and *A. sieberiana* with moderate amount of flavonoids. Rutin was present in all species except *A. rhemniana*. *A. rhemniana* contained only three flavonoids (glucose, sucrose and pinitol).

Chemical structures like catechin gallate, epicatechin gallate, epigallocatechin, chalconaringenin-4-glucoside, methyl gallate and kaempferol-6-C-3-O-diglucoside were positively correlated ( $P < 0.05$ ) to both intake and relative palatability indices, whilst sucrose and glucose were both weakly negatively correlated to both intake and relative palatability indices (Table 3). Luteolin-7-

glucoside, gallicocatechin and rutin were not correlated ( $P > 0.05$ ) to both intake and relative palatability indices.

Chemical structures of flavonoids found in different types of *Acacia* species were shown in Figure 1 (a-l).

### 4. Discussion

The amount of feed an animal eats is a major determinant of the amount of the product that the animal will produce. Thus, intake is the quantity of food that an animal can consume in a period of time. The more food an animal consumes each day, the greater will be the opportunity for increasing its daily production. It is generally considered that intake in ruminants depends on the capacity of their digestive tracts, especially the rumen, and they will eat until a certain degree of 'fill' is achieved.

The high intake of hay in goats may be associated with the familiarity of this feed. *Acacia rhemniana* and *Acacia karroo* had a lower intake as compared to other feeds, and this means feeds produce a taste or smell which is not liked by the animals.

The term palatability is used to describe the degree of readiness with which a particular food is selected and eaten but palatability and food intake are not synonymous. Palatability involves only the senses of smell, touch and taste. With the sense of taste, most animals show preferences for certain foods when presented with a choice. Foods with intake less than expected may also be called unpalatable.

The length of the palatability trial in this experiment was in line with the observations of Salem et al (1994) and Kaitho et al (1997) who concluded that at least 5 days are appropriate for palatability assessment.

The relative palatability indices of *Acacia rhemniana* was lower in goats followed by *Acacia karroo*, this suggests that taste, smell or feel may be playing an important role in the determination of palatability of each feed. The unappealing taste of these two species may have been due to phenolics compounds. The *Acacia* species with good nutritive value such as *Acacia sieberiana*, *Acacia tortilis* and *Acacia nilotica* had high intake and palatability indices in goats and, therefore, this is in line with the assertions made by Marten (1978) and Arnold (1970) that palatability influences voluntary intake.



Flavonoids belong to a group of polyphenolic compounds, which are classified as flavonols, flavonones, flavones, flavanols, flavan-3-ols and isoflavones according to the positions of the substitutes present on the C-ring (Wang et al. 2000).

Flavonoids are involved in various biological processes, including flower pigmentation and protection against UV irradiation and in the morphogenesis of legume nodules. They also inhibit a number of enzymes such as aldose reductase, xanthine oxidase, phosphodiesterase,  $\text{Ca}^{+2}$ -ATPase, lipoxygenase and cyclooxygenase (Wang et al. 2000). They also have a regulatory role on different hormones like estrogens, androgens and thyroid hormone (Wang et al. 2000).

Phytochemical studies of five Acacia species, *A. karroo*, *A. nilotica*, *A. tortilis*, *A. sieberiana* and *A. rhemniana* to establish the distribution of flavonoids and carbohydrates resulted in isolation of two known carbohydrates (sucrose and glucose), the flavan-3-ols (catechin gallate, gallicocatechin, epigallocatechin and epicatechingallate), the flavonols (rutin and kaempferol-6-C-,3-O-diglucoside), one glycosylated flavones (luteolin-7-glucoside), chalconaringenin-4'-glucoside and methylgallate.

Flavan-3-ols characterized by the deshielded oxygen linked H-2 (~4.87 ppm), H-3 (~5.25 ppm) (1.9-2.1 ppm) and H-4 (2.6-2.70 ppm) in their  $^1\text{H}$  NMR spectra, are distributed in several species. From  $^1\text{H}$  NMR spectrum, pinitol was characterized by the presence of an aliphatic methoxy group ( 3.5 ppm) and six protons linked to the oxygenated aliphatic carbons. Luteolin-7-glycoside was characterized by the H-3 as a singlet resonating around 6.3 ppm in their  $^1\text{H}$  NMR spectra.

Catechin gallate, epigallocatechin, epicatechingallate, Chalconaringenin-4-glucoside, methyl gallate and Kaempferol-6-C-3-O-diglucoside were positively correlated ( $P < 0.05$ ) to both intake and relative palatability indices, whilst sucrose and glucose were both negatively correlated to both intake and relative palatability indices.

*Acacia rhemniana* contained carbohydrates, high levels of condensed tannins (Mokoboki et al. 2011) and low level of intake. Tannins can suppress intake by reducing digestibility or by causing illness. Tannins may bind to cell walls and cell soluble (Kumar and

Vaithiyathan 1990; Reed 1995) and in the process reduce the digestion of protein and energy-rich by-products of microbial fermentation such as volatile fatty acids (Robbins et al. 1987). This in turn may adversely affect preference of the feed containing the tannins. Usually, tannins bind with proteins, carbohydrates and minerals and dramatically inhibit digestive and absorptive processes in the gastrointestinal tract of animals (Kumar and Singh, 1984; Makkar, 2003). Tannins in *A. rhemniana* bind with energy and make it unavailable to animals which lead to negative correlation between intake and carbohydrates.

The Acacia species (*A. nilotica*, *A. tortilis*, *A. karroo* and *A. sieberiana*) with a variety of compounds may in a way control fungal invasion, inhibit fungal growth, treat cough and among other diseases, and can provide energy for the animals. The practical implication which could benefit smallholder farming systems could, among others, entail development of a valuable feed resource that will include harvesting of the best acacia species which can be utilized during the dry seasons when there is a shortage of protein. Development of the acacia trees should contribute to the successful commercialization of the acacia species in the Limpopo Province. Future analysis of the species should include development of uniform analytical and quantification methods to allow proper comparison of data from different sources.

This study concludes that chemical structures of flavonoids have potential in predicting nutritive value of Acacia species and correlate well with intake and palatability of tannin-containing browses and could improve prediction of feed value of these feeds. The null hypothesis was reached. It is recommended that for further studies it is necessary to determine the amount or quantity of flavonoids found in different types of Acacia species.

#### Acknowledgements

This research was supported by National Research Foundation. We thank Department of Chemistry, University of Free State for allowing the principal author to analyze for flavonoids using Nuclear Magnetic Resonance.



Table 1. Intake and relative palatability indices of Acacia species and hay

Species	Intake (g/day)	Relative Palatability indices
<i>Acacia karroo</i>	105.42 <sup>c</sup>	0.59 <sup>b</sup>
<i>Acacia nilotica</i>	198.34 <sup>b</sup>	1.09 <sup>a</sup>
<i>Acacia rhemniana</i>	69.71 <sup>d</sup>	0.38 <sup>c</sup>
<i>Acacia tortilis</i>	194.01 <sup>b</sup>	1.07 <sup>a</sup>
<i>Acacia sieberiana</i>	199.78 <sup>b</sup>	1.10 <sup>a</sup>
Hay	273.97 <sup>a</sup>	1.00 <sup>a</sup>
s.e	10.852	0.062

<sup>a, b, c,</sup> Column means with common superscripts do not differ ( $P > 0.05$ )

Table 2. Name of structures found on Acacia species

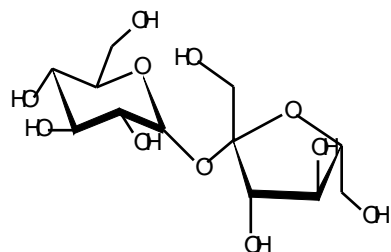
Structure	<i>A. nilotica</i>	<i>A.tortilis</i>	<i>A.karoo</i>	<i>A.sieberiana</i>	<i>A.rhemniana</i>
1.Sucrose					x
2.Pinitol	x	x	x	x	x
3.Glucose					x
4.Luteolin-7- glucoside		x	x	x	
5.Catechin gallate	x	x			
6.Gallocatechin	x	x	x		
7.Epigallocatechin	x			x	
8.Epicatechin gallate	x				
9.Rutin	x	x	x	x	
10.Chalconaringenin-4-glucoside	x				
11.Methyl gallate				x	
12.Kaempferol-6-C-3-0-diglucoside				x	

Table 3. Correlation ( $P < 0.05$ ) between intake and relative palatability indices and presence of chemical structures

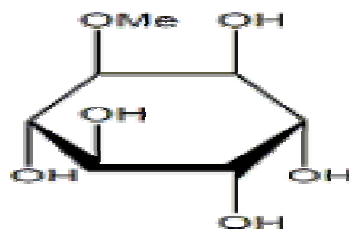
Parameters	INT	PAL	SUCR	GL	L7	CG	GC	EGC	ECG	RU	CHA
METH KAE											
INT	-										
PAL	0.91	-									
SUCR	-0.42	-0.37	-								
GL	-0.49	-0.39	-0.25 <sup>NS</sup>	-							
L7	-0.05 <sup>NS</sup>	-0.01 <sup>NS</sup>	-0.61	0.61	-						
CG	0.64	0.56	0.41	-0.41	-0.67	-					
GC	0.24 <sup>NS</sup>	-0.26 <sup>NS</sup>	0.61	0.41	-0.17 <sup>NS</sup>	0.67	-				
EGC	0.68	0.60	-0.61	-0.41	-0.17 <sup>NS</sup>	0.17 <sup>NS</sup>	-0.16 <sup>NS</sup>	-			
ECG	0.41	0.36	0.25 <sup>NS</sup>	-0.25 <sup>NS</sup>	-0.40	0.61	0.41	0.61	-		
RU	0.24 <sup>NS</sup>	0.25 <sup>NS</sup>	0.61	0.41	-0.17 <sup>NS</sup>	0.67	1.00	-0.17 <sup>NS</sup>	0.41	-	
CHA	0.41	0.36	0.25 <sup>NS</sup>	-0.25 <sup>NS</sup>	-0.41	0.61	0.41	0.61	1.00	0.41	-
METH	0.64	0.56	0.41	-0.41	-0.67	1.00	0.67	0.17 <sup>NS</sup>	0.67	0.67	0.61
KAE	0.42 0.41	0.38 -	-1.00	-0.25 <sup>NS</sup>	0.61	-0.41	-0.41	0.61	-0.25 <sup>NS</sup>	-0.61	-0.25 <sup>NS</sup>

INT = Intake, PAL = Palatability indices, SUCR = Sucrose, GL = Glucose, L7 = Luteolin-7-glucoside, CG = Catechin Gallate, GC = Gallocatechin, EGC = Epigallocatechin, ECG = Epicatechingallate, RU = Rutin, CHA = Chalconaringenin-4-glucoside, METH = Methyl gallate and KAE = Kaempferol-6-C-3-O-diglucoside.

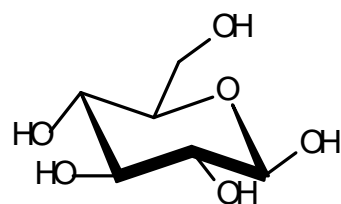
a. Sucrose



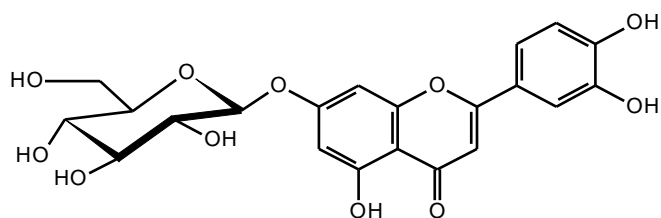
b. Pinitol



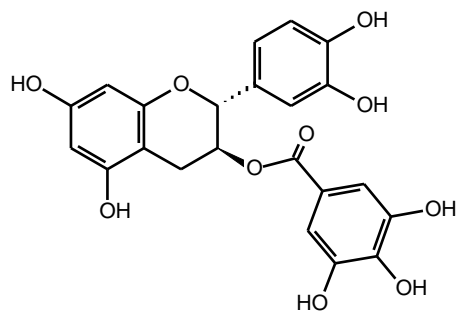
c. Glucose



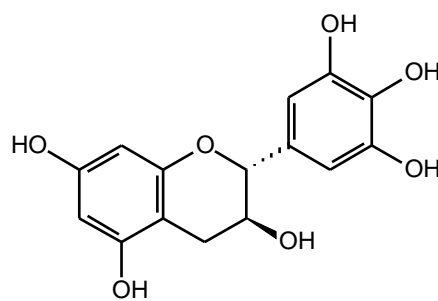
d. Luteolin-7-glucoside



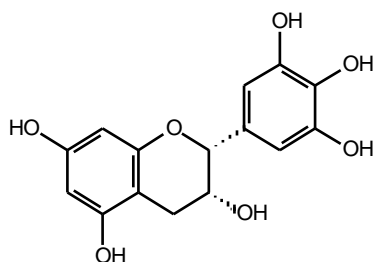
e. Catechin gallate



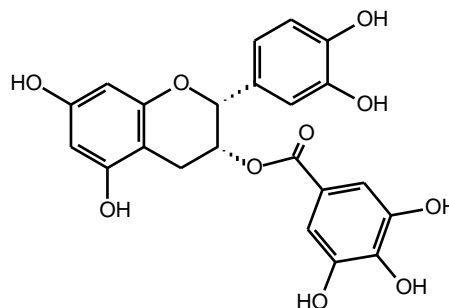
f. Gallocatechin



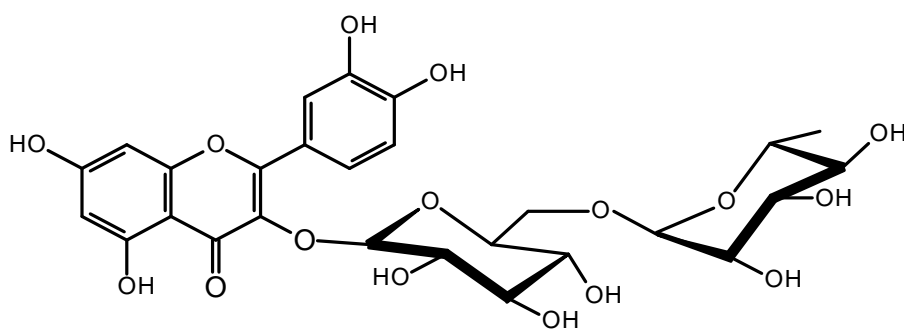
g. Epigallocatechin



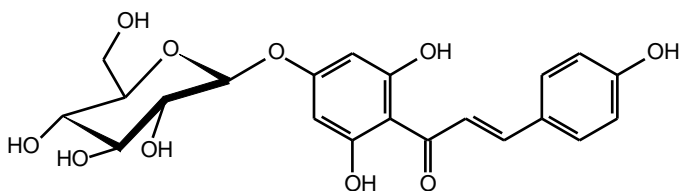
h. Epicatechin gallate



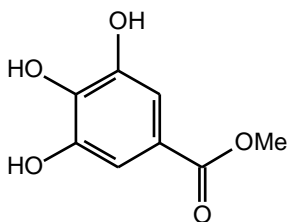
i. Rutin



j. Chalconaringenin-4'-glucoside



k. Methyl gallate



l. Kaempferol-6-C-3-O-diglucoside

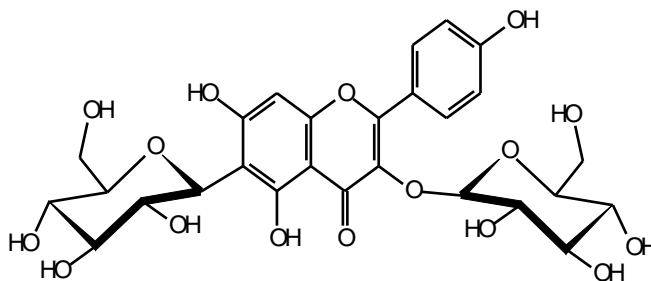


Figure 1. Chemical structures of flavonoids from Acacia species

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## Consumers Willingness To Pay For Safety Labels On Gari (Cassava Roasted Granules) In South Western Nigeria

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**Abstract:** This paper examines consumers' willingness to pay for safety labels on gari in south western Nigeria because of reported cases of hydrogen cyanide residue leading to food poisoning. The type of gari processing technique used determines the amount of cyanide residues. It is important therefore that gari is labeled based on the processing techniques. The use of labels as in other food products will however require additional payment by consumers. From a total of 15 major gari markets, seven were randomly selected through which 200 gari consumers were randomly selected for the study. Data were collected using a structure questionnaire and analyzed using frequency counts, percentages and probit regression model. The probit regression model is significant ( $\chi^2 = 2255$  df<sub>189</sub>,  $p < 0.05$ ). The model reveals that the probability of willingness to pay more for safety labels in gari is positively affected by the prior individual knowledge of safety labels, income level, education level, household size and frequency of consumption. However, it is negatively affected by price and perception of health risks due to cyanide. [Life Science Journal. 2011;8(S1):98-103] (14) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Willingness to pay, Gari, Food Labels, Nigeria, cyanide residues.

### 1. Introduction

Gari is a toasted food product that is very common in Nigeria than any other African countries (Hahn and Keyser, 1998). It is the most popular among cassava products. To prepare gari, fresh cassava are peeled, washed and grated the resulting pulp is put in a porous sack and weighted down with heavy objects for 3-4 days to express effluent from the pulp while fermenting. The dewatered and fermented lump of pulp is pulverized and sieved and the resulting semi-dried pulp is finally roasted (Olsen and Schall, 1999). The sequential processing of gari takes from 1-7-days (Sani, 1994). Palm oil is sometimes added during roasting in order to prevent the pulp from burning. The importance of gari in the western part of Nigeria can not be overemphasized in the sense that it is actually consumed in all its forms at all income levels (Sani, 1994). Oyo state is one of the major cassava producing states and there is high dependency on the food as a source of food security at the household level. Gari has assumed a prominent portion as a household food product due to shortage in supply of major food grain such as rice, maize and

sorghum. Gari provides a pre-cooked fast food with a high demand in urban areas and the need for processing also provides working opportunity and income for urban poor women as processors and marketers (Akintonwa and Tunwase, 1992).

As important as gari is to the people of Nigeria, it is known to contain some toxic cyanogenic glucosides which on hydrolysis become hydrogen cyanide (Food and Agriculture Organisation of the United Nations, 2004). Improperly processed gari contain appreciable proportion of hydrogen cyanide (Essers et al 1992, Mling et al 1992). The fact that gari contains certain toxic factors has been known since cultivation of cassava began and if present in sufficient quantities these compound can cause cyanide poisoning and death in man when consumed. The amount of this toxic compound varies according to the cultivars and growing condition of the cassava plant (Canadian Food Inspection Agency, 2005). In 1998, several cases of cyanide poisoning following meals of gari were reported in Nigeria. According to (Osuntokun, 1981) cases of exposure and acute intoxication have been reported, more serious is the



possibility of chronic toxicity associated with the habitual consumption of large quantities of gari containing high concentration of Hydrogen cyanide which can cause death due to metabolic asphyxiation.

It has also been discovered that processing technique can reduce cyanide content in gari and thus safe for consumption (Hahn and Keyser, 1998) Cyanogen level can be reduced through fermentation technique. This can be done by peeling of fresh cassava roots, washed and grated, fermented in sack, de-watered, granulated and finally roasted (Sani, 1994). The traditional method of gari processing and preparation as food usually remove most of the free cyanide, thus eliminating the danger of toxicity, if efficiently carried out. Different processing techniques are used to reduce cyanogen content in cassava products for safe consumption in different parts of the world. According to (Dufour, 1989) in Brazil, cassava can be processed by soaking the root in a stream for 3-4 days after soaking, the softened cassava is peeled, grated, fermented for about 3 days, dewatered, sifted to produce an even texture substance that is then roasted In Democratic Republic of Congo (formerly, Zaire) the roots are peeled directly after harvesting and soaked for three nights in fish ponds or some other standing water. Water is then extracted from the soaked roots by squeezing and pounded into a mash, further water is removed by squeezing portion of the mash by hand into 5-10cm balls which are then sun dried for at least four days (Mahungu et al, 1987). In Tanzania various processing methods are practiced. The most common in the South Eastern part of the country is the lengthy processing of sun drying peeled and split cassava roots: The sun drying of whole cassava roots takes several weeks if dried on roof tops and this has reduced cyanide content rapidly (Mling et al, 1992). According to (10) storage has some effects on the level of cyanogen in gari, he reported that the cyanogen content of gari stored for four months decreased from 26.6mg HCN equivalent kg to 2.9mg HCN equivalent mg-1 and that no cyanogens could be detected in 57 samples after 2 years.

Cyanogen in gari can also be reduced mechanically through drying in ovens or through natural drying sun-drying. If cassava is peeled and grated before fermentation and then combine with sun drying, it is possible to obtain cyanogen free gari. The fermentation process influences the taste of the final product. The longer the fermentation period, the

stronger the sour taste. Taste is an important attribute especially for consumers who eat cassava fermented product and who desire a strong sour taste. Gari also needs to be attractive to a buyer, colour is also a desirable attribute and the brightness of the colour depends on the fermentation process (Poulter et al, 1994). There are existing internationally acceptable standards for permissible levels of cyanogen in gari (4).

Based on the foregoing, to protect consumer, nutrition labels should be applied to all gari produced. It should include the level of cyanogen present. Consumer and marketers need to understand the needs to provide such information to safeguard and promote safe consumption. Food safety labels are one of the methods to provide information to consumers to ensure food safety. According to Codex Alimentarius Commission (2001) labels is a description intended to inform the consumers of nutritional properties of a food. Safety labels should contain the common name of the product, name and address of the product's manufacturer, names and contents of chemical compounds in the food, date (instruction manufactured and expiry date), storage instruction, direction for preparing the food, net contents in terms of weight, Measures, the ingredients which must be clearly written in descending order of predominance and weight. All these must be clearly written and well stated to guide the consumers in order to choose better products (Mling et la 1992).

The objective of the study is to determine factors that influence gari consumers' willingness to pay for safety labels on gari.

## 2. Materials and Methods

The study was carried out in south western Nigeria which consists of eight Nigeria states namely, Delta, Edo, Lagos, Ogun, Osun, Ondo, Ekiti and Oyo. The area lies between latitudes 4 and 14 south and longitude 2 and 8 east; they collectively cover 114,271 km<sup>2</sup>, which are approximately 12% of Nigeria's total area. The Atlantic Ocean, in the east binds it, in the south by River Niger, in the west by Republic of Benin and in the North by Kwara and Kogi States. The study made use of data obtained mainly from primary source through the use of structured questionnaires which were administered. Two hundred

gari consumers in the study area were randomly selected from a list of association of gari marketers by using a table of random number. Interviews were conducted on gari consumers at 7 major Gari markets in the study area from a total of 15 markets. The analytical tools employed for this study are frequency counts, percentages and probit model. The approach adopted here follows (Akintonwa and Tunwashe, 1992) that estimated econometric model in consumers' willingness to pay for food safety labels in urban Turkey. The model aims to estimate the demand shift due to the presence of a label and thus consumer's willingness to pay. Probit model can be expressed as described by (Akgungor, 2001) as:

$$Q = f(x_i\beta + e_i)$$

Where, Q= Consumers' willingness to pay for safety labels i.e pay higher price so far as there is safety label =1, otherwise = 0

$\beta$  = Vector of respective parameter

$e_i$  = Independent distributed error term

$x_i$  = Vector of explanatory variable

The explanatory variables are:

$X_1$  = Income in Naira

$X_2$  = Age of Consumers in years

$X_3$  = Level of Education in years

$X_4$  = Household Size (number of people in the house)

$X_5$  = Gender (female= 0, Male= 1)

$X_6$  = Unit price of gari ( $P_2$ ) in Naira due to payment for label

$X_7$  = Residue (0= absence, 1= Presence)

$X_8$  = Perception 0= No chance of health problem, 1= Chance of health problem overtime

$X_9$  = Consumption in kg per week per household

$X_{10}$  = Knowledge 0 = Not aware of Cyanide in gari 1 = Aware of cyanide in gari

### 3. Results

The distribution of the respondents by socio-economic variables is presented in Table 1.

Table 1. Personal characteristics of Respondents

Age Group (years)	Frequency	Percentage
$\leq 20$	22	11
21-30	104	52
31-40	22	11
41-50	20	10
$> 50$	32	16
Household Size		
$\leq 5$	110	55
6-10	24	12
$> 10$	66	33
Level of Education		
No formal	2	1
Primary	10	5
Secondary	20	10
Tertiary	168	84

The econometric results is presented in Table 2.

Table 2. Probit Model Result

	Coefficients	t Value
	Coefficients/S.E	
Constant	-3.5296 <sup>x</sup>	
	(0.38708)	-9.10
Income, $x_1$	0.00002 <sup>xx</sup>	
	(0.00001)	2.10
Age, $x_2$	0.00214	
	(0.00377)	0.57
Education, $x_3$	0.03663 <sup>x</sup>	
	(0.02306)	1.60
House hold Size, $x_4$	0.4693 <sup>x</sup>	
	(0.3177)	1.48
Gender, $x_5$	0.28178	
	(0.04982)	5.71

Price, $x_6$	-0.00466 <sup>x</sup>	
	(0.01040)	0.44
Residue, $x_7$	0.2043	
	(0.04874)	-4.20
Perception, $x_8$	-0.9388 <sup>x</sup>	
	(0.04806)	-1.95
Consumption, $x_9$	0.00569 <sup>x</sup>	
	(0.00360)	1.58
Knowledge, $x_{10}$	0.54379	
	(0.16914)	2.84
$\chi^2$	2255	
DF	189	
N	200	

x- Significance at the  $\alpha \leq 0.01$  level; xx- Significance at the  $\alpha \leq 0.05$  level (Figures in parenthesis are standard error)

#### 4. Discussions

Table 1 shows that 73 percent of respondents are between 21 and 50; about 55% had an average size of 5 members per household. About 99% of the respondents are educated which is expected to influence the awareness of consumers as regards the negative effect of hydrogen cyanide on consumer's health. Therefore, respondents sampled in the study are likely to be well informed on issues relating to the negative effect of hydrogen cyanide on human health.

In Table 2, the probit model has a good fit and it is significant at 1 percent and 5 percent respectively because the calculated  $\chi^2 = 2255.60$  is greater than the tabulated values of  $\chi^2$  at 1 percent and 5 percent significant levels respectively ( $\chi^2_{0.01, 189} = 135$ ,  $\chi^2_{0.05, 189} = 124$ ). The model is considered to be a good fit and consistent with theory and that significant relationship exist between the different explanatory variables and the willingness to pay for safety labels. The probit model seeks to explain the probability of willingness to pay for safety labels as a result of the ten identified independent variables. The signs of the coefficients of the independent variables and the significance of the independent variables were

estimated to determine the impact of each variable on willingness to pay for safety labels in gari.

The model reveals that the probability of willingness to pay more for safety labels in gari is positively affected by the prior individual knowledge of safety labels, income levels, education level, household size and frequency of consumption. However, it is negatively affected by price and perception of health risks due to cyanide. Some factors that influence the probability of willingness to pay for safety labels in gari were significant at 1 percent and 5 percent. Gender perception about residue in gari and a prior knowledge of effect of cyanide on human health were significant at 1 percent level of significance. Income and educational level of respondents were factors that were significant at 5 percent level of significance. The implication of this finding is that the more educated consumers have the higher probability of their willingness to pay for safety labels in gari. The negative sign on variables  $x_8$  (perception) implies that consumers' fear of chances of health problem as a result of consuming gari with cyanide also increases their probability of willingness to pay for safety labels. Result also revealed that the higher the awareness level of respondent on the cyanide, the higher the probability of their willingness to pay more for a safety labels by the consumers.

Xia, and Zeng (2010) reported that consumer's attitudes and willingness-to-pay for Green food in Beijing was influenced by age, the perception of green food and the access to information, while Oni, et al (2005) noted that education, gender, income and prior knowledge of bromate positively influence the probability of consumers' decision to pay for safety label on bread in Nigeria.

Loureiro and Umberger (2003) found that consumers in UK are willing to pay an average of \$184 per household annually for a mandatory country-of-origin labeling program on food. Huffman et al (2003) noted that consumers' willingness to pay for a food product decreases when the food label indicates the food product is genetically modified. The evidence shows consumers were willing to pay a 14% premium for food items they perceived as not genetically modified. Socio-demographic attributes of the participants gender, education, household income, and prior beliefs about GM-do not alter significantly a consumer's WTP for GM foods. Gao and Schroeder (2009) argues that willingness-to-pay result from the

interaction of several forces that may affect consumer preferences, which include decreasing marginal utility of additional product label attributes, substitution or complementary effects between presented attributes, and consumer's decreasing ability to process large amounts of information as additional product attributes are provided. Xu and Wu (2010) indicated that gender, age, educational level and income are the main determinants of Chinese consumers' willingness to pay for certified traceable food.

The study has clearly shown that consumers are willing to pay for the cost of safety labels if introduced in gari. This will influence the packaging of gari and instill the confidence in the consumers of the quality of gari being consumed in terms of the level of cyanide resulting from the processing technique used. This will raise the level of awareness among the processor, marketers and consumers. To introduce safety labels on gari, attention must be paid to the significant variables in the probit equation to ensure wide acceptability of this innovation. Consumers themselves can assist by insisting on the use of proper processing techniques that will lead to reduction of cyanide residue in gari.

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## PCR and sequencing assays targeting *mdh* and *gapA* genes for *Escherichia coli* and *Klebsiella* bacteria species identification in river water from the North West Province of South Africa.

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**Abstract:** Rivers carry a significant number of pathogenic bacteria mostly of faecal origin from untreated sewage that result in faecal contamination of the natural environment. This study, being the first of its kind to be reported from the study area, aimed at performing and evaluating standard PCR and sequencing assays based on the use of *mdh* and *gapA* genes for *E. coli* and *Klebsiella* species identified in the major rivers in the North West Province of South Africa. A total of 54 water samples were collected between November 2007 and March 2008 from the Crocodile, Elands, Hex, Mooi, Vaal, Molopo, Groot Marico, Harts and Skoonspruit rivers and cultured on selective media to isolate *E. coli* and *Klebsiella* species using the standard spread-plate method. Molecular characterisation of suspected isolates by PCR was performed to amplify an intragenic segment of the *mdh* and *gapA* genes, which detected *E. coli* and *Klebsiella* with a prevalence of 44% and 29%, respectively among the samples. The presence of these pathogens, amongst others, in these rivers indicates faecal contamination. This suggests that the use of untreated water from these rivers for drinking by humans may pose serious health problems, including diarrhoea and other water-borne diseases. The study emphasizes the need to provide potable water supplies particularly in rural areas, as well as routine monitoring for the presence of pathogens in these rivers and effective management of river catchments. [Life Science Journal. 2011;8(S1):104-112] (15) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** *E. coli*, *gapA*, *Klebsiella*, *mdh*, polymerase chain reaction, human health, and untreated water

### 1. Introduction

The importance of water as a vehicle for disease transmission has been widely documented, particularly in developing countries, where the availability of potable water supplies is limited (Shannon et al., 2007). In 2004, 1.1 billion people were estimated to be without access to potable water (WHO, 2004). Generally, rivers can carry a significant number of enteropathogens from municipal sewage discharge, rainfall runoff from agricultural farms, and faecal waste of humans, pets, farm animals and wild life (Arvanitidou et al., 2005). The presence in water of *E. coli*, *Klebsiella* and other etiologic agents, such as *Vibrio cholerae*, *Salmonella typhi*, *Shigella boydii*, *Campylobacter jejuni*, Hepatitis A, and *Giardia lamblia*, may lead to water-borne diseases (Ashbolt, 2003). Moreover, the resistance of these pathogens to antimicrobial agents such as tetracycline, erythromycin and ampicillin, has previously been reported (Lin and Biyela, 2005; Wose Kinge et al., 2010).

Globally, diarrhoea is the third largest cause of morbidity and the sixth greatest cause of mortality in humans. The situation is notably poor in South Africa, where 16 000 people die every year from

diarrhoeal disease (Obi et al., 2002). Incidences of diarrhoeal outbreaks *S. flexneri* and *S. sonnei* have previously been reported in the Mpumalanga, Limpopo, and Northern Cape (National Institute for Communicable Diseases, 2008).

Although *E. coli* is usually a harmless bacterium of the human intestinal flora, pathogenic strains such as enterohaemorrhagic *E. coli* (EHEC), shiga-toxin-producing *E. coli* (STEC), enteropathogenic *E. coli* (EPEC), enteroinvasive *E. coli* (EIEC), and enterotoxigenic *E. coli* (ETEC) have been implicated in cases of diarrhoea (Watterworth et al., 2005). The pathogen *E. coli* O157:H7 is now widely documented as a major cause of diarrhoeal diseases in humans as well as animals worldwide (Ateba et al., 2008; Müller et al., 2001).

*Klebsiella* species, on the other hand, are opportunistic pathogens frequently associated with nosocomial infections (Haryani et al., 2007). Whereas *K. pneumoniae* and *K. oxytoca* are the two most frequently found *Klebsiella* species, *K. pneumoniae* remains the most medically important opportunistic pathogen (Haryani et al., 2007). However their presence in water has also been reported (Syposs et al., 2005). Different molecular markers of genomic DNA



are being used for the detection and identification of the different strains of *E. coli* and *Klebsiella* species using PCR, a molecular tool used for microbial identification and surveillance with high sensitivity and specificity as it allows for the amplification of target DNA fragments using oligonucleotide primers (Watterworth et al., 2005).

*E. coli* and *Klebsiella* are faecal coliforms that generally, inhabit the gastrointestinal tract of all warm and some cold-blooded animals as normal commensals. As a result, their presence in water cannot be pinpointed to a specific source of faecal contamination. However, faecal material from human and animal sources can be regarded as high risk due to the possible presence of pathogenic bacteria (Harwood et al., 2000). In this study, the *mdh* and *gapA* home-keeping genes to identify *E. coli* and *Klebsiella* were targeted using a pair of oligonucleotide primers (Hall et al., 1992; Nelson et al., 1991).

The *E. coli mdh* gene was chosen as target gene because it is not vulnerable to horizontal gene transfer, the variable region is flanked by highly conserved regions, it is relatively short and contains sufficient allelic polymorphism to differentiate strains (Olive and Bean, 1999). Similarly, the *gapA* gene was selected because it exhibits an unusually high codon bias. The fact that the identification of pathogenic microbes is crucial for the surveillance, prevention and control of water-borne diseases, this study was part of our previous study, which focused on the characterisation of *Shigella* species in the river catchments of the North West province (Wose Kinge and Mbewe 2010). While no incidences of diarrhoea outbreaks due to *E. coli* and *Klebsiella* infection have been reported in the North West province, the possibilities of their occurrence cannot be underestimated as other water borne diseases such as cholera and typhoid have previously been reported (DoH 2003, 2005).

Therefore with little or no available information of diarrhoea outbreaks in the province, this study would create an awareness of the presence of pathogenic *E. coli* and *Klebsiella* spp in river waters and preparedness for any full-blown disease outbreak. Furthermore, with the shortage of potable water supplies in the province, this study highlights the need for effective management of river catchments and the provision of potable water supplies particularly to rural settlements. This will minimise

the risk of contracting any water-borne disease thus promoting a healthy community.

## 2.1 Materials and Methods

### 2.1.1 Sample collection

A total of 54 water samples were collected, using sterile 500ml McCartney bottles, downstream, midstream, and upstream of the Crocodile, Elands, Hex, Mooi, Vaal, Molopo, Groot Marico, Harts and Skoonspruit rivers between November 2007 and March 2008 (Fig 1). These rivers form the five major catchments in the province, which are the Crocodile and Eland, Marico and Hex, Marcio and Molopo, Mooi and Vaal, and Harts catchments. The location and description of the sampled sites is as shown in Table 1. Samples collected were transported to the laboratory for analysis.

**Figure 1:** A cross-section of the North West province map showing the rivers and dams sampled

### 2.1.2 Isolation of *E. coli* and *Klebsiella* isolates

Water was sampled for the isolation of *E. coli* and *Klebsiella* species using the spread-plate method following serial dilutions (Standing Committee of Analysts, 2002). Aliquots of 0.1 ml of each dilution were plated out on Eosin Methylene Blue (EMB) agar plates (Biolab, Merck Diagnostics, South Africa). All plates were incubated at 37°C for 24 h. *Escherichia coli* ATCC® 25922, *Klebsiella pneumoniae* ATCC® 15611 and *Klebsiella oxytoca* ATCC® 43086 were used as positive controls (Lu et al., 2000) while *Salmonella typhimurium* ATCC 14028 and *Shigella boydii* ATCC 9207 were included as negative control (Hsu and Tsen, 2001; Wang et al., 1997). Isolates were Gram-stained according to standard methods (Cruickshank et al., 1975).

### 2.1.3 DNA extraction

Genomic DNA was extracted from presumptive *E. coli*, *Klebsiella* and ATCC cultures as previously described by Doyle et al., 1997 with slight modifications of 350 µl of 2X hot (65°C) hexadecyl trimethyl-ammonium bromide (CTAB) isolation buffer and 150 µl of 5% polyvinyl pyrrolidone (PVP). The concentration of the extracted DNA in solution was determined spectrophotometrically (UV Visible spectrophotometer model S-22, Boeco, Germany) by measuring the absorbance at 260 nm.

### 2.1.4 PCR detection of the *mdh* and *gapA* genes

Amplification of the *mdh* and *gapA* genes was performed using the primer pairs shown (Table 2), as described previously (Diancourt et al., 2005; Hsu and Tsen, 2001) and electrophoresis of the PCR products was performed as previously described (Wose Kinge and Mbewe, 2010). Percentages were calculated by dividing the total number of PCR positive isolates obtained by the total number of presumptively positive isolates per catchment and multiplying by 100.

### 2.1.5 Sequence analyses of the *mdh* and *gapA* genes.

To confirm the identity of *E. coli* and *Klebsiella* bacteria isolated, the amplified products were sequenced by Inqaba Biotechnical Industries Pretoria, South Africa. The gene sequences corresponding to the bacteria genus/species were retrieved from BLAST searches.

## 3. Results

Table 3 shows the overall prevalence of *E. coli* and *Klebsiella* obtained from the different river catchments. *E. coli* was highest in the Crocodile and

Elands rivers followed by the Mooi and Vaal while the highest prevalence of *Klebsiella* was observed in the Mooi and Vaal rivers. A total of 77% of isolates from the Crocodile and Elands rivers tested positive for *E. coli*. Similarly, 29% of isolates from the Mooi and Vaal and 7% from the Marico and Hex rivers tested positive for *E. coli*. Furthermore, 19% of the total isolates from the Mooi and Vaal, and 11% of isolates from both the Marico and Hex, and Marico and Molopo rivers, tested positive for *Klebsiella*. In all, 44% of the positive *E. coli* isolates from all the rivers generated the 392bp product for the *mdh* gene as shown (Fig. 2). Similarly, 24% of the total *Klebsiella*-positive isolates generated a 700bp product depicted in Figure 3. Sequence analyses of *mdh* and *gapA* sequences from the *E. coli* and *Klebsiella* isolates and their comparison with those of closely related bacteria showed various homologies. After the BLASTN on GenBank, the first 11 results (presenting a high level of homology, 96-98%) all corresponded to *E. coli*. Similarly, the first 11 results presented 89% homology to *Klebsiella*. Multiple alignment of the first 11 results showed that all the *E. coli* and *Klebsiella* strains were identical for the *mdh* and *gapA* genes, respectively.

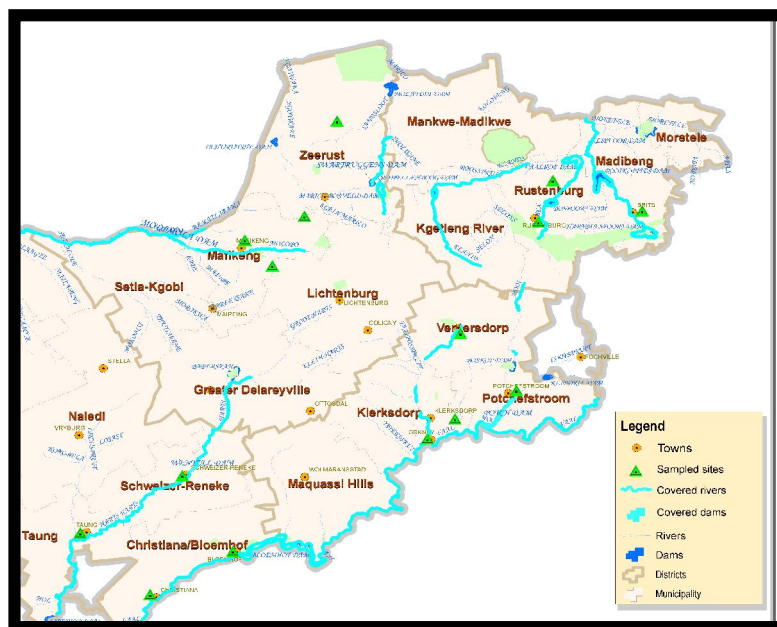
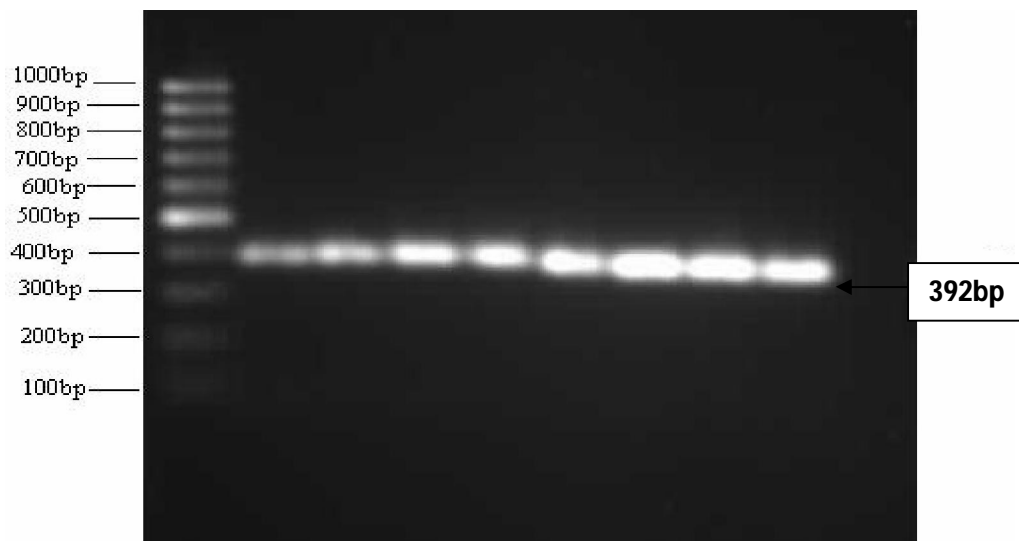
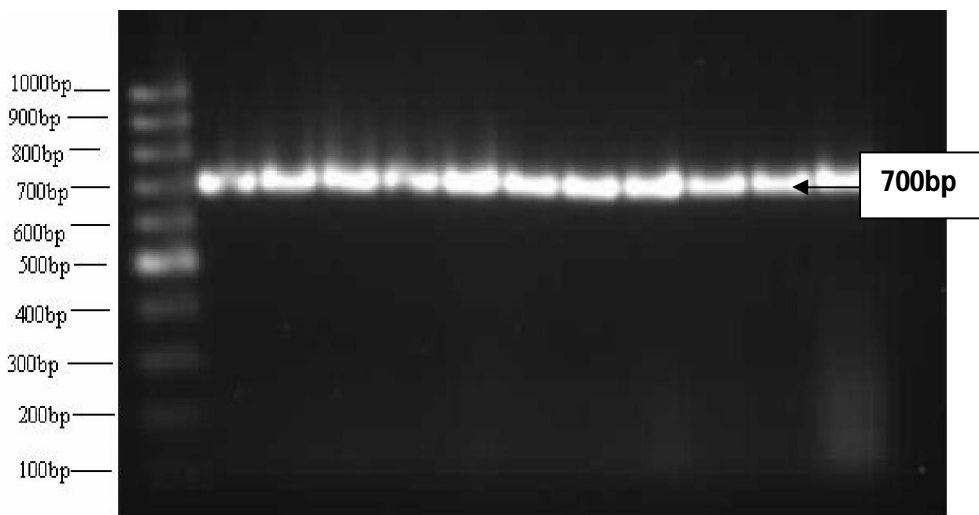


Figure 1. A total of 54 water samples were collected between November 2007 and March 2008



**Figure 2:** PCR amplification of *mdh* gene from suspected *E. coli* isolates. Lane M: 100bp DNA ladder, Lane 1: *E. coli* strain ATCC 25922, Lane 2: ERD24, Lane 3: ERU20, Lane 4: ERU45, Lane 6: HRM7, Lane 7: HRM39, Lane 8: VRM37, Lane 9: negative control.

**N.B:** ERM (Elands River Midstream), ERU (Elands River Upstream), HRM (Hex River Midstream), VRM (Vaal River Midstream).



**Figure 3:** PCR amplification of the *gapA* gene from suspected *Klebsiella* isolates. Lane M: 100bp DNA ladder, Lane 1: *K. pneumoniae* strain ATCC 15611, Lane 2: *K. oxytoca* strain ATCC 43086, Lane 3: GMM3, Lane 4: VRD40, Lane 5: VRD47, Lane 6: SRU5, Lane 7: SRU6, Lane 8: SRU8, Lane 9: MRU41, Lane 10: MRU42, Lane 11: MRU43, Lane 12: MRU44, Lane 13: negative control.

**N.B:** VRD (Vaal River Downstream), MRU (Molopo River Upstream), SRU (Skoonspruit River Upstream), GMM (Groot Marico Midstream).

**Table 1: Major rivers in the North West province where samples were collected**

<b>Catchments</b>	<b>Major rivers</b>	<b>Sampled sites</b>	<b>Area description of sampled sites</b>
Crocodile and Elands	Crocodile	Hartebeespoort dam, Brits and Rooikoppies dam	Madibeng Primidia Clinic next to the river; cattle farm 200 m away and a game reserve.
	Elands	Sun City, Swartruggens and Lindleyspoort dams	Cattle dung at river banks; Kgetleng Municipal Clinic approximately 500 m away.
Marico and Molopo	Groot Marico	Groot Marico, Marico Bosveld Dam and Derdepoort	Groot Marico Clinic approximately 200 m away.
	Molopo	Modimola dam, Cookes' Lake and Molopo Oog	Mmabatho Sewage Treatment Plant; informal settlement with pit toilets.
Marico and Hex	Groot Marico	Groot Marico, Marico Bosveld dam and Derdepoort	Groot Marico Clinic approximately 200 m away
	Hex	Lesung, Bospoort and Vaalkop dam	Informal settlements; cattle dung at river banks.
Mooi and Vaal	Mooi	Potchefstroom, before Potch dam, and Potch dam	Mooi Med Hospital 100 m away
	Vaal	Christiana, after Bloemhof dam and Bloemhof dam	Christiana Hospital 500 m away; cattle, duck and sheep farms approximately 200 m away; and Bloemhof Sewage Treatment Plant
	Skoonspruit	Orkney, Klerksdorp and Ventersdorp	Orkney Sewage Treatment Plant 100 m away, cattle dung at riverbanks; piggery and duck farm 200 m away.
Harts	Harts	Taung, Schweizer-Reneke and Barberspan	Taung District Hospital 200 m away, animal dung at riverbanks, informal settlement, Shweizer-Reneke District Hospital

**Table 2: Nucleotide sequences of primers**

Organism	Target gene	Primer	Primer sequence (5' 3')	Expected product size (bp)
<i>E. coli</i>	Malate dehydrogenase	<i>Mdh</i>	F: CGTTCTGTTCAAATGGCCTCAGG R: ACTGAAAGGCAAACAGCCAAG	392 <sup>a</sup>
<i>Klebsiella</i>	Glyceraldehyde 3-phosphate dehydrogenase	<i>gapA</i>	F: GTTTTCCCAGTCACGACGTTGTATGAAATATGACTCCACTCACG R: TGTGAGCGGATAACAATTTCTTCAGAAAGCGGCTTTGATGGCTT	450 <sup>b</sup>

<sup>a</sup>Hsu and Tsen, 2001; <sup>b</sup>Diancourt et al., 2005

**Table 3: Prevalence of suspected *E. coli* and *Klebsiella* isolates obtained by PCR.**

River catchments	<i>E. coli</i> (%)	<i>Klebsiella</i> (%)	Others (%)
Crocodile and Elands	77	0	23
Marico and Hex	7	11	82
Marico and Molopo	0	11	89
Mooi and Vaal	29	19	52
Harts	0	0	100

#### 4. Discussions

Although the dosage of these bacteria in water that can cause disease in humans is not known, however, according to World Health Organisation (WHO) and Department of Water and Environmental Affairs (DWEA) standards, no faecal coliform bacteria should be detected in any given body of water intended for domestic and recreational use. This is because of the potential risk of gastrointestinal effects (DWEA, 1999; WHO, 2001). The severity of such gastrointestinal effects increases with an increasing number of faecal coliforms present. Such increase is an indication of recent faecal contamination, inadequate treatment or post-treatment deficiencies (Zamxaka et al., 2004).

Crop, livestock, chicken and even crocodile farming, irrigation, informal settlements, and mining were seen to be the main human activities in these river catchments. These activities, independently or in combination, contribute to heavy discharges into the rivers sampled with significant impacts on the water quality in their catchment areas (DWEA, 2007; Germs et al., 2004; Nevondo and Cloete, 1999; Obi et al., 2002).

Previous studies conducted in other parts of South Africa have reported the presence of these bacteria in rivers using the *mdh* and *gapA* genes for *E. coli* and *Klebsiella* identification (Hsu and Tsen, 2001; Kong et al., 2002; Lin and Biyela, 2005; Obi et al., 2002). All sequences retrieved from BLAST searches were similar to those previously deposited in

GenBank, which confirmed the identity of our isolates (Stephen et al., 1997; Zheng et al., 2000).

Studies have shown that faecal coliforms, more specifically *E. coli*, increases after a rainfall but thereafter, decrease as a result of the process of sedimentation (Chigbu et al., 2005; Elmanama et al., 2005). The greater incidence of *E. coli* and *Klebsiella* bacteria in the Crocodile and Elands, and Mooi and Vaal catchments, respectively, may be attributable to the runoff from the wastewater treatment plants, hospitals, livestock farms, as well as informal settlements, which are in close proximity to the sample sites. These factors might have contributed independently or in combination to the relatively high prevalence observed. The shortage of potable water in the province, forces people living in the rural areas to use such untreated water supplies, hence the possible risk of infection, especially in immune-compromised individuals (Obi et al., 2002).

## 5. Conclusions

The presence of *E. coli* and *Klebsiella* in river water indicates faecal contamination and can be linked to runoffs from rain, and improper management of the river catchments. The high prevalence of these bacteria emphasizes the need for improved potable water supply, particularly to rural settlements that rely on surface water resources for domestic use, and the proper management of river catchments in the province. Consumption of untreated water from these rivers for drinking may pose serious health problems, including diarrhoea and other water-borne diseases that have serious health implications. Furthermore, the use of such contaminated water for irrigation may result in the transmission of these bacteria to humans through contaminated vegetables and other crops eaten raw, as well as milk from grazing cattle, hence the need for proper monitoring.

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#15

## Coliform flora in faeces of dogs presented to the Animal Health Clinic of North West University, Mafikeng Campus, South Africa

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**Abstract:** The purpose of this study was to investigate the coliform flora present in dog feces and their role as a reservoir of antimicrobial resistance. A total of thirty-one rectal swabs were randomly obtained from sixty client-owned dogs brought to the Animal Health Clinic of the North West University, Mafikeng Campus, during the month of June 2010. The dogs were presented with complaints varying from routine vaccination to anorexia and diarrhea. Samples were subjected to routine microbial culture and isolation procedures, followed by biochemical characterization and antimicrobial susceptibility testing of obtained isolates. Results showed the presence of *E.coli* spp (9.5%), *Salmonella* spp (4.8%), *Klebsiella* spp (33.3%), *Enterobacter* spp (19%), *Pasteurella multocida* (4.8%), *Proteus* spp (14.3%), *Vibrio* spp (4.8%) and *Serratia* spp (9.5%). All the isolates were resistant to at least two of the antibiotics tested. The antibiotics include ampicillin (10 µg), chloramphenicol (30 µg), cefuroxime (30 µg), cotrimoxazole (25 µg), tetracycline (30 µg), sulphadiazine (200 µg) and clindamycin (2 µg). The results suggest that dog feces could pose a zoonotic risk to humans and could also act as reservoir of antimicrobial resistance genes. It is recommended that dog owners and health workers particularly immunocompromised persons should exercise care when handling dog feces. [Life Science Journal. 2011;8(S1):113-118] (16) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Key words:** Faeces, dogs, coliforms, antimicrobial resistance, human, reservoir

## 1. INTRODUCTION

In many parts of the world including South Africa, pets, particularly dogs, are important members of families. Dogs have lived in close proximity to man for thousands of years, and are kept by people for various reasons. These include companionship, security/protection, and animal assisted therapy for physically-challenged individuals<sup>[1]</sup>. Furthermore, due to their interactive, affectionate and non-judgmental nature, dogs have been shown to play important roles in child development and the well-being of elderly people<sup>[2]</sup>. Despite the physical and emotional benefits derived from them, dogs constitute important source of zoonotic infections, which could pose significant threat to human health. Dogs have been implicated in the transmission of important enteric pathogens such as *Salmonella*, *Campylobacter* and *Cryptosporidia*, which could

cause life-threatening diarrhea in immunocompromised persons<sup>[3]</sup>. For example, *Salmonella virchow* has reportedly been transmitted from household dogs to an infant, as confirmed by pulse-field gel electrophoresis<sup>[4]</sup>.

In South Africa, there has been a tremendous increase in dog population from 3.93 million in 1992<sup>[5]</sup> to 9.1 million in 2008<sup>[6]</sup>. This could be as a result of increased acknowledgement of the benefits of dog ownership. Coincidentally, an increasing proportion of the human society is immunodeficient, principally through HIV infection<sup>[7]</sup>. Other groups of individuals included in the immunocompromised status are children, pregnant women and the elderly<sup>[8]</sup>. The current dog-human interaction, coupled with the need to protect human health, calls for continuous screening of dogs for zoonotic pathogens that could pose health risk to

humans. This is particularly in view of the fact that dogs frequently display no clinical signs when colonized with enteric pathogens that cause human disease but rather shed the pathogens in their faeces<sup>[9]</sup>. This will enable adequate risk communication to dog owners and care-givers. The aim of this study was to evaluate the incidence of enteric pathogens in dogs, particularly coliforms, and to determine their susceptibility to various antimicrobial agents.

## 2. MATERIALS AND METHODS

Thirty-one rectal swabs were randomly collected from sixty client-owned dogs that were brought to the Animal Health Clinic of the North West University, Mafikeng Campus, in June, 2010. The dogs were brought for various cases including routine vaccination, elective surgery (mostly ovariectomy and castration), and treatment of diarrhea. Sampling was done regardless of age, sex and physiological status. However, sampled dogs were freshly presented cases, with no history of recent antibiotic treatment. To obtain the rectal swabs, commercially available sterile cotton swabs were used. The swabs were moistened in sterile distilled water before being inserted into the rectum. Swabs with fecal materials were then dipped in tubes containing 10 ml of Amies Transport Medium (Merck, South Africa) and kept in the refrigerator at 4°C before analysis (usually within 24–48 hours of collection). Culture and isolation procedures were carried out using the conventional method of coliform isolation<sup>[10]</sup> with modifications. *S. typhimurium* ATCC 14208 was used as control strain.

Swabs were inoculated in 10 ml of Nutrient broth for enrichment and incubated at 37°C for 24 hours. A loopful of the enrichment broth was streaked on *Salmonella Shigella* agar (Merck, South Africa) for isolation and incubated at 37°C for 24 hours. Suspect colonies were further purified on *Salmonella Shigella* agar and later preserved on Nutrient agar (Merck, South Africa) for subsequent analysis. Suspect colonies were also Gram-stained to confirm Gram-negative rods. Biochemical characterization of presumptive isolates was carried out, starting with oxidase test to confirm *Enterobacteriaceae*. Thereafter, further biochemical tests were performed on the isolates using the Analytical Profile Index kit (API 20E, Biomerieux, South Africa). The seven-digit index number of each

isolate was determined and this was used to identify the isolates from Apiweb™ identification software (Biomerieux, South Africa).

Resistance of identified isolates to antimicrobial agents was determined using the Kirby Bauer disc diffusion method<sup>[11]</sup>. Bacterial inoculum was prepared from pure cultures that were preserved on Nutrient agar whereas Mueller-Hinton agar (Merck, South Africa) was used for the antibiotic testing. Antibiotic disks were obtained commercially (Davies diagnostics, SA) and included ampicillin (10 µg), chloramphenicol (30 µg), cefuroxime (30 µg), cotrimoxazole (25 µg), tetracycline (30 µg), sulphadiazine (200 µg) and clindamycin (2 µg). Inoculated plates, were after impregnation with antibiotic disks, inverted and incubated overnight for 18 hours at 37°C. Zones of complete inhibition were then measured and results were interpreted as resistant, intermediate and susceptible, using the CLSI<sup>[12]</sup> guideline. The multiple antibiotic resistance (MAR) index for the various phenotypes identified was calculated using the following equation as described by Singh et al.<sup>[13]</sup>

$$\text{MAR index} = \frac{\text{Number of resistance x antibiotic}}{\text{Total number of antibiotics tested}}$$

## 3. RESULTS

Out of the 31 rectal swabs analysed, two (6.5%) were presumably negative for fecal coliforms as evidenced by absence of growth on *Salmonella Shigella* agar. Of the remaining 93.5%, at least one group of fecal coliforms was isolated from each sample. In total, eight different fecal coliform groups were identified in this study, and included three species of *Klebsiella*, two species of *Enterobacter* and a species each of *Salmonella*, *E.coli*, *Serratia*, *Vibrio*, *Pasturella* and *Proteus*. The various groups of coliforms identified from samples and their percentage incidences are presented in Figure 1.

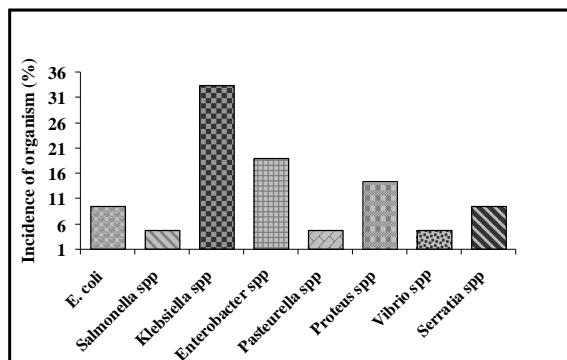


Figure 1 Percentage incidence of different coliform species in total dog feces

The identified isolates were tested for antimicrobial resistance and were all found to be resistant to more than one antibiotic agent. However, all isolates (100%) were susceptible to chloramphenicol and clotrimoxazole whereas they were all resistant to ampicillin and clindamycin. The percentage of isolates resistant to each antimicrobial

agent and the distribution of antimicrobial resistance in different isolates are presented in Figure 2 and Table 1 respectively. Similarly, Table 2 indicates the multiple antibiotic resistance (MAR) patterns of the isolates.

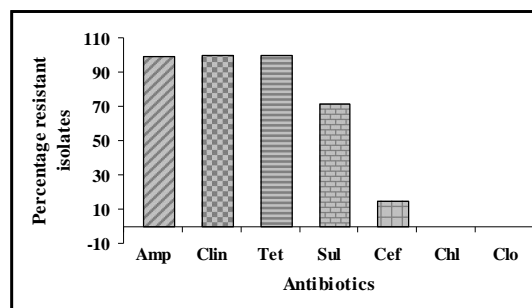


Figure 2 Percentage resistance of isolates to different antibiotics tested.

Amp = ampicillin, Chl = chloramphenicol, Cef = cefuroxime, Clo = clotrimoxazole,

Tet = tetracycline, Sul = sulphadiazine, Clin = clindamycin

Table 1. Percentage distribution of antimicrobial<sup>a</sup> resistance in obtained isolates

Resistance patterns	Amp	Chl	Cef	Clo	Tet	Sul	Clin
	(10)	(30)	(30)	(25)	(30)	(200)	(2)
<i>Klebsiella pneumoniae</i> ssp <i>pneumoniae</i>	38	0	0	0	38	0	38
<i>Klebsiella ornitholytica</i>	38	0	0	0	38	38	38
<i>Enterobacter cloacae</i>	75	0	0	0	75	0	75
<i>Enterobacter sakazakii</i>	25	0	0	0	25	25	25
<i>Salmonella arizonae</i>	100	0	0	0	100	100	100
<i>Escherichia coli</i>	100	0	100	0	100	100	100
<i>Proteus mirabilis</i>	100	0	0	0	100	100	100

<i>Klebsiella oxytoca</i>	25	0	0	0	25	25	25
<i>Serratia marcesens</i>	100	0	0	0	100	100	100
<i>Vibrio alginolyticus</i>	100	0	100	0	0	100	100
<i>Pasteurella multocida</i>	100	0	0	0	0	100	100

<sup>a</sup>Amp = ampicillin, Chl = chloramphenicol, Cef = cefuroxime, Clo = clotrimoxazole,

Tet = tetracycline, Sul = sulphadiazine, Clin = clindamycin

Table 2. MAR patterns of obtained isolates

MAR phenotypes	No observed	MAR index
Ap-T-Cl	2	0.86
Ap-Su-Cl	1	0.43
Ap-T-Su-Cl	6	3.43
Ap-Ce-T-Su-Cl	1	0.71
Ap-Ce-Su-Cl	1	0.57

Ap = ampicillin, Ce = cefuroxime, T = tetracycline, Su = sulphadiazine, Cl = clindamycin

#### 4. DISCUSSION

Results of this study indicate high incidence of fecal coliforms in dog feces, including known pathogenic strains. This agrees with the claim of Van Der Wel<sup>[14]</sup> who suggested that a gram of dog feces can contain 23 million fecal coliform bacteria. Pathogenic strains, such as *Salmonella* spp, identified in the current study have also been isolated from the feces of both healthy and diarrheic dogs in previous studies<sup>[15]</sup>. However, the incidence of 4.8% for *Salmonella* in the current study is higher than levels observed in some geographical areas such as Slovakia (0.53%)<sup>[16]</sup> and Trinidad (3.6%)<sup>[17]</sup>. Variations in fecal microbiota of dogs have been associated with age, diet and physiological status among many other factors<sup>[18,19]</sup>. Fecal coliforms are often considered as indicators of the presence of other pathogenic organisms in a system<sup>[20]</sup>. However, almost all the species recorded in this study have recently been associated with myriads of disease, with varying degrees of virulence. For instance, *E.*

*coli* and *Salmonella* species have been associated with severe cases of diarrhea in all human age groups, besides pneumonia, meningitis and urinary tract infections caused by *E. coli*<sup>[21]</sup>. Similarly, infections caused by *Klebsiella* strains, which have the highest percentage incidence in this study, have increased over the last two decades. Many dog owners live in close contact with their canine companions, and it is common for dogs to nuzzle / lick their owners even after licking their anal region. Thus the findings of this study indicate that dogs, and their feces, have the potential to play a significant role in disease transmission and public health.

Of greater concern, is the pattern of antimicrobial resistance exhibited by the isolates identified in the current study. This suggests previous exposure of the isolates to the antibiotics tested, which could be through veterinary antibiotic use in the dogs. The sensitivity of isolates to chloramphenicol and clotrimoxazole is in harmony with the findings of Seepersadsingh et al.<sup>[17]</sup> and



Kocabiyik et al.<sup>[22]</sup> for strains of *Salmonella* spp isolated from feces of non-diarrheic dogs in Trinidad and Turkey respectively. However, studies conducted by Tsai et al.<sup>[23]</sup> and Nam et al.<sup>[24]</sup> indicated resistance of *Salmonella* and *E. coli* strains, recovered from rectal swabs and intestinal samples of dogs, to these antimicrobials. Resistance of the isolates in this study to ampicillin, clindamycin and tetracycline agrees with the report of Costa et al.<sup>[25]</sup> and Tsai et al.<sup>[23]</sup>. The susceptibility of *Klebsiella* animal clinical isolates to antimicrobial agents was similarly investigated. Thirteen isolates were found to be resistant to two or more antimicrobials, with 99% resistance to ampicillin<sup>[26]</sup>. Contrary to the findings of this study, Seepersadsingh et al.<sup>[17]</sup> reported high sensitivity of *Salmonella* isolates to ampicillin. Differences in geographical locations and strains of bacteria isolates might be responsible for the variations in antimicrobial testing outcomes.

The resistance to antimicrobial agents by bacteria isolates could be due to possession of antimicrobial-resistant determinants such as Extended-Spectrum Beta-Lactamases (ESBLs), which are mostly borne on plasmids for easy transfer from one bacteria to another. Indeed, *K. pneumoniae*, *K. oxytoca*, *P. mirabilis* *E. coli* and *Salmonella* have been reported to be capable of producing different types of ESBLs<sup>[27,28]</sup>. Thus, resistant bacteria in pet animals such as dogs are able to reach human hosts and confer their resistance genes to bacteria resident in or on the human host<sup>[4]</sup>. This could result in treatment failure in human clinical cases involving these organisms. Although the risk of becoming sick from a fecally-transmitted pathogen from a dog is minimal to most people, it is higher for young children and immunocompromised individuals.

The results of this study suggest that dog feces could pose a zoonotic risk to humans and could also act as reservoir of antimicrobial resistance genes. Dog owners and health workers particularly immunocompromised persons should exercise care when handling dog feces.

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## Efficacy of nonfeed deprivation methods for molt induction in layers

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**Abstract** This study was aimed at comparing the efficacy of different nonfeed deprivation molting methods with feed withdrawal in terms of body weight loss, ovarian regression and post molt layer performance. A total of 384 Dekalb white laying hens, aged 72 weeks, were used in this study. Birds, which were kept in a 50 x 46 x 45 cm battery cage system, were randomly divided into four experimental groups. Feed was completely withdrawn from hens in group one for nine days (FW). Birds in group two were fed alfalfa meal (AM) for nine days and birds in group three were fed layer ration containing 20,000 ppm of zinc as ZnO (DZ) for nine days. From day 10, birds in groups one to three consumed cracked corn diet until day 28. Birds in the fourth group consumed cracked corn diet (CC) *ad libitum* for the 28 days. All the groups were then returned to normal layer diet *ad libitum*. Results indicate that body weight loss and reproductive tract regression in AM group was quite comparable to that of FW group. These were significantly lower in CC group. Short-term post molt egg production revealed significantly higher production in CC group than FW. There was however no significant difference between treatments in post molt egg quality, rate of deterioration of stored eggs, weights of liver, heart and spleen and bird mortality. In summary, alfalfa meal appears to be the most efficient molt induction method, comparable with feed withdrawal. However, long-term post molt performance of all the methods employed in this study, needs to be evaluated in order to draw comprehensive conclusions. [Life Science Journal. 2011;8(S1):119-124] (17) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Molt induction, layer, egg production, egg quality, nonfeed deprivation

### 1. INTRODUCTION

Molting is a natural seasonal event in which birds substantially reduce their feed intake, cease egg production and replace their plumage. It is usually referred to as a period of rest as marked by regression of the hen's reproductive tract. The entire process, which is normally triggered by any form of stress, is meant to prepare the bird for the next production cycle. Induced molting is a process that simulates natural molting events and has been widely employed in commercial layer management. The usual aim is to extend the birds' productive life and minimize the challenges of flock replacement<sup>[1]</sup>. Molt induction in layer flocks has an advantage of causing simultaneous molting of the entire flock, thus enabling uniform commencement of the next egg production phase. The commonest method of molt induction utilized by many commercial layer farmers is feed withdrawal for a number of days<sup>[2]</sup>. This is because it is cheap, easy to apply and efficient when compared with other molting methods.

This practice however tends to compromise both the well-being and the immune function of the birds, thereby inducing significant systemic and infectious disease conditions. For instance, *Salmonella enteritidis* infection has been linked scientifically to force-molting by feed withdrawal<sup>[3]</sup>. Thus, eggs from such birds constitute a health risk for the consumer. This has raised public health concern in recent times, leading to condemnation of the practice by Canadian Veterinary Medical Association and Scientific Veterinary Committee for the European Union<sup>[4]</sup>. In recent years, research focus has been on manipulating layer diets to induce molt with minimum stress to the birds, and yet obtain economic results comparable to feed withdrawal. Methods such as feeding low nutrient rations<sup>[5,6]</sup> and administration of metals<sup>[7]</sup> have been explored with variable results. The objective of the present study therefore, is to evaluate the influence of various molting methods on ovarian regression, post-molt egg production and egg quality.

## 2. MATERIALS AND METHODS

This study was conducted from 18<sup>th</sup> August to 30<sup>th</sup> October, 2009 at the Department of Animal Science Experimental Farm of the Northwest University, Mafikeng Campus, South Africa. A total of 384 Dekalb white laying hens, aged 72 weeks were used in this study. The birds were kept in a 50 x 46 x 45 cm battery cage system, in an open-sided house. The experiment was conducted according to the guidelines of the Institutional Animal Care and Use Committee. Cages were equipped with nipple drinkers and detachable feeding troughs. Prior to induction of molt, birds were fed complete layer ration for two weeks. Premolt performance (such as egg production and body weight) and egg quality data were taken. Thereafter, eight cages were randomly allotted to each of four force-molt treatment groups, with each cage containing three birds as an experimental unit. The four treatments included (1) complete feed withdrawal (FW) for 9 days (2) feeding of alfalfa meal (AM) for 9 days (3) feeding of layer ration containing 20,000 ppm of zinc oxide (DZ) for 9 days and (4) feeding cracked corn diet (CC) for 28 days.

Body weight of birds was monitored every two days while daily mortality was noted throughout the induction period. All treatment groups had *ad libitum* water supply. Following the 9 days of molt induction treatment, birds subjected to FW, AM and DZ treatments were fed cracked corn diet for 19 days to complete 28 days along with birds in CC treatment. To minimize crop impaction, birds on FW treatment were fed the CC diet at the rate of 50 gm/bird/day for the first two days. At the end of the trial, three birds randomly selected from each treatment group were sacrificed by cervical dislocation for ovarian weight assessment. The survivors were provided with complete layer feed ration *ad libitum* while hen performance and egg quality were monitored weekly for three weeks post molt. Furthermore, eggs were collected during the fourth week post-molt and stored for three weeks at cold temperature, after which the internal qualities were assessed. All data were subjected to analysis of variance using General Linear Model Procedure of SAS<sup>[8]</sup> for complete randomized design. Turkey's procedure was used to separate treatment mean difference of each response variable. Effects were considered significant at  $P < 0.05$ .

## 3. RESULTS

There were significant differences in body weight loss (expressed as percentage of initial weight)

between all the treatments. However, FW treatment group expressed the highest loss (23.6%), closely followed by AM group (21.1%) while the CC group had the lowest weight loss (12.5%) (Figure 1). Similarly, the highest ovarian and oviduct regression (in percentage of body weight) was noticed in FW treatment group, although this was not significantly different from AM and DZ groups (Table 1). The group induced with CC diet however had significantly lower regression rates compared with the other treatments. Other organs (liver, heart and spleen) were not significantly affected by the molting methods. The influence of different molting methods on complete egg cessation, onset of production and post molt weekly percentage production are shown in Table 2 and Figure 2 respectively. The CC-induced group took significantly longer days (10 days;  $P = 0.001$ ) than other groups to cease production, although there was no significant difference in average days of resumption.

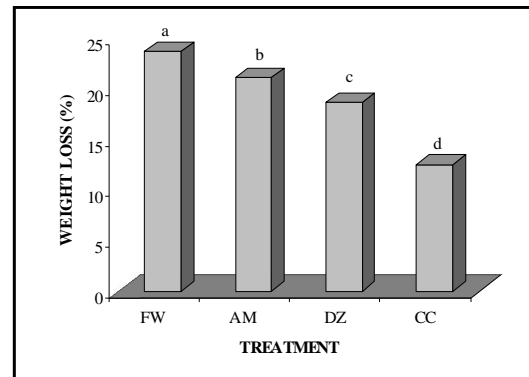


Figure 1. Average body weight loss (%) expressed by different molt induction treatments.

Bars with different letters are significantly different ( $P < 0.05$ ). FW = feed withdrawal; AM = alfalfa meal; DZ = dietary zinc; CC = cracked corn

The FW treatment showed the earliest egg cessation but was closely followed by the AM treatment. The latter however resumed production earlier and displayed a tendency for greater improvement in post molt production. There was no significant difference in post molt weekly performance between the treatment groups. However, as shown in Table 3, the average post molt production of the CC-induced group was significantly higher ( $P = 0.03$ ) than the FW-induced group but not significantly different from AM and DZ groups over the three-week period.

Table 1. Effect of different molting methods on organ weights

Parameter (in % of Body weight)	Treatment				Pooled SEM
	FW	AM	DZ	CC	
Ovary	0.36 <sup>b</sup>	0.62 <sup>b</sup>	1.00 <sup>b</sup>	2.5 <sup>a</sup>	0.26
Oviduct	1.07 <sup>b</sup>	1.16 <sup>b</sup>	1.60 <sup>ab</sup>	2.47 <sup>a</sup>	0.26
Liver	1.48 <sup>a</sup>	2.06 <sup>a</sup>	2.12 <sup>a</sup>	1.80 <sup>a</sup>	0.25
Spleen	0.10 <sup>a</sup>	0.10 <sup>a</sup>	0.13 <sup>a</sup>	0.10 <sup>a</sup>	0.01
Heart	0.43 <sup>a</sup>	0.43 <sup>a</sup>	0.41 <sup>a</sup>	0.47 <sup>a</sup>	0.03

Means within same row bearing different letters are significantly different ( $P < 0.05$ ). SEM = standard error of mean, FW = feed withdrawal; AM = alfalfa meal; DZ = dietary zinc; CC = cracked corn.

Table 2. Influence of different molting methods on complete egg cessation and onset of production

Parameter	Treatment				Pooled SEM
	FW	AM	DZ	CC	
AVDC	5 <sup>a</sup>	5.7 <sup>a</sup>	6.7 <sup>a</sup>	9.7 <sup>b</sup>	0.5
AVDR	21.7 <sup>a</sup>	17.7 <sup>a</sup>	18.3 <sup>a</sup>	20.3 <sup>a</sup>	1.9

Means within same row bearing different letters are significantly different ( $P < 0.05$ ). AVDC = Average days production cessation; AVDR = Average days production resumption; FW = feed withdrawal; AM = alfalfa meal; DZ = dietary zinc; CC = cracked corn

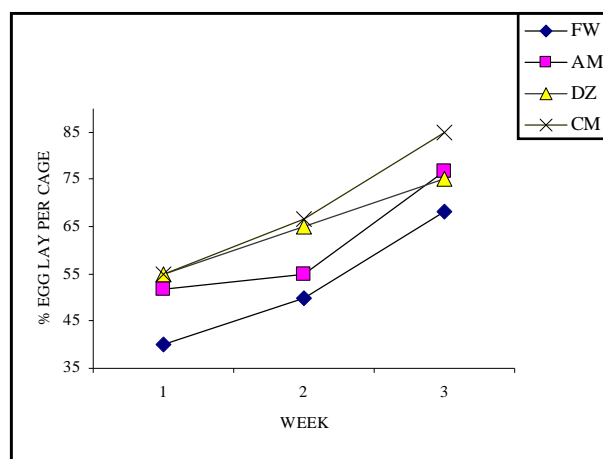


Figure 2. Influence of different molting methods on weekly post molt percentage egg production. FW = feed withdrawal; AM = Alfalfa meal; DZ = dietary zinc; CC = cracked corn

Table 3. Effect of different molting methods on post molt egg production and quality

Parameter	Treatment				Pooled SEM
	FW	AM	DZ	CC	
Ave. egg prod. (%)	37.7 <sup>b</sup>	43.7 <sup>ab</sup>	46.4 <sup>ab</sup>	49.2 <sup>a</sup>	2.8
Egg weight (g)	69.9 <sup>a</sup>	70.0 <sup>a</sup>	70.5 <sup>a</sup>	71.1 <sup>a</sup>	1.7
Yolk weight (g)	17.4 <sup>a</sup>	16.3 <sup>a</sup>	18.0 <sup>a</sup>	17.2 <sup>a</sup>	0.5
Shell weight (g)	6.6 <sup>a</sup>	6.5 <sup>a</sup>	6.4 <sup>a</sup>	6.9 <sup>a</sup>	0.1
Albumen weight (g)	45.9 <sup>a</sup>	47.2 <sup>a</sup>	46.1 <sup>a</sup>	47.0 <sup>a</sup>	1.6
Albumen height (mm)	9.4 <sup>a</sup>	9.2 <sup>a</sup>	9.5 <sup>a</sup>	9.0 <sup>a</sup>	0.5
Haugh unit	94.1 <sup>a</sup>	92.9 <sup>a</sup>	94.3 <sup>a</sup>	91.9 <sup>a</sup>	2.1
Albumen pH	8.32 <sup>a</sup>	8.32 <sup>a</sup>	8.26 <sup>a</sup>	8.31 <sup>a</sup>	0.06

Means within same row bearing different letters are significantly different. SEM = Standard error of mean; FW = feed withdrawal; AM = Alfalfa meal; DZ = dietary zinc; CC = cracked corn.

Table 4. Effect of molting on egg quality

Parameter	Premolt	Postmolt	Pooled SEM
Egg weight (g)	65.6 <sup>a</sup>	68.0 <sup>a</sup>	0.9
Yolk weight (g)	26.2 <sup>a</sup>	17.6 <sup>b</sup>	0.4
Shell weight (g)	6.5 <sup>a</sup>	6.5 <sup>a</sup>	0.1
Albumen weight (g)	33.0 <sup>b</sup>	43.9 <sup>a</sup>	0.9
Albumen height (mm)	8.0 <sup>a</sup>	8.9 <sup>a</sup>	0.4
Haugh unit	88.1 <sup>a</sup>	91.9 <sup>a</sup>	2.0
Albumen pH	8.11 <sup>a</sup>	8.71 <sup>a</sup>	0.03

Means within same row bearing different letters are significantly different ( $P < 0.05$ ). SEM = standard error of mean

Furthermore, post molt egg quality analysis revealed the lowest internal egg quality in the CC-induced group although this did not attain statistical significance (Table 3). Bird mortality was generally low in all the groups, with no difference in mortality among treatments. However, there was a general improvement in post molt egg quality, which was significant with albumen and yolk weights, when compared with pre molt quality (Table 4). Furthermore, the difference in quality deterioration of stored eggs from the different molting methods was not significant (Table 5).



Table 5. Effect of different molting methods on post molt egg quality during storage

Parameter	Treatment				Pooled SEM
	FW	AM	DZ	CC	
Egg weight (g)	62.9 <sup>a</sup>	64.1 <sup>a</sup>	65.1 <sup>a</sup>	63.8 <sup>a</sup>	1.4
Yolk weight (g)	18.2 <sup>a</sup>	17.8 <sup>a</sup>	18.6 <sup>a</sup>	17.6 <sup>a</sup>	0.4
Shell weight (g)	6.2 <sup>a</sup>	6.0 <sup>a</sup>	6.2 <sup>a</sup>	6.2 <sup>a</sup>	0.2
Albumen weight (g)	38.5 <sup>a</sup>	40.3 <sup>a</sup>	40.3 <sup>a</sup>	40.0 <sup>a</sup>	1.3
Albumen height (mm)	7.4 <sup>a</sup>	7.3 <sup>a</sup>	7.2 <sup>a</sup>	6.8 <sup>a</sup>	0.3
Haugh unit	85.0 <sup>a</sup>	83.8 <sup>a</sup>	83.0 <sup>a</sup>	79.7 <sup>a</sup>	2.2
Albumen pH	8.99 <sup>a</sup>	8.98 <sup>a</sup>	8.97 <sup>a</sup>	9.02 <sup>a</sup>	0.04

Means within same row bearing same letters are not significantly different. SEM = standard error of mean; FW = feed withdrawal; AM = Alfalfa meal; DZ = dietary zinc; CC = cracked corn

#### 4. DISCUSSION

In this study, three different molt induction methods were evaluated and compared with the conventional feed withdrawal method. Results obtained showed general improvement in post molt egg quality parameters, except shell weight that remained constant and albumen pH that has higher post molt value. This is an indication that molting is a beneficial procedure in layer management in improving egg quality. Although there were significant differences in body weight loss between the treatments, birds molted by FW method showed the highest weight loss, in accordance with the reports of previous studies by Onbasilar and Erol<sup>[9]</sup> and Landers et al.<sup>[10]</sup>. Complete egg cessation was obtained within five to six days of molt induction with FW and AM, in agreement with the reports of Biggs et al.<sup>[11]</sup> and Dunkley et al.<sup>[12]</sup> respectively. The AM-induced group however resumed production much earlier than the FW-induced group and with numerically higher production rate. This is in agreement with the observations of Landers et al.<sup>[10]</sup> who also noted earlier reentry date and numerically higher post molt production rate, when birds were molted with either alfalfa meal or alfalfa pellet compared with feed withdrawal. Similarly, Biggs et al.<sup>[11]</sup> noted that hens molted by FW method resumed production 23 days post molt induction. There was no significant difference in ovarian and oviduct regression between FW, AM and DZ groups, despite

significant differences in body weight loss. This indicates that the three groups had enough stimulation to induce molt and subsequent reproductive rest. Post molt egg production of the FW group however remained numerically lower than AM and DZ groups. The short-term post molt performance considered in this study may partially be responsible for this observation.

Although the CC-induced group apparently showed higher production rate within the post molt period, the internal quality of the eggs was lower than other molt treatments. This could be due to insufficient regression of the ovary and oviduct in this group, which is related to post molt egg production and quality. Regression of the reproductive tract is a result of removal of fat deposits, which in turn is affected through body weight loss. The aftermath of the processes is rejuvenation of the reproductive tract and subsequent improvement in tissue efficiency<sup>[13]</sup>. Although the optimal efficient body weight loss has not been specified, a target range of 15 to 35% has been reported<sup>[14]</sup>. In this study, both the body weight loss and reproductive tract regression were significantly lower ( $P < 0.05$ ) in CC-induced hens than hens induced with either FW, AM or DZ. It will not be surprising therefore, if the long-term post molt production of the CC group becomes lower than those of other treatments. Koelkebeck et al.<sup>[2]</sup> compared molt induction using wheat middlings molt

diet and corn molt diet with 4-day and 10-day feed removal methods. They observed that hens molted with the corn diet did not completely go out of production throughout the 28-day molt period. Subsequently, the cumulative hen-housed eggs per hen for weeks 5 to 44 post molt was much lower in that group than in other molt treatment groups.

The result of this study showed that alfalfa meal can successfully induce molt in layers in place of feed withdrawal, particularly in terms of body weight loss and ovarian regression, which are indices of successful molt induction. There is however a need to evaluate the long-term post molt performance of all the methods employed in this study, in order to draw a comprehensive conclusion.

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## The evaluation of sodium bicarbonate and hydroxy- $\beta$ -cyclodextrin as treatments for organophosphor and carbamate poisoning in poultry

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**Abstract:** Organophosphorus and carbamates are used world wide on a large scale and accidental poisonings are often seen. The objective of the trials was to evaluate newer antidotes, using chickens as experimental animals. Pilot trials were done to establish the lethal dosages of each poison. In Study 1, fourteen broilers were dosed orally with diazinon at 8 mg/kg and seven broilers were also given sodium bicarbonate at 504 mg/kg by intravenous route 30 minutes later. In Study 2, fourteen broilers received coumaphos orally at 25 mg/kg and 30 minutes later sodium bicarbonate was administered intravenously at a dosage of 504 mg/kg to seven broilers. In Study 3, fourteen broilers received aldicarb at 4 mg/kg and 30 minutes later seven broilers also received hydroxypropyl- $\beta$ -cyclodextrin at 250 mg/kg intravenously. In all the studies, the controls also received sterile, de-ionized water intravenously 30 minutes after dosing as a placebo. The results indicated that sodium bicarbonate had made a significant difference ( $P < 0.05$ ) to the survival times of broilers in trial 1 and trial 2. Hydroxypropyl- $\beta$ -cyclodextrin treated broilers also had significant longer survival times ( $P < 0.05$ ) than the controls in trial 3. The final conclusion is that sodium bicarbonate has the potential to inactivate organophosphors, while hydroxypropyl- $\beta$ -cyclodextrin can be useful for lipid-soluble insecticides with a molecular weight below 250 Daltons. The recommendation is to administer these compounds as adjunctive treatments together with the standard antidotes to improve the outcome of organophosphor or carbamate poisoning. [Life Science Journal. 2011;8(S1):125-129] (18) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Organophosphors, carbamates, sodium bicarbonate, cyclodextrins

### Introduction

The United States of America Environmental Protection Agency estimated that pesticides were used on more than 900 000 farms and in 69 million households in 1993. An estimated 281.5 million kilograms of herbicides, 112.1 million kilograms of insecticides, 59.5 million kilograms of fungicides and 37.7 million kilograms of other pesticides are used annually (Talcott and Dorman 1997). In 1968 during one outbreak, 6278 sheep were poisoned in Utah, USA after eating forage contaminated with an organophosphate compound. Of those affected, 4500 died or had to be euthanized (Van Kampen et. al. 1969). In South Africa, 37 positive cases of various organophosphors and 79 aldicarb cases were diagnosed at the Toxicology Division of the Onderstepoort

Veterinary Institute (OVI) during 2006 (Agricultural Research Council-OVI, unpublished data, 2007).

The mode of action of organophosphors is to inhibit the enzyme acetylcholinesterase, which results in accumulation of the neurotransmitter acetylcholine, which in turn, excessively stimulates cholinergic receptors. The mode of action of aldicarb is the same as organophosphors, except that the binding to acetylcholinesterase is reversible, whereas in organophosphors the binding becomes irreversible after a period of time (Mosha 1993). Muscarinic effects such as salivation, miosis, lacrimation, diarrhoea, urination, bradycardia and bronchoconstriction with excessive bronchial secretions predominate. Nicotinic effects manifest as weakness, muscle stiffness, tremors and paralysis (Desire and Saint- Andre 1987,

Ecobichon 2001). Central nervous system effects include restlessness, confusion, ataxia, convulsions and cardiorespiratory depression (Aaron and Howard 1994, Mosha 1993). The conventional treatments by using drugs such of atropine and pralidoxime are quite effective, but another approach can be to evaluate substances, which either inactivate or complex the organophosphors and carbamates.

Cyclodextrins are ring-shaped oligosaccharides, capable of binding fat-soluble substances of low molecular weight (Clarke et. al. 1988). The space within the cyclodextrin cavity increases with the number of D-glucopyranosyl residues (Clarke et. al. 1988). The extent of the complex formation depends on the polarity of the guest molecule. Strongly hydrophilic and ionised groups are not (or weakly) complexable (Fromming and Szejtli 1994). Cyclodextrins may host a great variety of molecules of molecular mass less than 250 Dalton (Walker 1993). The complex renders lipid soluble molecules relatively more water-soluble and aids renal excretion (Stewart et. al. 1988). In addition, cyclodextrins act as true carriers by keeping hydrophobic drugs in solution and delivering them to the surface of a biological membrane. They act as penetration enhancers by increasing drug availability at the surface of the biological barrier. Cyclodextrins are also utilized for the stabilisation of light - or oxygen sensitive drugs; modification of chemical reactivity of guest molecules; fixation of very volatile substances; improvement of solubility of substances and protection against degradation of substances by micro-organisms (Martin del Valle 2004). The toxicity of hydroxypropyl- $\beta$ -cyclodextrin has been assessed in rats and monkeys in acute, subacute (14 days) and subchronic (90 days) studies, with no visible effects (Fromming and Szejtli 1994). In a study on Sprague-Dawley rats, hydroxypropyl- $\beta$ -cyclodextrin was successfully used to significantly increase the survival times of treated rats after dosing with lethal doses of aldicarb (Verster and Botha 2004). Sodium bicarbonate has been used experimentally to treat dogs which were injected with a dose of 30 mg/kg dimethyl-dichlorine vinylphosphate (DDVP). This dose is 100 % lethal in dogs within 27 minutes. Sodium bicarbonate was administered at 5mEq/kg intravenously after severe clinical signs appeared. Ten minutes later, a second dose of sodium bicarbonate at 2.5 mEq/kg was given intravenously. Results were excellent and improved the survival rate to 84.6 % of the 13 dogs used. Even though the pH of some dogs were as high as 7.5, no side-effects were observed (Cordoba et. al. 1983).

The objective of the trials was to investigate the effectiveness of sodium bicarbonate to neutralize organophosphors, while also evaluating

hydroxypropyl- $\beta$ -cyclodextrin as a means to bind aldicarb in broilers. It is not a guaranteed that the successful outcome in dogs and rats would apply to broilers, therefore the research was conducted in broilers.

## Materials and methods

### Experimental animals

Adult female broilers weighing between 1.5 kg and 2.2 kg were kept in wooden slatted cages and fed commercial broiler finisher pellets in plastic containers. Fresh water was available ad lib. The food was withdrawn at 16h00 the day before the trial to ensure empty crops, because absorption of insecticides may differ depending on stomach contents.

### Study 1

The acute oral LD<sub>50</sub> in Mallard ducklings is 3.5 mg/kg and in young pheasants 4.3 mg/kg (Tomlin 1994). A pilot trial was done to establish a fatal dose of diazinon (Riedel-de Haen), but which would provide adequate time for sodium bicarbonate to execute its effects. In the main trail, diazinon was dosed to 14 broilers orally at a dose of 8 mg/kg, but seven experimental chickens also received sodium bicarbonate intravenously at 6 mEq/kg (504 mg/kg) after 30 minutes. The control group received de-ionized water intravenously after 30 minutes. The survival times of all chickens were recorded for comparative purposes. The dosage of sodium bicarbonate was adapted from the dog trial (Cordoba et.al. 1983).

### Study 2

The acute oral LD<sub>50</sub> in bobwhite quail is 4.3 mg/kg and in Mallard ducks 29.8 mg/kg (Tomlin 1994). A pilot trial was done to establish a fatal dose of coumaphos (Riedel-de Haen), but which would provide adequate survival times. Coumaphos was dosed to 14 broilers orally at 25 mg/kg. Seven experimental chickens received sodium bicarbonate intravenously at 504 mg/kg intravenously after 30 minutes, while the control group received de-ionized water intravenously after 30 minutes. The survival times of all chickens were recorded.

### Study 3

Aldicarb is highly toxic to birds, where the oral LD<sub>50</sub> range from 1.78 mg/kg in the red-winged blackbird to 5.34 mg/kg in the ring-neck pheasant

(Kamrin 1997). A pilot trial was done to establish which fatal dose of aldicarb (Riedel-De-Haen) would be fatal, but provide adequate time for the trial to proceed prior to death. Aldicarb was dosed to 14 broilers at 4 mg/kg per os. Seven experimental chickens received hydroxypropyl- $\beta$ -cyclodextrin at 250mg/kg intravenously after 30 minutes, while the control group received de-ionized water intravenously after 30 minutes. The cyclodextrin dosage was adapted from previous trials in Sprague-Dawley male rats, where significant differences in survival times were observed with hydroxypropyl- $\beta$ -cyclodextrin at 250mg/kg, when the aldicarb dosage was either 40% or 60 % higher than the known LD<sub>50</sub> dose of 0.93 mg/kg (Verster and Botha 2004)).

### Statistical analysis

The t-test was done to test the hypothesis that experimental broilers have longer survival times than the control broilers ( $\mu_1 > \mu_2$ ). The means ( $y_1$  and  $y_2$ ) and standard deviations ( $s_1$  and  $s_2$ ) of the experimental group and the control group were calculated. Additional calculations were performed such as the difference between the means ( $y_1 - y_2$ ) and the standard error of the difference between the sample means (SE ( $y_1 - y_2$ )). Finally the test statistic (Ts) was calculated by dividing  $y_1 - y_2$  by SE ( $y_1 - y_2$ ). The Ts- value for 12 degrees of freedom ( $n_1 + n_2 - 2$ , where  $n_1$  and  $n_2$  represented the sample sizes of each group) was found by consulting the t-tables, which gave an area under the curve (Samuals and Witmer 1999). The differences were considered to be significant at  $P < 0.05$ .

### Results

The results were reasonably consistent, but the seventh replicate both experimental and control died sooner than all the other broilers. The experimental broilers of the other six replicates all had longer survival times than the controls. The t-test showed that the differences between the experimental group and the control group were highly significant ( $P < 0.05$ ) (Figure 1).

The control broiler of the first replicate survived longer than any of the experimental broilers and the reason for this is unknown, except that it may have been an exceptional resistant animal or gastro-intestinal binding of toxin, in spite of overnight starvation. All the other experimental broilers had longer survival times in the other six replicates and the differences were highly significant ( $P < 0.05$ ) (Figure 2).

Controls of replicate 1, 2, and 7 survived longer than the experimental broilers of replicate 3, 4 and 5. The results showed more variation than the expectation, but when the values were pooled, the differences between the experimental group and the control group were still significant ( $P < 0.05$ ) (Figure 3).

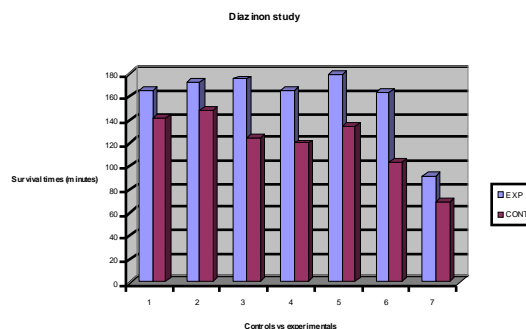


Figure 1. The results were reasonably consistent, but the seventh replicate both experimental and control died sooner than all the other broilers. The experimental broilers of the other six replicates all had longer survival times than the controls. The t-test showed that the differences between the experimental group and the control group were highly significant ( $P < 0.05$ ).

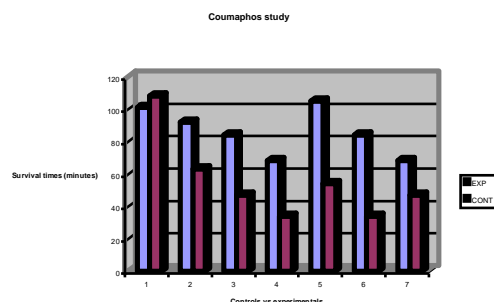


Figure 2. The control broiler of the first replicate survived longer than any of the experimental broilers and the reason for this is unknown, except that it may have been an exceptional resistant animal or gastro-intestinal binding of toxin, in spite of overnight starvation. All the other experimental broilers had longer survival times in the other six replicates and the differences were highly significant ( $P < 0.05$ ).



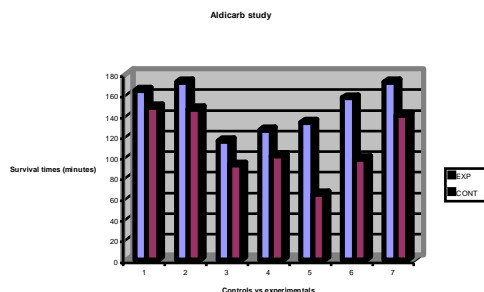


Figure 3. Controls of replicate 1, 2, and 7 survived longer than the experimental broilers of replicate 3, 4 and 5. The results showed more variation than the expectation, but when the values were pooled, the differences between the experimental group and the control group were still significant ( $P < 0.05$ ).

A secondary observation in all the trials was that the heavier broilers fared better than the lighter ones, even though they were all in the same age group. Perhaps the heavier broilers had more fat reserves, which may partially sequester the organophosphorus and carbamate compounds, depending on the lipid-solubility of such compounds. The variation in results may also be due to the normal distribution curve with a small percentage of sensitive and resistant birds on the two extremes, but most of them representing the population average.

## Discussion

The survival time of both groups had to be long enough to benefit the treatment groups, but if the doses of the insecticides had been too low, some controls and experimental broilers would have completely survived, thus complicating the interpretation of the results. However, if the dose had been too high, the two types of treatment would not have enough time to exert any noticeable effect. The beneficial effect of sodium bicarbonate may be two-fold. Firstly, to buffer the acidosis caused by the insecticides, indirectly caused by the bronchoconstriction, mucous accumulation in the bronchi and bradycardia. Secondly, the organophosphor compounds are sensitive to changes in pH, whereby the esteratic portion of the molecule is broken under alkaline conditions. This reaction detoxifies the molecule and the toxin does not persist in the environment (Cordoba et.al. 1983).

Hydroxypropyl- $\beta$ -cyclodextrin given at 250 mg/kg in broilers produced good results and this could be explained by the fact that aldicarb conform to some extent to the binding criteria for cyclodextrins. The molecular size of aldicarb at 190 Dalton is appropriate to fit into the cyclodextrin cavity and aldicarb is also partially lipid-soluble (Tomlin 1994). The most favorable ratio of a lethal aldicarb dosage and cyclodextrin to ensure complete survival in treatment broiler groups compared to 100 % mortality in the control groups has not yet been established. The low toxicity of cyclodextrins provides an opportunity to test intravenous administration of cyclodextrins at progressively higher dosages, which may possibly produce even more favorable results. The conclusion is that the two substances tested worked well in most broilers, but it is possible that other species of animals may also benefit, although more research is needed to test other species.

The recommendation is to use bicarbonate and cyclodextrins in cases of organophosphorus and carbamate poisoning to serve as an adjunctive therapy to supplement the standard drugs of choice. These supportive therapies will not replace the usual drugs such as atropine, due to some limitations. In the case of bicarbonate, too high dosages may cause alkalosis, while cyclodextrins are limited by the requirements of binding molecules with good lipid solubility and below a certain size. The advantages are the relative cheapness and availability of bicarbonates and cyclodextrins, together with their wide margins of safety.

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## Soil Physical and Biological Properties as Influenced by the Incorporation of Leaf Litter Biomass from Three Sub-tropical Fruit Trees at Nelspruit, Mpumalanga Province, South Africa

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**ABSTRACT** The majority of small-scale farmers in sub-Saharan Africa rely on organic inputs to replenish soil nutrients. The sub-tropical climate of Mpumalanga Province in South Africa favours the growth of tropical and sub-tropical fruit trees that produces relatively low quality litter that can be used to manage soil fertility. A pot experiment was conducted to assess the effects of incorporating leaf litter from avocado (*Persea americana*), mango (*Mangifera indica*) and litchi (*Litchi chinensis*) on soil properties. The treatments were a factorial combination of leaf litter types (avocado, mango and litchi), application rates (0, 1.6, and 3.3 t ha<sup>-1</sup>) and incubation periods (0, 6 and 12 months) laid in a randomised complete block design with five replicates. Soils that were amended with avocado leaf litter had significantly higher ( $p < 0.05$ ) particulate organic matter (1.53%) than mango (1.35%) and litchi (1.35%). The stability of aggregates was significantly higher ( $p < 0.05$ ) in soil amended with mango and litchi than avocado leaf litter. There were positive and significant correlations between soil organic carbon and particulate organic matter ( $r = 0.62$ ,  $p < 0.05$ ), microbial biomass carbon and microbial biomass nitrogen ( $r = 0.73$ ,  $p < 0.05$ ), particulate organic matter and microbial biomass carbon ( $r = 0.66$ ,  $p < 0.05$ ) and particulate organic matter and microbial biomass nitrogen ( $r = 0.65$ ,  $p < 0.05$ ). It is suggested that the amount of leaf litter applied was not large enough to make significant changes on soil quality over the period of incubation. The results suggest the need to increase the application and incubation time of litter with low quality in order to allow for decomposition of the organic materials to take place. This has practical implication for farmers who manage such leaf litter for increasing crop productivity. [Life Science Journal. 2011;8(S1):130-139] (19) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**KEYWORDS:** Incubation period. Leaf litter biomass. Litter application. Soil quality

## INTRODUCTION

Soils undergo changes in their quality during natural soil development and as a result of different management practices including the addition of organic materials. The term “soil quality” has been coined to describe the combination of chemical, physical and biological characteristics that enable soils to perform a wide range of functions. The existence of multiple definitions suggests that the concept of soil quality continues to evolve (Doran and Parkin 1994). The Soil Science Society of America Ad Hoc Committee on soil health defines soil quality as the “capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation (Karlen et al. 1997). This definition of soil quality has been based both on human uses of soil and the functions of soil

within the natural and agricultural ecosystems. Soil quality is evaluated using indicators that measures specific physical (aeration, aggregate stability, bulk density, particle size distribution, total porosity and water holding capacity), chemical (cation exchange capacity, electrical conductivity, nutrient cycling rates, pH, plant nutrient contents, salt adsorption ratio) and biological (microbial biomass, microbial respiration, organic matter mineralization and denitrification, organic matter content, soil microbial carbon, phospholipid analysis and soil enzyme) properties (Gregorich et al. 1997).

Many factors affect soil quality, but soil organic matter (SOM) is arguably the most critical because it constitutes an important source of energy for microorganisms responsible for the decomposition of organic residues. The increase in soil organic matter is seen as desirable by many researchers as higher levels

are viewed as being directly related to better plant nutrition, ease of cultivation, penetration and seedbed preparation, greater aggregate stability, reduce bulk density, improved water holding capacity, enhanced porosity and decrease soil acidification and aluminium toxicity (Carter and Stewart 1996; Mokolobate and Haynes 2001). Organic matter contributes to the stability of soil aggregates and pores through the bonding or adhesion properties of organic materials, such as bacterial waste products, organic gels, fungal hyphae and worm secretions and cast (Molope et al. 1987). The addition of organic materials particularly plant residues and organic manure is one of the ways of improving soil quality because they regulate soil microbiological biomass, affect carbon mineralisation and contribute to nitrogen availability for crops (Albiach et al. 2000). However, the effect of plant residues on soil properties and crop yields depends upon its chemical quality such as C:N ratios, lignin and polyphenol, lignin: nitrogen ratio and acid soluble carbohydrates (Cadisch and Giller 1997). Compared with chemical fertilizers most organic materials contain relatively low levels of nutrients and high organic compounds (low nitrogen, high polyphenol, high lignin content and high C:N ratio).

The climate of Mpumalanga Province in South Africa support growth of many sub-tropical trees whose litter biomass has potential to be used to improve soil quality. The aim of this study was to determine the short-term effect of incorporating leaf litter biomass from three selected sub-tropical fruit trees to improve some physical and biological properties of the soil.

## MATERIALS AND METHODS

### Study site

The experiment was conducted at the Agricultural Research Council's Institute for Tropical and Sub-tropical Crops research station located at Nelspruit (latitude 25° 27' S and longitude 30° 58' E) in the Mpumalanga province of South Africa with an elevation of 650 m asl. Nelspruit lies in a summer rainfall zone with rainfall that comes between November and February. The mean monthly maximum and minimum temperatures vary from 23.3 °C in June to 29.9 °C in February and 6.5 °C in July to 18.9 °C in January respectively. The average seasonal evaporation is 4.8 mm day<sup>-1</sup> during summer. The soils are predominately red to yellow-brown and are classified as Hutton form (Ferralsols, FAO) with a pH ranging

from 5.5 to 6.5 which is ideal for growth of most food crops and sub-tropical fruit trees.

### Collection of leaf litter and soil samples

Leaf litter used in this study was drawn from bulk samples of leaf litter which were collected from three most dominant fruit trees viz avocado (*Persea americana*), mango (*Mangifera indica*) and Litchi (*Litchi chinensis*) during the litterfall in 2006. The litter was collected from existing orchards in the research station. Samples of leaves from each tree were cut into pieces of about 20 mm in order to enhance their contact with soil and decomposition. The chemical composition of the leaves from the trees is shown in Table 1. The soil used was collected from uncultivated field at the station to a depth of 0-20 cm using a spade. The soil was air dried and passed through a 2.0 mm sieve (Table 1).

### Treatments and experimental design

The treatment consisted of the combinations of 3 leaf litter types (avocado, mango and litchi), 3 application rates (0, 1.6 and 3.3 t ha<sup>-1</sup>), and 3 incubation periods (0, 6 and 12 months). These were laid in a completely randomized block design with five replications.

### Incubation of litter-amended soil

The incubation of litter-amended soils commenced in December 2006 and end in June 2007, and December 2007 for the 12 and 6 month incubation respectively. About 250 g of air dried soil was mixed with leaf litter and filled into PVC pots measuring 15 cm in diameter and 12 cm high. Each pot was placed on a PVC saucer in order to collect and capture excess water and leached nutrients during and after irrigation. The mixture of soil and leaf litter was incubated in a greenhouse where the average day and night temperatures were 26 and 15 °C. The pots were watered once a week in order to maintain the soil at approximate field capacity. At the end of each incubation period soil samples were collected from each pot and analyzed for physical (bulk density and aggregate stability) and biological (soil organic carbon, particulate organic matter, microbial biomass carbon and microbial biomass nitrogen) properties.

### Analyses of soil quality properties

Soil organic carbon (SOC) was determined by the wet oxidation method (Walkley and Black 1934). Microbial biomass was determined on three replicated soil samples by the chloroform fumigation technique described by Jenkinson and Powlson (1976). Microbial biomass carbon (MBC) was determined using complete 'wet' oxidation method by acidified potassium dichromate (Anderson and Ingram, 1993). Microbial biomass nitrogen (MBN) was determined using micro-Kjeldhal technique outlined by Okalebo et al. (1993). Particulate organic matter (POM) was determined by physical fractioning of soil using a modification of the method described by Okalebo et al. (1993). Bulk density (BD) of the soil was determined using a clod method of Blake and Hartge (1986). The aggregate stability (AGS) of the soil to water was determined using a water-drop method described by Smith and Cernuda (1951).

### Analysis of data

Analysis of variance (ANOVA) was used to compare the effect of leaf litter type, incubation period and rate of litter application on the measured variables using GenStat ® (Payne 2008). The Duncan's Multiple Range Test was used to compare treatment means.

## RESULTS

A summary of the analyses of variance for biological and physical properties of the soil shows that there was a significant three way interactive effect by the three main factors on POM, MBC, MBN and AGS. Table 2 shows the effect of leaf litter type and rate on the physical and biological properties of the soil. Soil amended with avocado leaf litter had significantly

higher ( $p < 0.05$ ) concentration of POM, MBC and MBN at all rates of litter application compared to those amended with mango and litchi leaf litter. Interestingly, soil without leaf litter had higher MBC and MBN content compared to those that were amended with leaf litter at rates of 6 and 12  $\text{t ha}^{-1}$ . AGS was significantly higher ( $p < 0.05$ ) in mango and litchi litter at all rates of application. Increasing the rates of all litter application to 1.6  $\text{t ha}^{-1}$  produced the lowest AGS index suggesting poor aggregate stability (Table 2).

Table 3 compares the influence of litter application rates on the physical and biological properties of soil incubated at different times. There were significant effects ( $p < 0.05$ ) of litter application rates on the content of MBC, MBN and AGS of the soil which was incubated at different times. The soil that was not amended with leaf litter had significantly higher ( $p < 0.05$ ) MBC, MBN and AGS index. However, time of litter incubation and rate of application had no significant effect on SOC, POM and BD (Table 3).

A comparison of the influence of litter incubation period on the quality parameters of soils amended with different litter types is presented in Table 4. The results shows that litter incubation period had significant influence ( $p < 0.05$ ) on POM, MBC, MBN and AGS of soils amended with avocado leaf litter compared to those amended with mango and litchi leaf litter. Leaf litter incubation period had no significant effect on SOC and BD in all the tree species. Generally, high POM, MBC, MBN and AGS were observed in soils that were not incubated compared to those that were incubated (Table 4).

Table 5 shows there were significant positive correlations between OC and POM ( $r = 0.618^*$ ), POM and MBC ( $r = 0.656^*$ ) and MBN ( $r = 0.649^*$ ), AGS and OC ( $r = 0.176^{**}$ ) and MBC and MBN ( $r = 0.732^*$ ). There were negative correlations, albeit not significant, between BD and all the biological properties except MBN. An increase in OC, POM and MBN resulted in a decrease in BD which is common in most soils (Table 5).

Table 1: Quality of leaf litter from three sub-tropical fruit tree species used in the study

<i>Tree</i> <i>Type</i>	<i>Quality variable</i>				
	<i>Polyphenol</i>	<i>Lignin</i>	<i>Nitrogen</i>	<i>Carbon</i>	<i>C:N</i>
	(%)				
Avocado	2.31	24.7	1.15	42.6	49:1
Mango	6.09	34.6	0.94	49.0	46:1
Litchi	2.94	39.7	1.08	46.5	50:1
<i>Total</i>	<i>11.34</i>	<i>99.0</i>	<i>3.17</i>	<i>138.1</i>	<i>145</i>
<i>Mean</i>	<i>3.78</i>	<i>33.0</i>	<i>1.06</i>	<i>46.0</i>	<i>48.0</i>

Table 2: Effect of rate of litter application from the sub-tropical fruit trees on the physical and biological soil properties

<i>Tree</i> <i>type</i>	<i>Application</i> <i>rate</i>	<i>OC</i>	<i>POM</i>	<i>MBC</i>	<i>MBN</i>	<i>BD</i>	<i>AGS</i>
		(%)			(g cm <sup>-3</sup> )		(t ha <sup>-1</sup> )
Avocado	3.3	0.71a	1.63b	1.51a	0.53b	0.91a	139c
	1.6	0.70a	1.49b	1.42a	0.50b	0.91a	85ab
	0	0.73a	1.58b	1.64b	0.59b	0.91a	259d
	Mean	0.71	1.57	1.52	0.53	0.91	161
Litchi	3.3	0.65a	1.36a	1.41a	0.43a	0.91a	150c
	1.6	0.62a	1.36a	1.37a	0.41a	0.90a	53a
	0	0.68a	1.36a	1.46a	0.47a	0.90a	224d
	Mean	0.65	1.36	1.41	0.44	0.90	142

Mango	3.3	0.69a	1.37a	1.45a	0.51b	0.92a	189cd
	1.6	0.66a	1.36a	1.37a	0.45a	0.91a	42a
	0	0.67a	1.37a	1.50a	0.53b	0.92a	321e
	Mean	0.67	1.37	1.44	0.50	0.92	184

Vales are means (n=5); OC (organic carbon); POM (particulate organic matter); MBC (microbial biomass carbon); MBN (microbial biomass nitrogen); BD (bulk density); AGS (aggregate stability).

Means within a column bearing the same letter are not significantly different at  $p < 0.05$  by the Duncan Multiple Range Test

Table 3: Effect of litter application rates on soil quality parameters as influenced by time of litter incubation

<i>Incubation</i>	<i>Application</i>	<i>OC</i>	<i>POM</i>	<i>MBC</i>	<i>MBN</i>	<i>BD</i>	<i>AGS</i>	
<i>time</i>	<i>rate</i>	_____	(%) _____	(g cm <sup>-3</sup> ) _____	(Months)	(t ha <sup>-1</sup> )		
12	3.3		0.69a	1.43b	1.37a	0.49a	0.91a	103b
	1.6		0.66a	1.35a	1.32a	0.43a	0.90a	36a
	0		0.71a	1.43b	1.47b	0.52b	0.90a	138bc
	Mean		0.69	1.40	1.39	0.48	0.90	92
	6	3.3	0.66a	1.48b	1.49b	0.47a	0.92a	265d
	1.6	0.64a	1.42b	1.40a	0.47a	0.89a	108b	
	0	0.67a	1.42b	1.55b	0.52b	0.93a	382e	
	Mean	0.66	1.44	1.48	0.49	0.91	252	
	0	3.3	0.67a	1.45b	1.52b	0.51a	0.92a	110b
	1.6	0.65a	1.43b	1.45b	0.46a	0.92a	36a	
	0	0.70a	1.46b	1.57b	0.55b	0.90a	283d	
	Mean	0.67	1.45	1.51	0.51	0.91	143	

Vales are means (n=5); OC (organic carbon); POM (particulate organic matter); MBC (microbial biomass carbon); MBN (microbial biomass nitrogen); BD (bulk density); AGS (aggregate stability).



Means within a column bearing the same letter are not significantly different at  $p < 0.05$  by the Duncan Multiple Range Test

Table 4: The influence of litter incubation period on the quality parameters of soils amended with different litter types

<i>Tree type</i>	<i>Incubation time</i>	<i>OC</i>	<i>POM</i>	<i>MBC</i>	<i>MBN</i>	<i>BD</i>	<i>AGS</i>
		(%)				( $g\ cm^{-3}$ )	(Months)
Avocado	12	0.72a	1.48b	1.39a	0.50b	0.90a	111c
	6	0.73a	1.59b	1.58b	0.54b	0.92a	285f
	0	0.70a	1.63b	1.60b	0.59c	0.90a	87b
	Mean	0.72	1.57	1.52	0.54	0.91	161
Litchi	12	0.67a	1.35a	1.37a	0.41a	0.89a	48a
	6	0.64a	1.37a	1.40a	0.43a	0.92a	219e
	0	0.64a	1.36a	1.47a	0.47b	0.92a	160d
	Mean	0.65	1.36	1.41	0.44	0.91	142
Mango	12	0.67a	1.36a	1.40a	0.45a	0.92a	118c
	6	0.61a	1.37a	1.46a	0.51b	0.90a	252f
	0	0.67a	1.37a	1.46a	0.53b	0.92a	182d
	Mean	0.65	1.37	1.44	0.50	0.91	184

Vales are means (n=5); OC (organic carbon); POM (particulate organic matter); MBC (microbial biomass carbon); MBN (microbial biomass nitrogen); BD (bulk density); AGS (aggregate stability).

Means within a column bearing the same letter are not significantly different at  $p < 0.05$  by the Duncan Multiple Range Test

Table 5: Pearson correlation coefficients (r) between soil physical and biological properties

	<i>OC</i>	<i>POM</i>	<i>MBC</i>	<i>MBN</i>	<i>BD</i>	<i>AGS</i>
<i>OC</i>	1.000					
<i>POM</i>	0.618*	1.000				
<i>MBC</i>	0.583*	0.656*	1.000			
<i>MBN</i>	0.441*	0.649*	0.732*	1.000		
<i>BD</i>	-0.041ns	-0.062ns	-0.070ns	0.029ns	1.000	
<i>AGS</i>	0.176**	0.091ns	0.304*	0.532*	0.000ns	1.000

\* indicates ( $p < 0.001$ ); \*\* indicates ( $p < 0.05$ ); ns (not significant); OC (organic carbon); POM (particulate organic matter); MBC (microbial biomass carbon); MBN (microbial biomass nitrogen); BD (bulk density); AGS (aggregate stability)

## DISCUSSION

The results have shown that the effectiveness and efficiency of leaf litter on soil quality depends on litter type, litter incubation period and rate or amount of litter application. The leaf litter from different trees was of different quality (especially chemical composition) that may have influenced their effects on soil organic matter (Blair et al. 2003). High POM and MBN which was observed on soils incubated with avocado leaf litter may be due to its higher quality compared to mango and litchi litter. A high quality litter provides a suitable substrate for microbial

activities which enhances decomposition and soil organic matter formation (Cadisch and Giller 1997; Blair et al. 2003). The low concentration of POM in soils where litchi and mango litter was incubated could be attributed to slow rate of decomposition due to their low nitrogen, large C:N ratio and high lignin contents. This could have reduced microbial activity due to shortage of energy sources and thus decrease the soil organic matter content. Results of studies on the decomposition of mango and litchi litter conducted earlier indicated that it takes about 318 days for 50% of the mass of mango and litchi leaf litter to disappear.

The quality of the organic material, in particular their chemical composition, determines the effect on soil structure and aggregation (Martin 1971; Chaney and Swift 1984). Elliot and Lynch (1984) indicated that high quality organic materials encourage the accumulation of microbial biomass which is an important agent in soil aggregation and aggregate stability. It is suggested that the low quality mango and litchi litter could have stimulated greater microbial by-product production which is important in stabilizing soil aggregates. Bossuyt et al. (2001) reported that fungi dominate low quality residues while bacteria dominate the high quality organic materials. Fungi play a significant role on soil aggregation because they are capable of producing polysaccharides and other proteic and lipidic compounds which promote aggregate stability (Molope et al. 1987). Blair et al. (2003) reported a slow release of soil-binding agents from low quality *Flemingia macrophylla* residues which resulted in a slower but more sustained increase in the stability of soil aggregates.

It was interesting to observe that the 6 and 12 months periods of litter incubation did not show significant changes on some of the quality parameters that were measured when compared to soils that were not incubated for any periods of time. This could suggest that there was immobilization of nutrients in the poor quality leaf litter. The low quality materials are decomposed more slowly thereby reducing the activity of microorganisms and formation of organic matter which is the main source of soluble carbon and nitrogen (Giller and Cadisch 1995). Although the soil quality parameters measured in this study are sensitive to soil management practices, their changes occur relatively slowly so that longer periods of incubation are needed. The addition of low quality leaf litter may have altered the soil microbial species and activity which may have mobilized some of the nutrients in the soil. However, some authors have argued that in long-term, addition of low quality litter may increase organic matter and improve the stability of soil aggregates (Martin 1971; Aber and Melillo 1980; Giller and Cadisch 1995).

The positive correlations between SOC, POM and AGS demonstrate the central role that SOM serves in soil aggregation (Tisdall and Oades 1982). SOC improves aggregate stability by forming an organic core around clay and silt particles which in turn, increase the stability of the aggregates and limit their breakdown during wetting process (Six et al. 2000). The positive and significant relationship between MBC, MBN and AGS could explain the ability of various fractions of organic matter to bind and glue soil

aggregates together (Anderson and Domsch 1989; Haynes and Tregurtha 1999). The binding action of humic substances and other microbial by-products produced during the decomposition of organic materials cannot be ignored (Bronick and Lal 2005). The practical implications of these findings for small scale farmers is that in mixing of low quality leaf litter with other amendments rich in nutrients such as chicken or kraal manure could be used to increase the decomposition and avoid the negative effects associated with immobilization. Another option is to incorporate the leaf litter for a longer period of time (at least 365 days) prior to the establishment of food crops. This provides the leaf litter with adequate time to decompose and supply organic matter to the soil

## CONCLUSIONS

The study has shown that it is important to provide sufficient incubation time for the leaf litter from sub-tropical fruit trees to decompose and supply the much needed organic matter that improves soil properties. It is suggested that farmers should incubate leaf litter from such trees into the soil for at least 365 days before planting a food crop. Other options that could be used include mixing the litter with other high quality organic amendments.

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#19

## Settlement, Location and Rural Production: an alternative configuration for growth in Sub-Saharan Africa

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**ABSTRACT:** Studies of rural production systems, economic growth and poverty reduction across developing countries consistently take settlement for granted. This paper reports the results of a study centred on the spatial ramifications of settlement, location and production as an alternative platform in understanding variations in local and regional economic growth. The study is based on a survey of contemporary literature on rural poverty and production and corresponding statistics on regional performance with reference to infrastructure, services and the economy. The resulting information gaps are identified and used to design an interaction matrix in which settlement, location, and production are superimposed to produce an alternative growth model. This is then discussed in the context of empirical evidence, limitations and as a potentially more viable vehicle than contemporary approaches in economic growth and poverty reduction in Sub-Saharan Africa. [Life Science Journal. 2011;8(S1):140-146] (20) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Key Words.** Economic growth; human settlements; agglomeration; land use planning

### 1. Introduction

Human settlements in rural Sub-Saharan Africa (SSA) show diversity in structure, size, population, functions and participation in production activities. These differences are often a product of the interaction between social, institutional and physical environments. How these differences impinge on the possibilities of economic growth (World Bank 2009) at the locality level is an area that has not attracted much research attention. Consistent across contemporary research on SSA, settlement as a critical entity in rural livelihoods and spatial relations (Silberfein 1998) in a time-scale continuum hardly features. The research problem for this study is therefore how to situate settlement in the wider context of location, and production and use such a base as an alternative platform for understanding economic growth and poverty reduction in rural SSA (Scott 2010). To address this problem, four objectives are advanced. The first is to redefine settlement beyond conventional approaches and the second, is to conceptualize settlement, location and production as critical inputs in the growth process. The third is to survey literature on the state of infrastructure, services and economic growth and the fourth is to propose an alternative settlement model for facilitating increased production in rural SSA. The rest of the paper is made up of four core parts. The rest of part one addresses settlement, settlement growth and links this to location, rural

production and surveys contemporary literature thereof. Part two deals with methods and materials and part three presents results while discussion is presented in part four.

A settlement is a collection of homesteads in a locality where households share a certain identity as a result of being in close proximity. Conceptually, a settlement is presented as a product of the interaction between three planes of information. The physical environment provides the location and place for settlement and resources for economic and social activities. The location of the settlement relative to key markets (Naudè 2009) often indicates the adverse effects of distance on the development process. The social environment caters for people, culture, identity, and ethnicity, a sense of belonging and lifestyles that account for the diversity and momentum of human existence. The social dimension looks at settlement as providing a space for people's residence and includes population structure, size and growth patterns (Miller, 2009). The economic dimension deals with opportunities for households to participate in income livelihoods. The settlement economy describes the state of the factors of production but participation rates are dependent on a set of factors including the dynamics of the market. The output from the production system generates an exchange system (ECA 2007) where household participation should impact on poverty levels. The historical dimension traces the origins of



the earliest human structures that evolved into the settlement, the forces of attraction and changes in conditions - then and now. The political dimension deals with power relations at the settlement level with the nature, dynamics and trends in political power, decision making, classes and class conflicts (MIF 2010), vested interests and interactions between these. The strength and direction of such interactions in a space-time-continuum eventually dictates the rate, character and significance of settlement growth. For individual households, a settlement then acquires a status that goes beyond a home for residence. It becomes a mechanism for providing the support infrastructure (Miller 2009) and resources needed for sustaining various livelihoods. The need for interaction between communities generates movement, nodes, networks, hierarchies, surfaces and diffusion. Participation in such networks increases access of households to social capital (Du Toit 2004). Eventually these linkages build up into a hierarchy of settlements of different size and functions. A settlement in this context becomes a social organization made up of complex networks and planes of communication within itself proper and beyond its immediate reach. The institutional environment caters for law, order, civil society, governance, safety and security without which life would be a hazardous experience. These dynamics are placed within wider forces centred around perception and cognitive processes on one hand, and the state, regulation, control and governance on the other. These relationships continually shift in time and space giving rise to spatial variations in the way households and communities perceive location and situations, filter and process information and make choices. At the same time, such choices result in patterns of human settlement and activity conditioned by variations in resource allocation (ECA 2007).

Contemporary research literature on infrastructure and services in SSA reports of serious backlogs requiring billions of dollars to catch up (IMF 2009; World Bank 2008). A summary of statistics in Table 1 shows that SSA performs consistently poorer than other developing regions (Table 1. Status of infrastructure).

The poor road network in individual countries and the constraints facing inter-state trade mean that achieving the millennium development goals (MDG) becomes problematic. In general remoteness undermines the viability of locations (Hickey 2001) because it directly determines the forces of attraction on people and investments. Landlocked countries face even greater disadvantages (Figure 1). A settlement system built in the absence of formal land use planning is likely to respond differently to the long term impact

of modernization tendencies. This is because the state is constrained in providing adequate infrastructure in the form of road networks, fixed line telephones, grid power lines and piped water. Access to infrastructure and services hence provides a platform for production and growth. The distance between a location and access to services, higher order products not available locally eventually carry with it a cost overhead (Blackden and Wodon 2006). People in rural settlements spend more on movement in terms of time, energy, stress and cost (Barwell, 1996; Dorosh et al. 2009) than in urban settlements. Since particular locations define the socio-physical landscape of localities, location may influence the type and quality of resources available to households. Rural production then becomes a measure of the nature, intensity and occurrence of income-generating activities at any point. For production to occur on any significant scale, factor inputs need to be mobilized and deployed at specific points in the landscape. Such sites tend to gravitate to those settlements which offer comparative advantages. Land based resources are tied to certain locations and regional variations dictate which areas will attract which forms of production. Technology becomes an additional factor input whose rate of adoption is spatially constructed.

Literature on economic performance has been dominated by international organisations (UNDP 2009; World Bank 2008, 2009, 2010; IMF 2009; OECD 2009; Habitat 2009; USAID 2009). True, a significant volume of literature covers pre-conditions for economic growth and development. These include the need to shift from a top-down development approach to a bottom-up approach, market reform and facilitating globalization. Secondly, improving the institutional and governance capacity of countries, fighting corruption, building respect for the rule of law and human rights are strategies that still receive international support. Increasing international financial aid flows to Africa and how to achieve the millennium goals remain topical issues. The dominant thrust of literature is the use of western development models not only on SSA but also on all developing countries. In the period 2000-2007, SSA registered a sustained growth rate of 6.5 percent, the highest in more than 30 years (IMF 2009) and while growth has faltered due to the global recession, the SSA has still performed better than in the past (Figure 1: Extent of Sub-Saharan Africa).

Two schools of thought dominate the discourse on settlement structure in developing countries. Some researchers based within the SSA region argue that the western approach which favours dense, settlement clusters as potentially more efficient

than dispersed forms is inappropriate for studying settlement structure (Bolwig 2002; FHISER 2003). Instead, they argue that certain forms of settlement for example the semi-permanent homesteads associated with pastoral communities of the Sahel and Eastern Africa are a successful and sustainable adaptation to the environment. In this way, it is argued that settlement structure is not an impediment to development processes (Silberfein 1998). An alternative position is that given time that land reform and tendencies towards more stable property rights will see the erosion of rights to land of pastoral communities. The pressure on grazing lands by settled agriculturalists will increasingly make pastoral lifestyles associated with shifting temporary settlements a thing of the past (IRIN 2010). The other school is where the proponents believe that western settlement theories can be transferred to explain conditions not only in Sub-Saharan Africa, but in practically *all* developing countries. It is this second school that over the years has dominated discourses on settlement growth (UNDP 2009; Habitat 2009, 2010) development and change such that little is known in contemporary literature about alternative approaches. Indeed, SSA may today possess still the widest variety of rural settlement forms that cut across the permanent, semi-permanent, temporary and transient types (IRIN 2010) all indicating responses to the environment and adaptations (Bolwig 2002) to the needs of production. A simplistic transfer of theory and approaches developed outside the region may not do justice to an understanding of the nuances of SSA and hence the ability to analyze limitations, if any, imposed by settlement on the development process. It is accepted that each school has inherent limitations in interpretation, but the negative effects of projecting settlement in SSA as unique, needs to be appreciated. The use of contemporary settlement theory and as a tool for analysis of settlement growth- is encouraged. It is in interpreting outcomes of rural change that divergent views crop up.

The literature survey has addressed two critical issues. It has shown that there exists an inherent link between settlement, location and the dynamics of production. These linkages have not been fully applied in understanding both economic growth and the potential of such growth to contribute in reducing rural poverty. The result is that current approaches do not adequately focus on methodologies for improving the efficiency of rural settlement structure so as to act as potential nodes for agglomeration forces in the growth process. Indeed, the most common recommendations of contemporary research on SSA consistently shy away from suggesting transformational interventions. Certain

key issues are noted. Literature on settlement structure, location of economic activity and approaches to economic growth consistently fail to give adequate attention to the role of settlement. The diversity of settlement patterns in SSA negates the simple application of western inspired settlement theory and models in explaining change. The current state of settlement structure creates inherent impediments to the production process mainly because it departs from the requirements of efficiency. In order to facilitate faster rates of production in the rural space, it is necessary to intervene through some form of settlement planning. This provides the rationale for proposing an integrated settlement systems model for SSA.

## 2. Materials and Methods

Decision-making processes are built on spatial perception so that patterns of behaviour in space generate activities that alter the socio-physical landscape around a particular location. Responses and the resulting land use patterns show spatial variations in time and scale. Modeling an alternative production system requires a quantification of these elements. Settlement growth (S) is measured in terms of the stock of new housing units added each year. The exchange market value of physical resources available to a settlement is given as (R) while a ranking of opportunities as perceived by households (P) is affected by environmental resistance – which is a measure of the mean unit costs of any additional investment (E) in the locality. The value of annual domestic investments in capital projects is given as (I) while the relative role of technology in the production process (H) and time as (t) also enter into the relationship. The rate at which a settlement grows and hence the potential for economic growth is a product of the interaction between these inputs:

Expression 1:  $S = (R.P.H.E.I) t$  where S= rate of settlement growth, R=resources, P= perception of opportunities by residents, E=environmental resistance, I=the value of investments, H= technology, t= changing context of time. How then does the growth of settlement impact on rural production? Production- as a process- requires input factors: land (L), labour (O), entrepreneurship (E), organisation (G), technology (H) and capital(C) seen in the context of time (t):  
Expression 2:  $P = (L.O.R.G.H.C) t$ . Merging input elements in Expression 1 and 2 gives the role of settlement in rural production:

Expression 3:  $GRP = (R.P.M.H) t$  where GRP=growth of rural production, R=resources, P= perception, M=market, t=time while H= changing levels of

technology adoption. Resources (R) in 1 absorbs L,O,R,G,C,I in expression 2 while 1 in expression 1 is absorbed into C in 2. P and E in 1 are absorbed into M in 3 which represents market conditions. Market conditions in 3 describe not only the market proper but includes also the location of the settlements, accessibility, connectivity and the state of transport development, the legal, institutional and political environment in individual countries. Ultimately, the model as expressed in 3 implies that for rural production to occur on a sustainable scale and give rise to economic growth, it is necessary to appreciate resources, perception, markets and the changing role of technology with time. These elements need to be mobilized at particular nodes in space. The elements in Expression 3 are then presented in the form of an interaction model in Figure 2 (Figure 2. Integrated settlement platform).

#### 4. Results

Settlement planning for rural areas in SSA is not a common practice and at present, settlement structure remains inefficient. Densification of human settlements into few clusters decays distances between homes, services and infrastructure. It is cheaper and easier to supply services and infrastructure to dense

settlements rather than low population dispersed settlements. Such a settlement structure facilitates easier accessibility, connectivity and transport efficiency. Re-organising settlement layout provides conditions towards an efficient settlement platform. An integrated settlement platform developed in this paper provides a possible strategy for achieving this.



Figure 1. The extent of Sub-Saharan Africa

Source: [www.worldmap.org](http://www.worldmap.org)

Table 1. Status of Infrastructure status

Normalized Units	<sup>2</sup> SSA-LIC's	Other LIC's
Pave road density	31	134
Total road density	137	211
Mainline density	10	78
Mobile density	55	76
Internet density	2	3
Generation capacity <sup>1</sup>	37	326
Electricity coverage	16%	41%
Improved water	60%	72%
Improved sanitation	34%	51%

Source: World Bank, 2008

<sup>1</sup>Generation capacity is in megawatts of power per 1 million people. <sup>2</sup> LIC's= low income countries

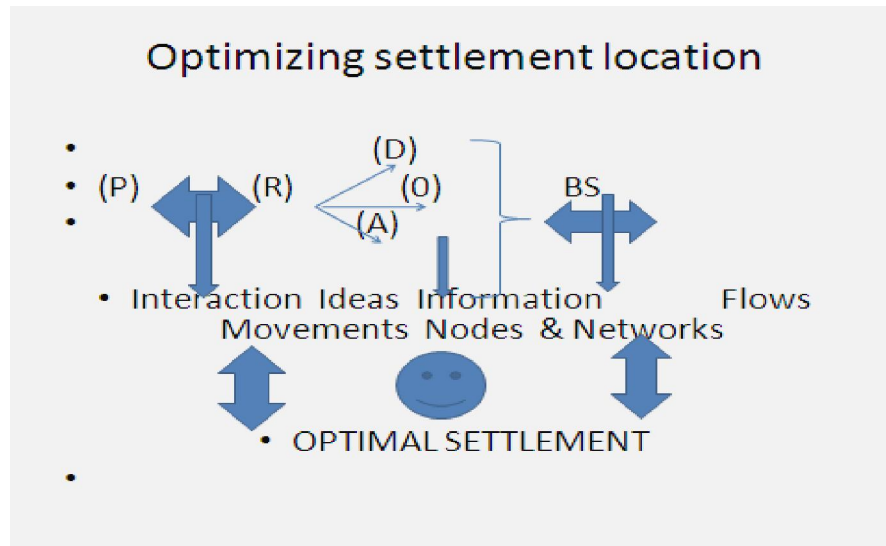


Figure 2. An integrated settlement platform

## 5. Discussion

The first assumption of the model is that growth is contextualized within an interaction-communication model- meaning that the greater the household density of a settlement, the greater will be the frequency of interactions between individuals, households and groups therein. The second assumption is that responses of people to development interventions may depart from expectations. But, while all communities may not necessarily be driven by a similar urge to develop, the immediate environment and perceptions thereof dictate that there will be certain predictable responses towards opportunity spaces. Third, instead of repeating the disastrous mistakes of resettlement schemes in the past, the model advances the view that people will respond to perceived opportunities created by improved accessibility, services, infrastructure and market without the need for forced relocations. Such responses should eventually generate population and settlement re-distribution in time and space resulting in more responsive and efficient settlement patterns. Fourth, that settlement densification in clusters facilitates higher levels of production. A radical form of local, regional planning and land reform has to precede the developments envisaged in the model. Finally, the state has to accept and support the implementation which amounts to a paradigm shift in development thinking.

The model faces certain limitations. There is empirical evidence in South Africa's former homelands (Green and Isely 1998) that settlement can grow in the physical dimension without an accompanying increase

in production capacity. A settlement can increase in population and density but still experience increasing poverty. In some isolated cases, production and settlement size may not be related in the manner in which the model predicts. The model may be criticized for giving undue emphasis to resources as an input package, but this is due to the extended meaning allocated to the term. The model appears to ignore the history of settlement and the cultural footprint but, this is justified on grounds of difficulties in modeling these two. The model is constrained in that it applies to those parts of SSA with permanent settlements but this is not a constraint as such, rather a specification of application. Empirical evidence today indicates that certain production patterns develop in areas of dense settlement (Bolwig, 2002), adequate accessibility and good connectivity. In the same vein, dense settlements generally attract higher levels of production than dispersed settlement. Today variations in the intensity of geographical productivity (GGP) show that the Sahel zone and other regions associated with a poor road network, low population density and dispersed settlement patterns all register limited economic activity. There is therefore adequate support for the view that dense settlement impacts on rural production.

How then does the model address economic growth and poverty reduction? Formal land use planning systems apply in urban areas while the rural countryside operates under a wide array of tenure systems that lack standardization and often legal protection. Extension of bulk infrastructure in the form of piped water, electricity, roads, fixed line telephones, public health clinics, hospitals and schools all impact



heavily on the national budget partly due to an absence of planned settlements. Without exception, formal land use planning in developing countries is associated with urban areas. Settlement today represents therefore the outcomes of natural growth and historical developments rather than a product of planning interventions. On the basis of the model developed in this paper, the author argues that settlement structure has had a serious handicap on growth because settlements are not designed to reinforce agglomeration forces that would initiate tendencies towards the intensification of economic activities. This would lead to an increase in mean household productivity. Dispersed, low population areas with scattered settlements are disadvantaged by location and access to resources. They are the last to be considered in extending infrastructure and services.

Development planning today in SSA is based on area units whose demarcations and extent are often not based on population size or resources but on colonial demarcations in the past. Settlement is of no particular import in these units. The focus of planning in SSA results in extreme urban-rural differentials (Jamal and Weeks 1988) in the distribution of services and reinforcement of inequality in access. Planning based on such administrative areal units is handicapped because the integrating of resources, opportunities and key market players in economic growth (ECA 2007) is difficult. Major activities and the resulting growth arise only on the basis of mobilizing critical inputs at certain nodes in space. Planning should reinforce and facilitate such nodes. Investments in the rural countryside should be strategically located to aid in creating certain forms of agglomeration. Indeed, this may underlie the persistence of poverty in the rural countryside and the absence of major movements set into motion by state inspired planning interventions. This position is a sharp departure from World Bank strategies (2008, 2009) that have been followed in SSA in recent years.

Resource allocation for development purposes across SSA shows urban bias because of a combination of the historical past, current state policies, the urbanization of political power and control over governance systems. The voice of the rural constituency remains insignificant (Scott, 2010) because decision making is in the hands of the urban power-elite. But the model advances the view that access to resources alone will not guarantee growth and development. What matters is how such resources are deployed into existing integrated development strategies to contribute in reinforcing multipliers already active in the local market. What is critical instead is the ability of a country to make intelligent

use of its resources in addressing effectively the needs of growth and development. This is not possible without long-term economic planning that emphasizes reinforcing the triggers of growth coupled to supportive governance and legislative systems that provide protection for individual property rights and investments. A tendency towards lowering inequality in resource allocation presupposes planned settlements each with a capacity for a high degree of self-sufficiency through domestic production and the ability to join supply chain networks in disposing of surplus production. This would call for a policy of rural dense settlement clusters or accelerated linear-corridor urbanization. Few developing countries so far have tried since 1970 anything close to this other than failed experiments in Tanzania, Ethiopia and Mozambique (IRIN 2004). Failure to understand the need to re-configure settlement structure and location means that many rural areas today remain remote and are not likely to get infrastructure and services critical in the rural production system in the near future.

In conclusion, settlement structure, location and rural production are linked in a complex exchange of resources that facilitate not only growth but eventually development. This paper urges that contemporary development planning approaches do not give adequate attention to the forces that an efficient settlement system can generate. The thrust of the settlement systems model introduces structure as an additional input in the economic growth process. It provides a mechanism for a radical re-ordering of the rural landscape to facilitate greater participation in production thereby providing a sustainable means for addressing economic growth and poverty reduction. Ultimately it implies a call for more efficient methodologies for optimizing the impact of investment decisions and a paradigm shift in development planning approaches. While the model developed here has inherent limitations, it has been shown to offer an alternative configuration of forces that may provide a better platform for tackling poverty reduction through a focus on increasing household productivity. Further work is needed in testing the applicability of the model at the scale of individual countries, in building settlement structure into integrated rural development strategies, in unpacking the place of households in the production process and finally in developing methodologies for optimizing access to services, infrastructure and opportunities for greater production.

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## Coping with HIV/AIDS Stigma by Women who lost their Partners to AIDS in the North West Province

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**Abstract:** The aim of this article is to explore and describe how women who lost their partners to the Acquired Immune Deficiency Syndrome (AIDS) in the North West Province, cope with the stigma of the disease. A phenomenological design was used. The sampling was purposive and the sampling size was determined by data saturation, with fifteen participants. The data was collected by means of a single open-ended phenomenological question. Data analysis was done by means of the technique of content analysis by Tesch. From the results the following conclusions could be drawn: Women whose partners died of AIDS cope by focusing on the problem which includes positive and negative strategies such as undergoing voluntary counseling and testing, disclosure of their HIV status, seeking social support, adopting a healthy lifestyle, non-disclosure, expression of grief and hurt and threatening lawsuits against perpetrators of the stigma. Regarding coping by focusing on emotions, strategies that arose from data analysis included coping by self acceptance, support by the family members, the emotional, social and the material support from families, friends, neighbors and social welfare; seeking of spiritual comfort, de-individualization of the disease, ignoring negative remarks and attitudes and forgiving, blaming their late partner or other people for their HIV status, and coping by using defense mechanisms. The recommendations were made in the form of strategies to assist these women to cope effectively with the stigma. [Life Science Journal. 2011;8(S1):147-154] (21) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Key words:** Coping, stigma, stigmatization, partner, HIV/AIDS

### 1. Introduction

The focus of this article is on the strategies for coping with the stigma of Acquired Immune Deficiency Syndrome (AIDS) by women who lost their partners to the disease. These women were stigmatized as a result of having partners who died of AIDS and the discovery that they themselves were also infected with the Human Immunodeficiency Virus (HIV). At the end of 2007 it was reported that 5.7 of the 46.4 million South Africans were living with HIV and AIDS (Dube and Nkosi 2008). The stigma of HIV/AIDS seems to nullify the efforts being made to deal confidently with the pandemic, whether it is treating those infected or preventing others from being infected (Ogden and

Nyblade 2005). The difficulty of dealing with HIV/AIDS is due to the fact that the stigma itself makes it difficult, if not impossible, for sufferers to go for Voluntary Counseling and Testing (VCT), to disclose their HIV status when already diagnosed, and to access the available treatment or resources (Siyam'kela 2003). These women coped differently with the stigma, particularly because they were also HIV positive themselves.

Coping, according to Kleinke (1998), is associated with the efforts that one engages in to manage situations that one appraises as being stressful and potentially harmful. Lindemann (in Cleiren 1993)

describes coping as, recovering and returning to the state that prevailed before the stressful situation. According to Nyblade et al. (2003), some women attempt to cope with the stigma of HIV and AIDS by denying their late partners' AIDS status or, avoiding disclosure especially if they anticipate stigmatization. Alternatively, some are able to cope by directly challenging or confronting the stigmatizing attitudes or behaviors, while others seek explanations other than sexual transmission. Some women apparently, are able to cope by joining support groups, by volunteering to care for or seeking jobs within the circles of HIV and AIDS, while others turn to religion for comfort, solace and support (Nyblade et al. 2003).

Some women who experience the stigma seek care and support from their families or health care providers (Nyblade et al. 2003). The ability to cope with the experience of stigmatization poses a challenge for carers with regard to how best these women can be assisted. These women need caring and compassionate carers who can assist them to deal with the internal stigma which develops due to the received stigma, leading to their experience of negative self concept as well as negative self identity (Fife and Wright 2000).

The stigma of HIV and AIDS is not decreasing and mechanisms to deal with it are required in order to assist and support those suffering from it. For this to happen, an exploration of the coping mechanisms used by women who lost their partners to AIDS, is necessary in order to inform the empowerment strategies that will assist them to cope effectively. It is for these reasons that the researcher finds this study significant, motivated by the passion to assist the widows stigmatized by the community, as well as the need to promote their mental health. The objectives are therefore, to explore and describe the experience of coping with the stigma by women whose partners died of AIDS, as well as developing mechanisms to assist these women to cope with the stigma experienced due to having lost their partners to AIDS.

The meta-theoretical assumptions of this article are grounded in the belief that every person is a totality of the biological, psychological, social as well as spiritual being. The theoretical statement of this research includes the Central Theoretical Argument as

well as the methodological statement that: Coping with widowhood status is, in itself, a difficult process due to the stress and pain of loss. In the context of this article, the difficulty is aggravated by HIV and AIDS, because both conditions carry the stigma. Women in the context of this article are faced with stigmatization of widowhood, compounded by the loss of partner to AIDS as well as their HIV positive status. The fact that these women were also HIV positive was not pre-determined but was co-incidental.

## 2. Literature Study

Coping is said to be an old concept that has evolved, according to Aldwin (2000), with time. Aldwin motivates this statement by stating that in the fifties, the American dictionary referred to it as "proving oneself as a match for", whereas modern dictionaries define coping as efforts to resolve environmental pressures that could not be handled. In most of the literature on coping, it is documented that defense mechanisms feature more often because they are usually used without the person being fully aware of them (Aldwin 2000; Carr 2004; Gottlieb 1997; Kleinke 2004; Lazarus 1976; and Parry 1990).

Coping with the HIV and AIDS stigma, whether one is infected or affected, also depends on the individual's self efficacy in dealing with the problem, hence Cassidy (1999) viewed it as the person's cognitive and behavioral effort to manage, minimize, master, or tolerate his/her internal and external demands. One may appreciate the broadness or openness of this definition in implying that when one faces a stressful situation, one attempts to cope in order to prevent, or minimize the impact, to master or if nothing comes out of those efforts, to tolerate the stressor. This definition supports that of Bailey and Clarke (1989) because attempting to cope would aim at achieving an outcome that will enable one to either reduce, master or live with the stressor. Sikkema et al. (2000) confirmed in their study that people with HIV and AIDS, who utilized active coping strategies tend to improve their quality of life; that is, they may be considered as having mastered the stressor.

## 3. Research Design and methods

A qualitative, phenomenological, research design was followed with the aim of exploring and describing the experience of coping with stigma, by women who lost their partners to AIDS, and who are themselves HIV positive (Creswell 1998). In-depth

interviews with participants enabled the researcher to explore and describe the phenomenon of coping. The population from which the sample was drawn consisted of women who lost their partners to AIDS in the four regions of the North West Province of South Africa. These regions are Bojanala, Dr Ruth Mompati, Dr Kenneth Kaunda, as well as Ngaka Modiri Molema. A purposeful voluntary sampling technique was used (Burns and Grove 1997; Streubert and Carpenter 1999). The women were identified through the non-governmental organization that renders home-based care to people living with HIV and AIDS (PLHA). Home-based carers in each region obtained the consent of PLHA to connect them with the researcher. The author then visited the potential participants individually, accompanied by carers, to establish rapport as well as to inform them of her intention of conducting research. Letters to obtain their consent to participate were subsequently written and delivered personally by the researcher, thus ensuring a prolonged engagement. For the purpose of this article, participants were selected according to the following criteria: The women must: have lost their partners to AIDS within a year, be resident in any of the five regions of the North West Province of South Africa, be able to communicate in Setswana, Sesotho, Sepedi or English, be open and willing to share their experience in a semi-structured interview, be willing to give consent to be recorded on an audio-tape. The women were included on the basis of their consent to participate without considering numbers per region. A total of fifteen women were interviewed.

#### 4. Data Collection and Analysis

Data was collected by means of interviews using a single open ended in-depth question (Brink and Wood 1998), **“how do you experience coping with the stigma after your partner died of AIDS?”**. The question was first given to experts to evaluate its applicability. The pilot study was conducted initially with one of the participants who met the inclusion criteria in order to confirm its applicability. This in- depth, single, open-ended question, was posed in order to explore the participants’ experience of the stigma. The interviews were tape recorded. Field notes were written immediately after each interview to ensure that all observations were recorded whilst the researcher still remembered them clearly (Morse 1989; Creswell 1998). The interviews recorded on audio-tapes were transcribed verbatim, and translated from other languages into English. Data analysis was conducted according to the content analysis technique of Tesch as

outlined in Creswell (2003). After the co-coding was completed, a meeting was organized by the co-coder and the researcher in order to reach a consensus on the themes and categories.

#### 5. Trustworthiness

Trustworthiness was ensured using the model of Lincoln and Guba (in Krefting 1991) integrated with that of Woods and Catanzaro (1998). The criteria applicable to ensuring the trustworthiness of the study according to these authors are credibility, transferability, dependability and conformability (See table 1).

#### 6. Ethical aspects

Permission to conduct the study was obtained from the North West Provincial Department of Health as well as from the Home Based Care Organization under whose care the women were. Ethical approval was given by the North West University-Potchefstroom Campus School of Nursing as well as the Faculty of Health Sciences Ethical Committees. The participants’ rights to privacy, anonymity, confidentiality, fair treatment, and protection from discomfort and harm were observed throughout the study (Burns & Grove 1997). The principles of human dignity (Ubuntu) were observed in order to obtain co-operation from the participants and all other parties who were involved in this study.

#### 7. Results and Discussion

Data analysis on coping with the stigma by women whose partners died of AIDS showed that most of the women used the usual common coping strategies that could be classified as problem-focused and emotion-focused. These strategies were as follows: deciding on voluntary counseling and testing in order to know their HIV status, disclosure of their HIV-status for family support, joining support groups for emotional and moral support, joining church organizations to seek spiritual support, compliance with healthy lifestyle, and keeping their HIV status secret. This article revealed some unique findings that could be misunderstood as being similar to those of some of the authors referred to earlier on, whereas they are different in the manner in which they were experienced by women in this article. These are addressed in the following discussion.

## Problem-focused Coping Strategies

Coping strategies that are considered as unique include, falling back on spirituality, complying with Ante Retroviral Therapy (ART), awareness of living a healthy lifestyle, as well as disclosure versus non-disclosure of their HIV status.

### Falling back on Spirituality

One of the outstanding results in this study was that these women mentioned that after being devastated by discovering that they were HIV positive, they found effective coping to be, falling back on spirituality. This was motivated by their Christian belief that 'God is above every problem'. This they did through affiliating to church organizations both for emotional support and for spiritual fulfillment. They also mentioned that they sought solace in their God by means of prayer, and bargaining with Him to grant them health and to increase their days of life so that they could bring up their children. This is evident in the women's expressions such as, "God is the only one who knows our days of life and who can extend"; "ask God to protect and secure you all the time; pray! That is how I manage in life", and "I do ask Him to keep me until I have done my best for my children, that they become educated and achieve something you see". Yarhouse and Anderson (2002) concurred that prayer could assist Christians with HIV and AIDS to come to terms with their relationship with God. Such a relationship may help them to resolve forgiveness issues especially that the stigma associated with HIV and AIDS may be moral-based. This finding is unique because participants reported having sought solace in spirituality as their coping strategy after being devastated by the loss of their partners to AIDS, and realizing that they themselves were positive. However, they could not receive the support that they expected, but instead they were shunned and rejected by their fellow Christians. Their disappointment could be detected in their expressions such as, "I thought the church was where you would get comfort yet you don't get it at all".

"I used to sing in the church choir but my fellow members started to say funny remarks and rejected me until I stopped". These quotes indicate that even though the women resorted to falling back on spirituality for support, this was not achieved because they continued to be shunned until they quit in despair.

## Compliance with Healthy Lifestyle

Participants accepted their HIV and AIDS status and thought it wise to live a healthy lifestyle. The subcategories under this category are, complying with ART, eating a healthy diet, do physical exercises, and either abstain from sex or use condoms as it is reported by other authors (Fife and Wright 2000; Sowell et al. 1997; Weiss and Ramakrishna 2002). Participants who had already developed signs of AIDS mentioned that they thought it wise to adhere to their prescriptions in order to cope with the symptoms and signs that aggravated stigmatization such as sores, exhaustion, loss of weight and others. This coping strategy can be realized in the quotes, "they usually tell us to stick to the same time of taking treatment; my time for taking treatment is eight so I have to eat first so I vary my food, like sometimes I eat sorghum, I eat beans, samp, mielie rice with some chicken and veggies" and, "I am regular with my appointments; if anybody asks me about my problems I just say I have come for treatment, I don't have problems". These experiences were contrary to the evidence discovered by Siegel and Schrimshaw (2005) that women in the highly active ART did not seem to report a great sense of control or positive results. Almost all the women, over and above complying with the ART regimen, also mentioned that they adhered to a healthy diet after being advised by their counselors to do so. However, this result is also unique because although these women mentioned eating healthy as their way of coping, they did it as a response motivated by factual knowledge that they learnt during counseling. Evidence during home visits showed that due to poverty, there was actually no foodstuff and hence it was very difficult to have a healthy diet. It is documented that engaging in physical exercise could enhance coping (Carr 2004; Kleinke 1998). However, the uniqueness of this finding is that coping by doing exercises has been mentioned by these women as a known fact but, having observed their wasted state as well as their weakness due to severe weight loss one could think that they probably mentioned it to impress the researcher. Women participants mentioned either practicing safe sex by using condoms or totally abstaining from sex. As almost all of the women went through counseling, they mentioned that they were aware of re-infection hence they took precautions to prevent it as expressed in, "if I get a partner I have been warned to use a condom"; "They said that we must stay far from men or if you have one never sleep with him without a condom". Although the researcher actually observed that these women wished to take precautions, their partners did not cooperate as evident in their failure to either disclose or protect their partners. These are



problem-focused coping strategies because the women reported that they engaged in concrete measures to cope with the stigma, as opposed to the emotion-focused strategies that follow.

### **Emotion-focused functional coping**

The women also mentioned that they felt emancipated from pain once they were accepted by their family members. This they expressed as follows: "It's because I just thought my mother would reject me; no, she accepted me and even took me to her house to nurse me"; "my child has accepted me, so I no longer have problems". And, "other people think that support is only financial but that's not so, when people accept you, they support you". These feelings of the participants being happy about being accepted by their family members were believed to have contributed to positive coping by People Living with HIV or AIDS (PLHA) (Brown et al. 2003). On the contrary, Miller and Kaiser (2001), found that acceptance may be somewhat less adaptive for the stigma than for other types of stressors because of its constant and pervasive nature. This result was found to be unique because some participants were rejected by their in-laws, who became their primary family after marriage. In their culture, after marriage, the woman leaves the family to leave with the husband's family. Being rejected suddenly after the partner's death, and the fact that in-laws influenced the community and the church against them further paralyzed their coping strategies. They became severely humiliated and their ability to use their support systems became paralyzed as it was difficult even to access medical services. All the women who participated in this study mentioned some form of support that they received from close family members, neighbors, as well as from social welfare in the form of grants. Some of these forms of support were, for example, "the priest told me to take pride in myself and should not listen to criticism, for God has a purpose for everything in life"; "I cope with these very cents that I get from government, it is my share and my daughter's"; Another form of coping that was found was when participants considered the stigma attached to HIV and AIDS as 'our problem' rather than 'my problem' hence the researcher terms it de-individualization. Women seemed to feel less anxious in realizing that they are not the only ones suffering from and experiencing the stigma of HIV and AIDS. This experience resulted in the relief of pain associated with the HIV and AIDS stigma. The implication of

this result could be detected in the words used by these women such as, "so I did not have fear because it is our disease, and I went to test because I wanted to know ...", and "it means I'm thinking that we are of the same flock, yes we are of the same flock. So you ask yourself that am I going to be like so and so, or so and so, just like that". In the latter quotation, the participant was referring to the victims of AIDS that she saw during their final stage, in anticipation of how she is going to be like. The literature consulted does not necessarily refer to the stigmatized people de-individualizing the disease but that, they can empathize with each other because they share the same experiences (Gaines 2001). Miller and Kaiser (2001) also documented that stigmatized people, when they share the support of other stigmatized people could probably cope through cognitive restructuring. Compared with the former problem-based coping, the latter is evidence that some women coped with the stigma at the emotional level as could be detected in the manner in which they expressed themselves. However, some results showed that women coped by using defense mechanisms as in the discussion that follows.

### **Defense mechanisms as means of coping with the stigma**

During data analysis the following quotes that suggest the use of defense mechanisms were detected. "I no longer want any man next to me; I am only satisfied when I am with my daughter", or "even when I feel sick I don't sleep or just sit, I try to keep myself up, I refuse to be sick" and "I am HIV-positive and I am proud because I know my status". The literature on coping with the stigma has identified denial as a form of escape-avoidance coping, which can prevent the PLHA from accepting their status and gaining access to support and resources (Coetzee and Spangenberg 2003). However, the same authors found that denial could make it possible for the person to make the cognitive adjustment, especially during the initial phase of shock. After the analysis of the coping mechanisms used by the participants, recommendations were suggested in the last part of this article to assist them to cope effectively as some of their present coping strategies appear to be ineffective.

**Table 1. Strategies to ensure trustworthiness**

Strategy	Criteria	Application
Credibility	Prolonged field experience	Letters to request participation delivered by the researcher and spent time with the women to establish a trusting relationship.  Confirmation of appointments also done personally by the researcher to strengthen the relationship. The participants allowed enough time to verbalize their experiences and beliefs respectively, during interviews.
	Reflexivity	The field notes were written immediately and subjected to analysis
	Member checking	The literature control of experiences of coping with stigma was undertaken.
	Interview technique	The researcher is trained on the research methods and on the interviewing skills.  Research supervised by experts who are experienced in qualitative research.
Transferability	Selection of sample	The sampling method was purposive voluntary as well as judgmental.
	Dense description	Through the description of the research methodology and literature control of the results.
Dependability	Stepwise replication	Co-coder involved in independent data analysis.
	Dense description	Detailed description of methodology.
	Code-recode procedure	Data analysed twice and results compared.  Consensus discussion held with co-coder.
	Peer Examination	Expert supervision provided throughout the process. Ethics Committee comprises experts in the field of research
Conformability	Conformability audit	Done by co-researchers who are experts in Qualitative Research.
	Reflexivity	Field notes written and subjected to data analysis.

## 8. Conclusions and Recommendations

It would benefit women whose partners died of AIDS if programs are developed to facilitate Voluntary Confidential Counseling and testing (VCT), to assist them through a process of disclosure as well as in acceptance of their status so that there is prompt seeking of treatment in order to cope, as well as preventing the debilitating effects of HIV and AIDS. Following their pre and post-test counseling, a follow-up could be done to monitor their coping skills on subsequent visits by evaluating them so that should the need arise, help is readily available. This could increase openness that will improve coping. The community could be made

aware of the need to support PLHA by accepting them and respecting their human rights such as the right to receive care and treatment, the right to belong to a family, as well as other rights that are enjoyed by all citizens, so that they can cope with the stigma. Government and non-governmental organizations should support programs aimed at assisting PLHA, such as home-based care, support groups and the other initiatives aimed at empowering these women to deal with the stigma associated with their widowhood status as well as the disease. It would benefit these women if they could be trained on assertive skills so that rather than ignoring all negative remarks, they would respond in a positive and assertive manner, thus preventing



aggression and negative responses. Budgeting skills are also essential so that they could effectively use the little money that they receive from social grants in order to meet their basic needs. They could also be advised to use NGO's that would assist them in the cultivation of vegetables so that they can produce their own, as well as accessing other support initiatives aimed at poverty relief so that the stigma could be reduced. It could be to their advantage if the faith-based organizations are involved since they hold strong Christian beliefs. They could benefit from prayer meetings and spiritual counseling sessions, either as individuals or as groups.

In conclusion, the results revealed that unlike what is documented in the literature, the manner of coping of these participants is different and unique. The uniqueness is that their voluntary counseling and testing is for reasons of accessing the government grant and ART due to poverty rather than just voluntary. Most of them disclosed to their close family members because they needed their emotional support as well as material support in the form of food, as most of them are not working and are dependent on their late partners. This support was needed after they were rejected by their in-laws who contributed to their paralyzed coping. Some women also mentioned that they disclosed their status with an intention of preventing gossip, but found this to be ineffective, as was their falling back on spirituality. Healthy living through eating healthy food and exercising frequently were realized as strategies that participants knew about but found difficult to comply with due to poverty. Emotion-focused functional coping revealed that the women also felt better if they considered HIV and AIDS as collective problem rather than an individual problem. Some mentioned the use of defense mechanisms as ways of coping.

**Abbreviated title:** Coping with HIV/AIDS Stigma by Women who lost their Partners to AIDS in the North West Province

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# Life Science Journal

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## Life Science Journal 8(S1) Full Text

### Contents

#1

#### **Capacity of *Pseudomonas syringae* pv. *glycinea* Strains and their Method of Application on *Striga hermonthica*-infested Maize and Sorghum**

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**Abstract:** One variety of Maize (8338-1) and two varieties of Sorghum (CK60B and Mokwa local) were grown in potted soils with 3,000 seeds *Striga hermonthica*. Three strains of *Pseudomonas syringae* pv. *glycinea* designated as 16/83, 19/84 and 8/83 were tested for their effects on germination of *S. hermonthica* seeds via inoculation. Results showed that application of bacteria by root dip or seed pelleting method in Sorghum demonstrated greater heights (~6.72 cm) for all the three bacteria over the non-inoculated control. For CK60B, average stover dry weight in the control was the lowest ( 0.71 g/plant). All the 3 isolates improved stover dry weight ( 2.5 g/pot) over the non-inoculated control on the Maize host. *S. hermonthica* infection indices were significantly different between plants grown in steam pasteurized soil and those grown in natural soil. The knowledge of these application methods in reducing sources of variation in bacterial studies on *S. hermonthica* is discussed. [Life Science Journal. 2011;8(S1):1-10] (01) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** bacterial treatment; *Pseudomonas syringae*; root dip; greenhouse; seed pelleting; *Striga*

#2

#### **Determinants Of Loan Repayment And Bank Loan Default Among Small Scale Farmers In North West Province, South Africa**

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**Abstract:** The study examined the factors which influence loan default among small scale farmers in North-West Province, South Africa. It specifically identifies socio-economic characteristics of the responded and quantitatively determines some socio-economic characteristics of farmers that influence the level of loan defaults. A simple random technique was used to select 160 farmers from Molopo, Rustenburg, Lichtenburg, Zeerust, Ganyesa and Kuruman. A structured questionnaire was developed based on the study objective and related literature to collect data which were analyzed using frequency count, percentages and multiple regression analysis. The result shows that farmers had a mean age of 58.5, and majority had primary education. The mean monthly income among farmers was R831 while the mean monthly was R1403. Significant determinants of loan defaults among farmers were educational level ( $t = 3.09$ ), monthly expenditure ( $t = 5.05$ ) amount of loan ( $t = 6.11$ ) financial management scale ( $t = 6.26$ ) and time of loan disbursement. This implies that the significant variables should be giving proper policy considerations in order to improve loan repayment among small scale farmers. [Life Science Journal. 2011;8(S1):11-18] (02) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** small scale farmers, loan default, socio-economic characteristics, South Africa

#3

### Postural analysis of risk of neck and low back pain of adolescents in a high school in Pretoria, South Africa

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**Abstract:** The risk of developing back and neck pain was investigated amongst 84 learners in a high school in Pretoria, South Africa. The design of this study was a cross sectional descriptive study. Ninety percent of the participants reported a high risk of developing neck pain. The findings of the study revealed that there is a high risk of back pain at age 14 (100%), with females (94%) at higher risk than their male (84%) counterparts. There was a significant association between age and risk of back pain ( $p = 0.019$ ). No significant association between neck pain and age, gender, and hand dominance ( $p = 0.670$ ;  $p = 0.286$ ;  $p = 0.542$  respectively), upper back pain and age, gender and hand dominance ( $p = 0.904$ ;  $p = 0.608$ ;  $p = 0.500$  respectively), and lower back pain and age, gender and hand dominance ( $p = 0.176$ ;  $p = 0.473$ ;  $p = 0.675$  respectively). The prevalence of neck pain was found to be 35%. [Life Science Journal. 2011;8(S1):19-23] (03) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Postural analysis; Back pain; Adolescents, Ergonomics, School furniture; Seating designs

#4

### Socio-Economic Benefits of Urban Sprawl in Mafikeng, South Africa

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**Abstract:** The socio-economic impact of urban sprawl has been a major concern around the world. This paper reports the benefits of urban sprawl in Mafikeng, South Africa. Arc Map software was used to evaluate three spatial

images of Mafikeng: 1968, 1996 and 2008. Results indicate extension of the Central Business District to the outskirts and an increase in infrastructure development. Additional benefits include growth in professional services and the migration of the service sector from the city centre. These findings have immediate policy and planning implications for urban development. [Life Science Journal. 2011;8(S1):24-28] (04) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Key words:** Central business district; land use planning; road network; air pollution; traffic congestion

#5

**Experiences of Nurses Caring for People Living with HIV and AIDS in Vhembe district, Limpopo Province.**

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**Abstract:** The purpose of this study was to explore and describe the experiences of nurses caring for people living with HIV and AIDS (PLWHA) in Vhembe district, Limpopo Province. A qualitative research design which was exploratory, descriptive and contextual was used, with a purposive and theoretical sample of nurses who provided care in a regional hospital in Vhembe district of Limpopo Province. Data saturation occurred after in-depth interviews with fifteen participants, field notes were also used during data collection. The findings revealed that nurses caring for PLWHA experience physical, emotional and psychological burden of caring, lack of social support by colleagues and managers and the need for education on HIV/AIDS care. Recommendations that are described focused on supporting nurses to cope in caring through provision of work-based support programmes. [Life Science Journal. 2011;8(S1):29-37] (05) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Caregivers, caring, HIV and AIDS; nurses

#6

**An investigation into the prevalence of *Toxoplasma gondii* among indigenous, communally reared goats in the Mafikeng area of the North West Province of South Africa.**

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**Abstract:** An enzyme-linked immunosorbent assay (ELISA) based study was conducted to determine the seroprevalence of the zoonotic infection *Toxoplasma gondii* in indigenous, communally reared goats around Mafikeng. Sera from 172 goats from 5 areas around Mafikeng in the North West Province were tested. The seroprevalence ranged between 11.1 and 14.8% (= 6.4%). Sixty percent of the sampled areas tested positive, so were 50% of the herds. Only 25% of the farmers had prior knowledge of toxoplasmosis. Sixty three percent of the farmers consumed goat milk, while 87.5% slaughtered goats for own consumption. The prevalence of the infection among goats raises public health concerns due to the zoonotic nature of the parasite. Health officials are encouraged to review policies that involve human exposure to the parasite as well as mount awareness campaigns about the infection. [Life Science Journal. 2011;8(S1):38-41] (06) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** enzyme-linked immunosorbent assay (ELISA); infection; *Toxoplasma gondii*; toxoplasmosis; parasite

#7

### **Risk assessment for *Salmonella* contamination of pig carcasses in abattoirs in the North West Province, South Africa**

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**Abstract:** One hundred and eighty blood samples were run using the ELISA method to determine the seroprevalence of *Salmonella* in slaughter pigs at various abattoirs in the North West Province of South Africa. Seroprevalence ranged from 18.8-47.4% (= 28.3%), while 100% of the abattoirs tested positive. Indications were that infections were occurring at farm level. Further farm level qualitative investigations are recommended in order to identify the actual factors associated with the infections. Consideration should be made for the introduction of *Salmonella* monitoring programs at farm level to assist in the prevention of contamination. [Life Science Journal. 2011;8(S1):42-45] (07) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Abattoirs, ELISA; North West Province, pig, *Salmonella*, Seroprevalence.

#8

### **Settlement structure and energy access in rural Sub-Saharan Africa**

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**ABSTRACT:** The purpose of this paper is to report the results of an investigation on energy access in rural Sub-Saharan Africa. Three objectives were advanced for this study: to review literature on rural energy access, comment on energy policy and planning, identify constraints to increasing rural access and finally, develop an alternative intervention for the energy sector. The methodology was based on adaptation of the shortest path model (SPM), the maximum flow (MFM) model and the minimum cost flow (MCF) model in network design. Statistics from international organisations on the energy sector, population, land use and road networks were handled using correlation analysis to identify key relationships. The results highlight serious shortfalls in energy provision, infrastructure, and policy, planning and capital investments in the energy sector. The absence of a correlation between power generation, rural energy access, population density and road density point to the inadequacy of current planning practices. Current settlement patterns appear to impose constraints on the optimization of rural energy provision in spite of immense untapped potential for renewable energy sources. An alternative integrated energy platform (EAP) based on restructuring settlement is suggested that could allow for a radical increase in energy access at national level by exploiting opportunities provided through rural settlement densification. [Life Science Journal. 2011;8(S1):46-58] (08) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Installed capacity; grid network; generation; transmission; distribution; renewable energy; biomass energy

#9

### **Applications of Remote Sensing and GIS Techniques in Analyzing the Effects of Rainfall Variability on Crop Acreage**

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**Abstract:** Climate change is a global concern and has a major impact on overall economic development. This is even more prominent in developing countries, especially in Sub-Saharan Africa. As one of the major elements of



climatic change, rainfall variability is one the most unpredictable factor and a common cause of failure in agricultural production. The impact and the pattern of the variation in crop acreage changes in this region are investigated with particular reference to the semi-arid parts of Southern Africa. Satellite images of Mafikeng municipal area, North West Province, South Africa, are used to detect changes since 1988 with an image processing tool (ERDAS-Imagine). The resulting output allows for change detection and image classification for different land cover classes. The GIS package (Arc Map9.3) was used for mapping and visualizing the results on the screen and paper. The findings indicate that the periodic variation and irregularity of rainfall in the region does not have a particular negative effect on the size of crop land in the study area. The insights have direct policy and planning implications for dry land agriculture in the face of current climatic variations. [Life Science Journal. 2011;8(S1):59-67] (09) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Key words:** Climate change; satellite images; land cover change; Mafikeng

#10

### **Seasonal weather events and their impact on buildings around Mafikeng, North West Province, South Africa**

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**Abstract:** The study used time series analysis of climatic data (1978 to 2009) of rainfall, temperature and wind to investigate the impact of extreme weather events on buildings and their surroundings in Mafikeng, South Africa. Questionnaires were administered on 100 households in order to establish residents' experiences on seasonal weather events. Mafikeng and its environs, belong to arid climate regions; it features a long term mean seasonal rainfall of approximately 76mm and it receives a unimodal rain season which starts in October and end in April of the following year. In this study, the results reveals that Mafikeng experienced the highest rainfall during the 1997 with a seasonal rainfall mean of 117 mm and the lowest rainfall was experienced during the 1991 season (32 mm). The 1997 rainfall resulted into waterlogging and leaking of roofs in the homes. Extreme temperatures were experienced in the area during 1992 summer season where the highest mean maximum temperature of 37<sup>0</sup>C was recorded. Usually the maximum temperature in Mafikeng range between 25<sup>0</sup>C and 32<sup>0</sup>C. The lowest minimum temperature (-7.5<sup>0</sup>C) was observed in 1994 during the cold season. The study identified that the extreme weather events in Mafikeng are associated with building fatigue, which resulted into structural damages such as cracked walls, windblown roofs, dust accumulating indoors from dust storms and noise pollution. The study highlights the need for maintaining appropriate building standards, designs and regular review of standards in Mafikeng and its surroundings in order to address climate extreme and the climate change issues. [Life Science Journal. 2011;8(S1):68-73] (10) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Seasonal weather events, Climate change, Mafikeng.

#11

### **General knowledge and utilization of Indigenous Leafy Vegetables by villagers in the Mafikeng area of South Africa.**

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**Abstract:** The role of wild indigenous leafy vegetables (ILVs) for nutritional and medicinal purposes, and in food security is recognized in African countries; however, their use and consumption in South Africa is diminished since

they can be associated with poverty and low self-esteem among rural people. This study was conducted to investigate villagers' general knowledge and utilisation of ILVs through a survey conducted among thirty randomly selected households in each of three villages (Lokaleng, Moshawane and Tsetse) in the Mafikeng area of South Africa. Data was collected using a structured questionnaire administered face to face (personal interview) with the researcher completing the questionnaire as each villager responded. The results show that all villagers have knowledge of the most common ILVs. The most common ILVs recognized and used were *Amaranth*, *V.inguiculata*, *C.maxima* *C.gynandra* and *C.album*. However, *Amaranth*, *C.gynandra* and *C.album* were identified as the three most commonly used ILVs as sources of food. Most participants (67%) cited that in the presence of both ILVs and exotic vegetables, they would prefer ILVs for food. This preference of ILVs versus exotic vegetables was age specific but not gender specific. The youngest age group of <20 years was the only group which preferred exotic vegetables (63%). Additionally, it was determined that ILVs were simply used as found in the wild and were not domesticated. [Life Science Journal. 2011;8(S1):74-79] (11) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** knowledge; indigenous leafy vegetables (ILVs); rural villagers; utilisation

#12

### The effects of cattle manure and harvesting frequency on the growth and yield of *Cleome gynandra*

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**Abstract:** A study was conducted to determine the effects of cattle manure and harvesting frequency on the growth and yield of *C. gynandra*. The experimental design was a RCB with four replicates. A factorial experiment of 4 x 3 combinations was used. Treatment combinations consisted of four manure application rates (0 ton ha<sup>-1</sup>, 15 tons ha<sup>-1</sup>, 30 tons ha<sup>-1</sup> and 45 tons ha<sup>-1</sup>) and three harvesting frequencies (weekly, bi-weekly and at termination). Results indicated that cattle manure application had a significant effect on growth and yield parameters (dry weight, leaf number, plant height). The highest yield (1.73 g/pot) was obtained with a 45 tons ha<sup>-1</sup> application rate which was not significantly different from the 30 tons ha<sup>-1</sup> (1.51 g/pot). The highest leaf number (180) was obtained with a rate of 45 tons ha<sup>-1</sup>, which was not significantly different from 30 tons ha<sup>-1</sup> (173). The greatest plant height (55.1cm) was recorded for 45 tons ha<sup>-1</sup>. There was no significant difference in plant height for 0, 15 and 30 tons ha<sup>-1</sup> (43cm, 49cm and 51.2cm, respectively). Harvesting frequency had a significant effect only on dry weight. There was no significant difference for yield recorded for weekly or bi-weekly harvests. In conclusion, the study recommends that farmers use cattle manure at a 30 tons ha<sup>-1</sup> application rate and harvest bi-weekly. Results established that soil properties (pH, organic carbon, organic matter, and available phosphorus) increased with an increase in manure application and may be a cause of the observed increased yield and growth of *C. gynandra*. [Life Science Journal. 2011;8(S1):80-88] (12) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** cattle manure; *Cleome gynandra*; harvesting frequency; indigenous leafy vegetables.

#13

### Do chemical structures of flavonoids have potential in predicting intake and relative palatability indices?

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**Abstract:** The main aim of this study was to test the potential of chemical structures of flavonoids in predicting intake and relative palatability indices. Six pedi male goats were used in a completely randomized design to determine intake and relative palatability indices of *Acacia karroo*, *Acacia nilotica*, *Acacia sieberiana*, *Acacia tortilis*, *Acacia rhemniana* and hay. Chemical structures were also isolated from *Acacia* species using nuclear magnetic resonance. Correlation analyses were done to establish the relationship between chemical structure, intake and relative palatability indices. The null hypothesis for the study was chemical structures of flavonoids will have a potential in predicting intake and relative palatability indices. *Acacia sieberiana* had the highest intake and relative palatability indices as compared to *A.rhemniana*. Leaves from *Acacia* contained carbohydrates, flavan-3-ols, flavanols and glycosilated flavones. Methyl gallate, epigallocatechin and catechin gallate had highest correlations with intake and palatability whilst sucrose and glucose were weakly negatively correlated to both intake and relative palatability indices. Luteolin -7-glucoside, rutin and catechin gallate were not correlated to intake and relative palatability indices. The results indicated that chemical structures of flavonoids have potential in predicting intake and relative palatability indices. [Life Science Journal. 2011;8(S1):89-97] (13) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Flavonoids, intake, relative palatability indices, nutritive value

#14

#### **Consumers Willingness To Pay For Safety Labels On Gari (Cassava Roasted Granules) In South Western Nigeria**

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**Abstract:** This paper examines consumers' willingness to pay for safety labels on gari in south western Nigeria because of reported cases of hydrogen cyanide residue leading to food poisoning. The type of gari processing technique used determines the amount of cyanide residues. It is important therefore that gari is labeled based on the processing techniques. The use of labels as in other food products will however require additional payment by consumers. From a total of 15 major gari markets, seven were randomly selected through which 200 gari consumers were randomly selected for the study. Data were collected using a structure questionnaire and analyzed using frequency counts, percentages and probit regression model. The probit regression model is significant ( $\chi^2 = 2255$  df<sub>189</sub>,  $p < 0.05$ ). The model reveals that the probability of willingness to pay more for safety labels in gari is positively affected by the prior individual knowledge of safety labels, income level, education level, household size and frequency of consumption. However, it is negatively affected by price and perception of health risks due to cyanide. [Life Science Journal. 2011;8(S1):98-103] (14) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Willingness to pay, Gari, Food Labels, Nigeria, cyanide residues.

#15

#### **PCR and sequencing assays targeting *mdh* and *gapA* genes for *Escherichia coli* and *Klebsiella* bacteria species identification in river water from the North West Province of South Africa.**

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**Abstract:** Rivers carry a significant number of pathogenic bacteria mostly of faecal origin from untreated sewage that result in faecal contamination of the natural environment. This study, being the first of its kind to be reported from the study area, aimed at performing and evaluating standard PCR and sequencing assays based on the use of *mdh* and *gapA* genes for *E. coli* and *Klebsiella* species identified in the major rivers in the North West Province of South Africa. A total of 54 water samples were collected between November 2007 and March 2008 from the Crocodile, Elands, Hex, Mooi, Vaal, Molopo, Groot Marico, Harts and Skoonspruit rivers and cultured on selective media to isolate *E. coli* and *Klebsiella* species using the standard spread-plate method. Molecular characterisation of suspected isolates by PCR was performed to amplify an intragenic segment of the *mdh* and *gapA* genes, which detected *E. coli* and *Klebsiella* with a prevalence of 44% and 29%, respectively among the samples. The presence of these pathogens, amongst others, in these rivers indicates faecal contamination. This suggests that the use of untreated water from these rivers for drinking by humans may pose serious health problems, including diarrhoea and other water-borne diseases. The study emphasizes the need to provide potable water supplies particularly in rural areas, as well as routine monitoring for the presence of pathogens in these rivers and effective management of river catchments. [Life Science Journal. 2011;8(S1):104-112] (15) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** *E. coli*, *gapA*, *Klebsiella*, *mdh*, polymerase chain reaction, human health, and untreated water

#16

#### **Coliform flora in faeces of dogs presented to the Animal Health Clinic of North West University, Mafikeng Campus, South Africa**

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**Abstract:** The purpose of this study was to investigate the coliform flora present in dog feces and their role as a reservoir of antimicrobial resistance. A total of thirty-one rectal swabs were randomly obtained from sixty client-owned dogs brought to the Animal Health Clinic of the North West University, Mafikeng Campus, during the month of June 2010. The dogs were presented with complaints varying from routine vaccination to anorexia and diarrhea. Samples were subjected to routine microbial culture and isolation procedures, followed by biochemical characterization and antimicrobial susceptibility testing of obtained isolates. Results showed the presence of *E.coli* spp (9.5%), *Salmonella* spp (4.8%), *Klebsiella* spp (33.3%), *Enterobacter* spp (19%), *Pasteurella multocida* (4.8%), *Proteus* spp (14.3%), *Vibrio* spp (4.8%) and *Serratia* spp (9.5%). All the isolates were resistant to at least two of the antibiotics tested. The antibiotics include ampicillin (10 µg), chloramphenicol (30 µg), cefuroxime (30 µg), cotrimoxazole (25 µg), tetracycline (30 µg), sulphadiazine (200 µg) and clindamycin (2 µg). The results suggest that dog feces could pose a zoonotic risk to humans and could also act as reservoir of antimicrobial resistance genes. It is recommended that dog owners and health workers particularly immunocompromised persons should exercise care when handling dog feces. [Life Science Journal. 2011;8(S1):113-118] (16) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Key words:** Faeces, dogs, coliforms, antimicrobial resistance, human, reservoir

#17

#### **Efficacy of nonfeed deprivation methods for molt induction in layers**

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**Abstract** This study was aimed at comparing the efficacy of different nonfeed deprivation molting methods with feed withdrawal in terms of body weight loss, ovarian regression and post molt layer performance. A total of 384 Dekalb white laying hens, aged 72 weeks, were used in this study. Birds, which were kept in a 50 x 46 x 45 cm battery cage system, were randomly divided into four experimental groups. Feed was completely withdrawn from hens in group one for nine days (FW). Birds in group two were fed alfalfa meal (AM) for nine days and birds in group three were fed layer ration containing 20,000 ppm of zinc as ZnO (DZ) for nine days. From day 10, birds in groups one to three consumed cracked corn diet until day 28. Birds in the fourth group consumed cracked corn diet (CC) *ad libitum* for the 28 days. All the groups were then returned to normal layer diet *ad libitum*. Results indicate that body weight loss and reproductive tract regression in AM group was quite comparable to that of FW group. These were significantly lower in CC group. Short-term post molt egg production revealed significantly higher production in CC group than FW. There was however no significant difference between treatments in post molt egg quality, rate of deterioration of stored eggs, weights of liver, heart and spleen and bird mortality. In summary, alfalfa meal appears to be the most efficient molt induction method, comparable with feed withdrawal. However, long-term post molt performance of all the methods employed in this study, needs to be evaluated in order to draw comprehensive conclusions. [Life Science Journal. 2011;8(S1):119-124] (17) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Molt induction, layer, egg production, egg quality, nonfeed deprivation

#18

### **The evaluation of sodium bicarbonate and hydroxy- eta-cyclodextrin as treatments for organophosphor and carbamate poisoning in poultry**

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**Abstract:** Organophosphorus and carbamates are used world wide on a large scale and accidental poisonings are often seen. The objective of the trials was to evaluate newer antidotes, using chickens as experimental animals. Pilot trials were done to establish the lethal dosages of each poison. In Study 1, fourteen broilers were dosed orally with diazinon at 8 mg/kg and seven broilers were also given sodium bicarbonate at 504 mg/kg by intravenous route 30 minutes later. In Study 2, fourteen broilers received coumaphos orally at 25 mg/kg and 30 minutes later sodium bicarbonate was administered intravenously at a dosage of 504 mg/kg to seven broilers. In Study 3, fourteen broilers received aldicarb at 4 mg/kg and 30 minutes later seven broilers also received hydroxypropyl- cyclodextrin at 250 mg/kg intravenously. In all the studies, the controls also received sterile, de-ionized water intravenously 30 minutes after dosing as a placebo. The results indicated that sodium bicarbonate had made a significant difference ( $P < 0.05$ ) to the survival times of broilers in trial 1 and trial 2. Hydroxypropyl- cyclodextrin treated broilers also had significant longer survival times ( $P < 0.05$ ) than the controls in trial 3. The final conclusion is that sodium bicarbonate has the potential to inactivate organophosphors, while hydroxypropyl- cyclodextrin can be useful for lipid-soluble insecticides with a molecular weight below 250 Daltons. The recommendation is to administer these compounds as adjunctive treatments together with the standard antidotes to improve the outcome of organophosphor or carbamate poisoning. [Life Science Journal. 2011;8(S1):125-129] (18) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Keywords:** Organophosphors, carbamates, sodium bicarbonate, cyclodextrins

#19

**Soil Physical and Biological Properties as Influenced by the Incorporation of Leaf Litter Biomass from Three Sub-tropical Fruit Trees at Nelspruit, Mpumalanga Province, South Africa**Romeo Ndamuleleni Murovhi<sup>1</sup> and Simeon Albert Materechera<sup>2</sup><sup>1</sup> ARC-ITSC (Institute for Tropical and Sub-tropical Crops), Nelspruit, 1200, South Africa<sup>2</sup> North-West University (Mafikeng Campus), Mmabatho, 2735, South AfricaE-mail: [romeo@arc.agric.za](mailto:romeo@arc.agric.za)

**ABSTRACT** The majority of small-scale farmers in sub-Saharan Africa rely on organic inputs to replenish soil nutrients. The sub-tropical climate of Mpumalanga Province in South Africa favours the growth of tropical and sub-tropical fruit trees that produces relatively low quality litter that can be used to manage soil fertility. A pot experiment was conducted to assess the effects of incorporating leaf litter from avocado (*Persea americana*), mango (*Mangifera indica*) and litchi (*Litchi chinensis*) on soil properties. The treatments were a factorial combination of leaf litter types (avocado, mango and litchi), application rates (0, 1.6, and 3.3 t ha<sup>-1</sup>) and incubation periods (0, 6 and 12 months) laid in a randomised complete block design with five replicates. Soils that were amended with avocado leaf litter had significantly higher ( $p < 0.05$ ) particulate organic matter (1.53%) than mango (1.35%) and litchi (1.35%). The stability of aggregates was significantly higher ( $p < 0.05$ ) in soil amended with mango and litchi than avocado leaf litter. There were positive and significant correlations between soil organic carbon and particulate organic matter ( $r = 0.62$ ,  $p < 0.05$ ), microbial biomass carbon and microbial biomass nitrogen ( $r = 0.73$ ,  $p < 0.05$ ), particulate organic matter and microbial biomass carbon ( $r = 0.66$ ,  $p < 0.05$ ) and particulate organic matter and microbial biomass nitrogen ( $r = 0.65$ ,  $p < 0.05$ ). It is suggested that the amount of leaf litter applied was not large enough to make significant changes on soil quality over the period of incubation. The results suggest the need to increase the application and incubation time of litter with low quality in order to allow for decomposition of the organic materials to take place. This has practical implication for farmers who manage such leaf litter for increasing crop productivity. [Life Science Journal. 2011;8(S1):130-139] (19) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**KEYWORDS:** Incubation period. Leaf litter biomass. Litter application. Soil quality

#20

**Settlement, Location and Rural Production: an alternative configuration for growth in Sub-Saharan Africa**Tabukeli Musigi Ruhiiga<sup>1</sup><sup>1</sup>Department of Geography & Environmental Science, Mafikeng Campus, North West University, Mmabatho 2735, South Africa. [tabukeli.ruhiiga@nwu.ac.za](mailto:tabukeli.ruhiiga@nwu.ac.za)

**ABSTRACT:** Studies of rural production systems, economic growth and poverty reduction across developing countries consistently take settlement for granted. This paper reports the results of a study centred on the spatial ramifications of settlement, location and production as an alternative platform in understanding variations in local and regional economic growth. The study is based on a survey of contemporary literature on rural poverty and production and corresponding statistics on regional performance with reference to infrastructure, services and the economy. The resulting information gaps are identified and used to design an interaction matrix in which settlement, location, and production are superimposed to produce an alternative growth model. This is then discussed in the context of empirical evidence, limitations and as a potentially more viable vehicle than contemporary approaches in economic growth and poverty reduction in Sub-Saharan Africa. [Life Science Journal. 2011;8(S1):140-146] (20) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.



**Key Words.** Economic growth; human settlements; agglomeration; land use planning

#21

**Coping with HIV/AIDS Stigma by Women who lost their Partners to AIDS in the North West Province**

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**Abstract:** The aim of this article is to explore and describe how women who lost their partners to the Acquired Immune Deficiency Syndrome (AIDS) in the North West Province, cope with the stigma of the disease. A phenomenological design was used. The sampling was purposive and the sampling size was determined by data saturation, with fifteen participants. The data was collected by means of a single open-ended phenomenological question. Data analysis was done by means of the technique of content analysis by Tesch. From the results the following conclusions could be drawn: Women whose partners died of AIDS cope by focusing on the problem which includes positive and negative strategies such as undergoing voluntary counseling and testing, disclosure of their HIV status, seeking social support, adopting a healthy lifestyle, non-disclosure, expression of grief and hurt and threatening lawsuits against perpetrators of the stigma. Regarding coping by focusing on emotions, strategies that arose from data analysis included coping by self acceptance, support by the family members, the emotional, social and the material support from families, friends, neighbors and social welfare; seeking of spiritual comfort, de-individualization of the disease, ignoring negative remarks and attitudes and forgiving, blaming their late partner or other people for their HIV status, and coping by using defense mechanisms. The recommendations were made in the form of strategies to assist these women to cope effectively with the stigma. [Life Science Journal. 2011;8(S1):147-154] (21) (ISSN: 1097 – 8135). <http://www.lifesciencesite.com>.

**Key words:** Coping, stigma, stigmatization, partner, HIV/AIDS

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