African Journal of Agricultural Research Vol. 8(6), pp. 507-518, 25 February, 2013
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.1108
ISSN 1991-637X ©2013 Academic Journals

Full Length Research Paper

The use of scientific and indigenous knowledge in agricultural land evaluation and soil fertility studies of two villages in KwaZulu-Natal, South Africa

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Accepted 4 March, 2012

Local people and small-scale farmers have knowledge of their lands based on soil and land characteristics that remain largely unknown to the scientific community. It is therefore important for researchers to understand farmers' knowledge of soil classification and management. To address this, indigenous knowledge was elicited by questionnaires from 59 households in two villages (Ezigeni and Ogagwini), near Durban in KwaZulu-Natal. Farmer vernacular soil and land suitability evaluations were compared to scientifically obtained soil and land suitability maps. Yield was used as a quantifiable indicator to test the effect of fertility management practices. It was found that farmers' soil classification was based mainly on topsoil colour and texture. Slope position was the main factor determining land suitability. Crop yield, crop appearance, natural vegetation, soil colour, soil texture, and mesofauna were used to estimate soil fertility. Despite this, there was a correlation between farmers' indigenous evaluation and scientific evaluation, implying that there are similarities between the two approaches.

Key words: Local knowledge, scientific knowledge, soil properties, crop indicators, soil fertility.

INTRODUCTION

Land degradation is a threat to the sustainability of agricultural soils. Hence there is an urgent need for more sustainable management of this fundamental resource (Ingram, 2008). Barrera-Bassols et al. (2009) emphasize the importance and relevance of soil information in land use planning and land management. It is, however, evident that rural communities' local knowledge about land, in terms of soil and land characteristics, still remains largely unknown to the scientific community (Ingram, 2008). Local farmers derive this knowledge mainly from informal experiential learning as they interact with their and adapt to constantly changing natural environments. For example, farmers in West Java used traditional agroforestry to improve biophysical properties of the soil and to sustain the economy of their villages (Christanty et al., 1986).environment (McGregor, 2004). This knowledge has assisted rural communities to manage natural resources Due to inadequate arable land available for crop production; farmers in the High Andes of Peru manipulated the agricultural potential of a highly elevated area using sectoral fallowing (Pestalozzi, 2000). He et al. (2007) also reported a case of farmers in the Sichuan region in China where farmers had developed slope-land management practices to avoid loss of soil through erosion. These case studies reveal how local farmers have developed innovative ways of survival using indigenous knowledge.Land evaluation processes have been done mainly through soil surveys which farmers may not fully understand and which exclude social and cultural aspects. Brinkman and Smyth (1972) reported that these factors are essential when conducting and

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interpreting land evaluation, because that approach allows people to contribute directly to land use planning. The exclusion of local knowledge from land evaluation systems often resulted in the failure of scientific interventions to improve land use, especially in rural areas where scientific logic is lacking (Sillitoe, 1998; Barrera-Bassols and Zinck, 2003a, b; Ingram, 2008; Ingram et al., 2010). According to Gadgil et al. (1993), indigenous knowledge can complement more general scientific knowledge with site-specific, highly contextualized knowledge. It would provide sustainable solutions by bringing a 'locally informed perspective' to development strategies which ensures the inclusion of socioeconomic factors as well as cultural diversity (Agrawal, 1995; Sillitoe, 1998; Crevello, 2004; Briggs, 2005; Sillitoe and Marzano, 2009).

Land use planning at farm level is mainly based on local perceptions of the quality of the natural resource base (Krogh and Paarup-Laursen, 1997). For example, farmers in many countries have comprehensive local soil quality indicators (Neef et al., 2006; Mairura et al., 2007; Kissing et al., 2009; Tesfahunegn et al., 2011). Having limited access to soil analytical services and synthetic fertilizers, farmers have used this soil knowledge to develop proper management plans that for many decades have ensured both agricultural and environmental sustainability (Materechera, 2008; Handayani and Prawito, 2010; Tesfahunegn et al., 2011). Therefore, more information is needed for better understanding of this knowledge and the consequent contribution it can make towards agricultural sustainability (Phillips-Howard and Oche, 2006). This will further secure agricultural sustainability in both subsistence and commercial farming. It is noteworthy that there is a wide spectrum of studies ranging from those proposing and testing possible integration methodologies (Norton et al., 1998; Braimoh, 2002; Gowing et al., 2004; Barrios et al., 2006) to others highlighting the benefits and challenges associated with the integration of these two knowledge systems (Nadasdy, 1999; Newton et al., 2005; Ocholla, 2007; Gagnon and Berteaux, 2009; Sileshi et al., 2009; Lynch et al., 2010; Raji et al., 2011).

Despite such information on the indigenous knowledge of soil, there have been few studies on farmers' knowledge of soils in South Africa. Materechera (2008) investigated and documented practices used by farmers in the North West Province of South Africa in soil fertility management. He found that farmers had developed contextualized and cost effective strategies such as using ash from veld fires, animal manure, agroforestry, fallowing and earthworms. Moreover, he reported that farmers also had the ability to assess the quality of manure using characteristics such as colour, wetness, presence of moulds and sand content. Using a participatory survey, Nethononda and Odhiambo (2011) studied the local classification of soils by farmers in Vhembe district of Limpopo province in South Africa. In the same location, Mutshinyalo and Siebert (2010) conducted a study that investigated the use of myth as a biodiversity conservation strategy. Hart and Vorste (2006) reported a number of innovations used by rural communities to achieve agricultural and livelihood sustainability. Phillips-Howard and Oche (2006) gave a comprehensive account of indigenous knowledge and fertilizer use in the Transkei (currently part of the Eastern Cape Province), South Africa.

The main objectives of this study were to (a) explore soil indigenous knowledge of small-scale subsistence farmers in relation to land evaluation, (b) compare indigenous and scientific land evaluation and (c) assess soil fertility management by the farmers using scientific methods.

MATERIALS AND METHODS

Study site

The study was conducted in two villages (Ezigeni and Ogagwini) of the uMbumbulu area (KwaZulu-Natal). The area is located inland from Durban at 29° 59' South, 30° 42' East between 394 and 779 m a.s.l. Members of the Ezemvelo Farmers Organization form part of the population of both Ezigeni and Ogagwini villages. This group of farmers was the first subsistence farmer organization certified to supply organic vegetables to supermarkets. Farmers rely on crop rotation, crop residues and animal manure for soil fertility management. Primary cash crops grown are amadumbe (taro), sweet potatoes and potatoes.

Indigenous land evaluation

A total of 59 farmers from both villages were interviewed to gain a general background of indigenous agricultural land evaluation and management. A questionnaire focused on local soil classification and its importance in land evaluation. Another questionnaire was produced to gather more detailed information on indigenous soil management from each farmer. To obtain this information, six (three from each village) of the 59 households were chosen. These were chosen based on their willingness and farming experience. The questionnaire required information on the cropping history, knowledge specific to the cultivated lands, and detailed soil description and fertility assessment. The information gathered from both sets of interviews was recorded and analyzed using SPSS version 15.

Scientific land evaluation

A general purpose free survey was conducted at a scale of 1:10 000. Soil forms and families were classified according to the Soil Classification Working Group (1991). Soils were classified for land suitability (for maize, taro and dry bean) and capability based mainly on soil form, depth and drainage (Davidson, 1992).

A total of 24 representative samples were taken from the six randomly chosen homesteads. These were taken from the two most common agricultural soils from both villages (that is, Hutton and Oakleaf). Pairs of samples were taken from each homestead. Each pair consisted of sub-samples taken from 0 to 30 cm and 30 to 60 cm depth. The samples were collected from different management practices (that is, fallow, veld, taro and vegetable production lands). However, not all six homesteads had all four land uses hence the total number of samples.

Table 1. Characteristics of the households interviewed.

Gender	No.	Education level	No.
Males	5	Not educated	6
Females	54	Grade 1 - 8	26
		Grade 9 - 12	21
		Higher education	6
Age		***Family size***	
< 30	15	1 - 5 members	11
31 - 45	15	6 - 10 members	31
46 - 55	13	> 10	11
>56	13		
Missing data	3		6

Table 2. Multivariate analysis showing the significance of age, gender and education level and their interactions on farmers' indigenous knowledge (n=59).

Factors	F	DF	P
Gender	0.180	1	0.894
Age	0.457	1	0.237
Level of education	1.163	4	0.345
Gender* age	0.589	2	0.560
Gender* education	0.456	1	0.504
Age* education	0.602	8	0.770
Gender* age*education	6.054	1	0.019

Soil samples were air-dried and passed through a 2 mm sieve before analysis. Soil pH was measured using a 1:2.5 ratio of soil:distilled water as well as a 1:2.5 ratio of soil:1 M KCl. Particle size distribution was determined using the pipette method (Gee and Bauder, 1986). The potassium dichromate oxidation procedure was used to determine organic carbon (Walkley, 1947). For soil fertility, the samples were analyzed by the Soil Fertility Analytical Service at Cedara (Riekert and Bainbridge, 1998). For microbial analysis, the soil samples were rewetted to 50% water holding capacity before carrying out microbial activity analysis. The 50% water holding capacity was calculated using texture and organic carbon (Smith, 1995; Smith et al., 2001). The samples were then incubated for four weeks to allow for the regeneration of microorganisms. They were then put in the refrigerator a day before the analysis. The analysis with two replications was done using the FDA (fluorescein diacetate) method (Schnürer and Rosswall, 1982).

Comparison methodology

Scientific and indigenous evaluation systems were compared based on the land suitability classification. The information provided by the scientific suitability maps was compared to the vernacular suitability evaluation provided by farmers. Farmers' fertility assessment was also compared with the scientific perception. Yield was used as a quantifiable indicator to test the effect of fertility management practices implemented by Ezigeni and Ogagwini farmers. This was measured in terms of total biomass of the dominant available crops including maize, amadumbe (taro) and dry beans. Data were analyzed using Genstat® Statistical Package 11. Multivariate analysis was used to determine correlations. Significant differences were determined at $p \leq 0.05$ and least significant differences (LSD) are presented to indicate differences between treatments.

RESULTS AND DISCUSSION

Household characteristics

Household characteristics acquired are summarized in Table 1. There were a comparable number of farmers across the age groups. Only 5 of 59 respondents were men. The reason for this, according to the farmers, was that men work away and only comes home on weekends. Hence the responsibility for farming is mainly taken by the women.

Table 2 shows that there was no significant effect of gender in the knowledge gathered. This may be attributed to the fact that there were very few male compared to female farmers. Most farmers had either grade 8 or grade 12 as the highest level of education. The respondents with matriculation could not afford to go to institutions of higher learning and so these young people stay at home and are available to help in the fields. Even those that are still at school are taken to the fields during weekends and school vacations. Because of this exposure of young people to indigenous farming there was no significant effect of age and education on

Table 3. Local soil taxonomy used by farmers of Ezigeni and Ogagwini villages.

Local name	Texture	Colour	Location	Uses
Ugadenzima	Clayey (*ubumba*)	Reddish black	Midslope	Agriculture
Idudusi	Loam (*uthambile*)	Black	Lower slope	Agriculture
Isibomvu	Clayey (*ubumba*)	Dark Red	Upslope	Agriculture
Udongwe	Clayey (*ubumba*)	Grey	Footslope	Agriculture
Umgogodi	Clayey (*ubumba*)	Grey	Footslope	Plastering
Isdaka	Clayey (*ubumba*)	Black	Footslope	Agriculture
Umgubane	gravelly (*ungamatshe*)	black or red	Upslope	Construction
Ugwadule	Clayey (*ubumba*)	black or red	Upslope	NS*
Isduli	Clayey (*ubumba*)	Black	Footslope	Agriculture
Ugedle	Sandy (*isihlabathi*)	Red	Upslope	Agriculture

*NS = Not specified.

the knowledge elicited (Table 2). This is contrary to the results reported by Birmingham (2003) from Ivory Coast who found that older farmers had more detailed knowledge than younger farmers. However, the combination of gender, age and education had a significant effect on status of knowledge (Table 2). Younger people, because of their education, are able to easily grasp the knowledge being passed on to them, and may even be able to develop and make it better.

Indigenous soil management

The area cultivated by each farmer in both villages ranged from 0.6 to 4 ha. Farming is the livelihood for most of the households in uMbumbulu and food production is for both marketing and subsistence. All farmers from randomly selected households were involved in organic farming of mainly amadumbe (taro) and other crops such as dry beans, maize, potatoes, pumpkins and sweet potatoes. They only practiced traditional farming, although tractors were used for tilling the soil. Farmers in both villages, with a few exceptions, owned livestock and practiced similar management systems. These included mixed cropping and rotation systems (below-ground followed by above-ground type of crop) for fertility management. Respondents recommended frequent rotation in taro plots especially when planted in dark soils to avoid reduction in yield. A study by Asao et al. (2003) showed that this decrease in yield is attributed to a detrimental effect of taro roots exudates. In the current study, farmers rotated taro with either maize or beans, depending on the soil type and drainage in order to avoid this effect. They used kraal manure, stubble mulch and fallowing to replenish depleted nutrients. Farmers that have infertile soils in their fields had observed the positive response in yield when these soils are treated with large amounts of manure one or two months before planting. However, the scarcity of organic amendments has encouraged some of the farmers to try anaerobic composting suggested to them by an extension officer. Unfortunately, this alternative was not successful because of high interference from pests (birds, wild hogs and soil organisms). Overall, despite similar management practices, farmers have observed that crops yield more when planted in Ogagwini soils and hence consider these soils more fertile than the soils of Ezigeni village.

Famers' soil classification

Farmers recognized 10 soil types (Table 3). Farmers were only concerned with the topsoil, because they use this part of the profile for their agricultural activities. This follows a trend observed for other local classification systems (Sillitoe, 1998). Culture, which is an integral part of farmers' lives in this region, does not allow for digging as it is believed to anger the ancestral spirits. Subsoil is only seen when digging for a grave and hence is not important for a farmer's agricultural knowledge. This explained why farmers' land evaluation focuses only on suitability of the land for production systems (Ettema, 1994). Farmers were asked to critique the scientific approach and they were concerned with the time and labour involved in this approach. Hence their classification was based on descriptive soil characteristics rather than characteristics of the whole profile as in the scientific classification. Although their soil classification was based on different soil morphological attributes, soil colour and texture were key properties recognized by over 80% of the farmers. This is consistent with the findings of Sandor and Furbee (1996) and Talawar and Rhoades (1998). The use of texture may not be surprising due to the large influence it has on other soil properties such as structure, water holding capacity, permeability and drainage.

Farmers' land suitability assessment

In common with scientific evaluation, farmers recognized

Table 4. Crop suitability for the local soil names according to Ezigeni and Ogagwini farmers.

Local name	Fertility status*	Principal crops
Ugadenzima	Low to moderate	Potatoes, maize, beans
Idudusi	High	Maize, taro, beans
Isibomvu	Moderate to high	Sweet potatoes, maize, beans
Udongwe	Moderate	Beans, taro
Isdaka	Moderate to high	Spinach, taro
Isduli	Low to moderate	Taro, maize, beans
Ugedle	Low	Potatoes, sweet potatoes

*Fertility status estimated from farmers responses.

drainage status and soil depth (referred to as the amount of topsoil) as limiting factors for land use. However, slope was also considered an essential factor affecting land suitability (indicated by 60% of farmers). Farmers preferred footslope soils for agriculture as these are regarded as more fertile compared to upslope and midslope soils. They attributed this difference in fertility to the removal of soil from upslope and deposition downslope resulting in higher nutrient levels in footslope soils. Twenty percent of farmers used natural vegetation focusing mainly on vegetative growth and species diversity. Consistent with a healthy soil ecosystem, farmers in these villages associated agriculturally suitable land with high species diversity (Mäder et al., 2002). Some farmers' land suitability evaluation was based on the differences they observed between the soils in both villages, and hence they used 'villages' as a classification criterion. Farmers had an understanding of the effect of soil type on land suitability for different crops (Table 4). Farmers have observed the effect of soil type on yield differences between the two villages with higher yields from Ogagwini. Farmers thus regard Ogagwini soils as more fertile because they do not demand high supplementary fertilizer inputs.

Scientific land evaluation

Soil types mapped ranged from highly suitable, deep, well drained soils to the least suitable, shallow soils (Figures 1 and 2). Similar to the indigenous evaluation, scientific evaluation showed that the limited suitability of Ezigeni soils was mainly due to constraints which were rarely observed for Ogagwini. These included shallow soil depth, poor drainage and stoniness. Despite deep soils (> 120 cm), many at Ezigeni had a duplex character. Despite these differences between the villages, Table 3 shows that the soils in both villages are generally suitable for crop production. Moreover, land suitability maps showed higher agricultural potential for the Ogagwini than Ezigeni soils. This correlation between indigenous and scientific approaches shows that there are similarities between the local and scientific land use evaluation (Habarurema and Steiner, 1997; Barrera-Bassols et al., 2006).

Soil fertility indicators

Farmers used a combination of indicators to rate the land as either 'good' or 'bad' (Figure 3). In scientific terms these lands will be either fertile or infertile, respectively. Soil colour and texture were used by 48% of farmers with dark soils indicating higher fertility than lighter soils. The abundance of mesofauna was used by 51% of farmers. Natural vegetation (18%), especially weed growth and diversity observed before planting, also gave a statement about soil fertility. However, the presence of weeds did not always reflect fertile soil conditions and led to errors by some farmers in their fertility assessment. Crop production factors are considered most reliable as they are said to clearly reflect soil fertility differences. These include crop colour and firmness (32%) during the establishment stages and crop yield (70%). This shows that crop yield forms a benchmark for soil quality in the indigenous approach (Gruver and Weil, 2006). It is clear that farmer fertility assessment is mainly concerned with food security which is highly dependent on land productivity.

Soil fertility analysis

Only two soil types (that is, Hutton 2200 and Oakleaf 1210) were sampled from the six homesteads chosen for the detailed questionnaire. The following discussion is based on the assumption that these two soils would behave similarly under similar management. Both Hutton and Oakleaf are red or brown indicating good drainage, they are both very deep soils (> 120 cm) and both are formed from dolerite, the Hutton on *in-situ* rock; the Oakleaf on doleritic colluvium.

Plant nutrients and soil pH

Tables 5 to 8 show that the average soil pH (H_2O) was

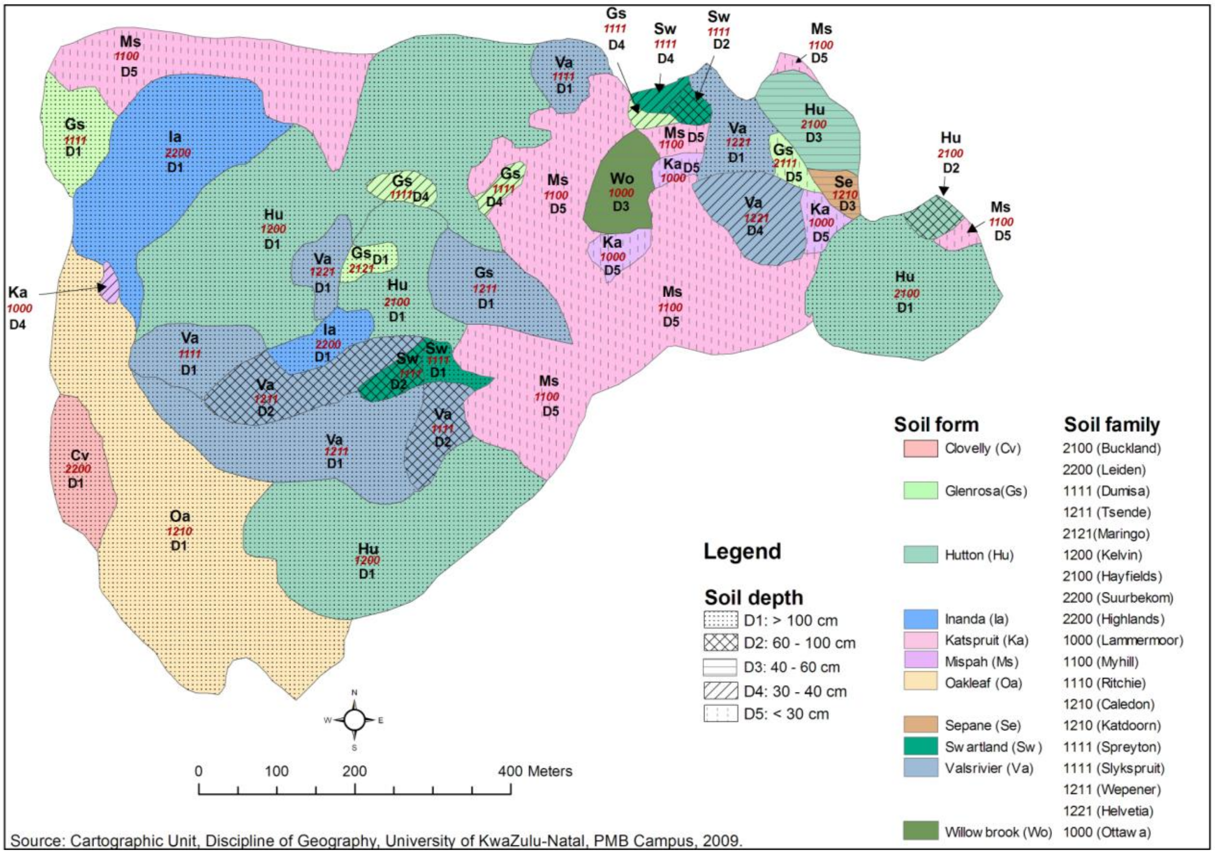

Figure 1. Soil map of Ezigeni.

comparable across the two villages for both A (5.79 and 5.93) and B (6.07 and 6.00) horizons. There was high acid saturation in both Ezigeni and Ogagwini soils. However, Ezigeni topsoils had a higher median acid saturation value of 44% compared to 30% in Ogagwini topsoils. This inevitably results in a decrease in exchangeable basic cations (Foth and Ellis, 1997). Ogagwini soils therefore had higher plant nutrient levels than Ezigeni soils. For example, Ogagwini topsoils had an average of 3.24 mg kg^{-1} available P (Table 7) compared to 1.88 mg kg^{-1} P in Ezigeni topsoils (Table 5) and the average effective cation exchange capacity (ECEC) of the soils from Ogagwini village was higher (5.09 and 5.03 $cmol_c$ kg^{-1} in the A and B horizon, respectively) than the soils from Ezigeni village (4.16 and 3.43 $cmol_c$ kg^{-1}, respectively). Calcium and P values were significantly different between homesteads ($p < 0.05$). This may be due to past soil management rather than intrinsic soil differences. In addition to the effect of soil pH and acid saturation, N and Mg were significantly affected by land use ($p < 0.05$). Although the overall nutrient levels were relatively low in the soils from both villages, there was moderately high N under cultivated land (that is, taro and vegetable fields). This can probably be attributed to the N retained in cereals and vegetable residues, especially those from legumes, which are recycled during decomposition (Hartemink et al., 2000).

Although Ezigeni soils had higher amounts of organic C and were less sandy, the ECEC of the soils is on average lower than soils of Ogagwini. The high average acid saturation value for Ogagwini is inflated by the values of the Ngcamu homestead (86 and 71% in the A and B horizon, respectively). If this topsoil value is omitted, the mean acid saturation drops to 26% in the topsoils, compared to 37% in the Ezigeni topsoils. The same homestead has the highest available P value (6.25 mg kg^{-1}) but even this, and the generally higher P in Ogagwini soils, would be deficient for most crops. The pH (KCl) values are also similarly low in all soils from both villages. In general, it appears from these data that the soils in the two villages are not very different in terms of their fertility parameters and that the most marked differences are most likely due to differences in management practices. This is noticeable in the microbial activity results if the disturbed and undisturbed land uses are compared.

Yield

Both scientific and farmer suitability evaluation found Ogagwini village to be more highly suitable than Ezigeni.

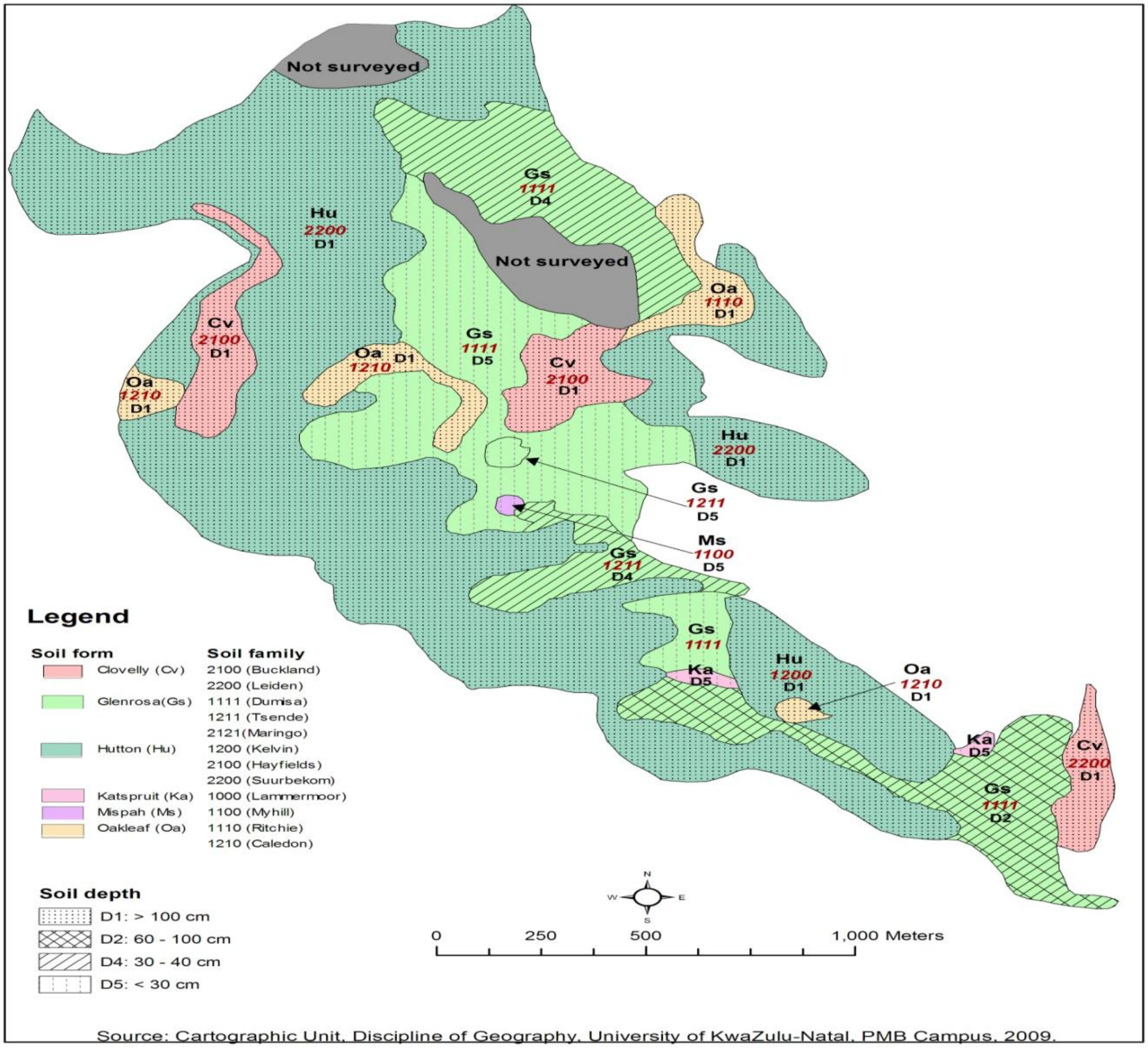

Figure 2. Soil map of Ogagwini.

This was further confirmed by yield measurements taken for beans, maize and taro (Figure 4). There was a significant difference ($p < 0.05$) in yield between homesteads. However, maize and taro yields in both villages were generally lower than those obtained on large commercial farms. Dry beans are known for their survival strategy of releasing citric acid which chelates Al in the rhizosphere thus preventing the detrimental effects of Al (Ma et al., 2001). Dry beans thus yielded satisfactorily. However, these yields were not very different between villages, a result again predicted by the similar fertility status of all soils analysed. This supports the scientific data (Tables 5 to 8) which showed that none of the sampled soils from either village is very fertile and that all have considerable constraints. Thus, while yields from Ogagwini were higher than from Ezigeni, all were low as predicted by the scientific fertility data. The differences observed in yield may therefore reflect management factors (e.g. time of planting, weeding, availability of organic amendments, etc.) since most of the differences in soils in both villages are inherent. For example, although kraal manure was widely used in both villages not all homesteads own a herd of cattle. There was also only one tractor to assist farmers to till their soils at the beginning of the season. This sometimes led to delays in planting as farmers have to wait their turn and for the tractor driver to be available. Thus it is noteworthy that the soil properties (measured scientifically) follow and support the trend of the vernacular land suitability evaluation. The effect of management clearly plays the

Table 5. Soil chemical properties and particle size distribution of the A horizon of soils from Ezigeni village.

Homestead	Soil form and family	Land use	pH		N	P	K	Ca	Mg	H	ECEC*	Acid saturation	Organic carbon	Clay	Silt	Sand	Microbial activity
			H_2O	KCl	%	mg kg $^{-1}$	cmol$_c$ kg^{-1}					%					µg g^{-1} h^{-1}
F. Mkhize	Oa 1210	Veld	5.65	4.40	0.60	1.92	0.04	2.58	0.88	1.13	4.63	24	7.6	11	54	35	17.21
Mbili	Oa 1210	Fallow	6.01	4.44	0.33	1.08	0.01	0.94	0.50	1.51	2.96	51	5.9	21	44	28	1.72
Bhengu	Hu 2200	Fallow	5.83	4.35	0.29	1.85	0.04	0.97	0.30	1.30	2.61	50	5.3	27	40	33	8.87
Mbili	Oa 1210	Vegetables	5.79	4.16	0.28	3.09	0.08	1.70	0.86	2.62	5.25	50	5.1	31	40	29	4.30
Bhengu	Hu 2200	Vegetables	5.51	4.35	0.33	3.16	0.07	1.00	0.51	1.57	3.15	50	6.1	16	45	39	4.13
F. Mkhize	Oa 1210	Vegetables	5.77	4.58	0.41	1.08	0.06	2.17	0.59	0.74	3.56	21	8.1	20	48	32	3.89
Mbili	Oa 1210	Taro	5.97	4.15	0.23	0.97	0.05	3.98	1.77	1.15	6.94	16	2.7	43	22	34	1.90
		Mean	5.79	4.35	0.35	1.88	0.05	1.91	0.77	1.43	4.16	37	5.8	24	42	33	6.00
		Median	5.79	4.35	0.33	1.86	0.05	1.80	0.68	1.37	3.86	44	5.9	23	43	33	4.13

*ECEC- effective cation exchange capacity (sum of bases + H).

Table 6. Soil chemical properties and particle size distribution of the B horizon of soils from Ezigeni village.

Homestead	Soil form and family	Land use	pH		N	P	K	Ca	Mg	H	ECEC*	Acid saturation	Organic Carbon	Clay	Silt	Sand	Microbial activity
			H_2O	KCl	%	mg kg $^{-1}$	cmol$_c$ kg $^{-1}$					%					µg g^{-1} h^{-1}
F. Mkhize	Oa 1210	Veld	6.15	4.58	0.46	1.19	0.02	1.27	0.43	0.94	2.66	35	7.4	11	42	47	11.29
Mbili	Oa 1210	Fallow	6.25	4.49	0.33	1.04	0.01	1.14	0.57	0.98	2.70	36	3.9	19	39	42	0.87
Bhengu	Hu 2200	Fallow	6.27	4.53	0.26	1.09	0.02	1.34	0.62	0.62	2.60	24	3.0	43	40	17	2.51
Mbili	Oa 1210	Vegetables	6.00	4.25	0.29	2.08	0.06	1.58	0.81	2.25	4.69	48	4.5	35	36	29	4.01
Bhengu	Hu 2200	Vegetables	5.90	4.49	0.30	1.11	0.07	0.66	0.50	0.88	2.11	42	3.8	28	37	35	3.21
F. Mkhize	Oa 1210	Vegetables	6.13	4.62	0.43	1.11	0.06	1.76	0.51	0.66	2.98	22	6.3	18	43	39	2.72
Mbili	Oa 1210	Taro	5.80	4.08	0.18	0.97	0.04	2.89	1.54	1.77	6.24	28	2.5	56	14	30	0.19
		Mean	6.07	4.43	0.32	1.23	0.04	1.52	0.71	1.16	3.43	34	4.5	30	36	34	3.54
		Median	6.10	4.49	0.31	1.11	0.04	1.43	0.60	0.96	2.84	34	4.2	29	38	35	2.72

*ECEC- effective cation exchange capacity (sum of bases + H).

major role in whether farmers achieve a high yield rather than the village they reside in.

Conclusion

As expected, the farmers' soil indigenous knowledge is rather abstract when compared to the more commonly obtained scientific knowledge. This is evident in farmers' soil classification which only takes into account the topsoil and extends to the way farmers perceive and assess soil fertility. Farmers' fertility indicators and soil taxonomy are based only on visible soil and crop properties and show that farmers are more concerned with soil productivity and food security. On the other hand, the scientific approach seeks to understand the processes of soil formation and has specific measured attributes that influence soil fertility (e.g. soil mineral elements). Despite many differences between the scientific and indigenous approaches,

Table 7. Soil chemical properties and particle size distribution of the A horizon of soils from Ogagwini village.

Homestead	Soil form and family	Land use	pH		N	P	K	Ca	Mg	H	ECEC*	Acid saturation	Organic carbon	Clay	Silt	Sand	Microbial activity
			H_2O	KCl	%	mg kg $^{-1}$	cmol$_c$ kg $^{-1}$					%					µg g^{-1} h^{-1}
Z. Mkhize	Hu 2200	Veld	5.75	4.24	0.25	2.83	0.05	2.55	1.83	1.12	5.56	20	3.6	33	22	45	13.90
Z. Mkhize	Hu 2200	Fallow	6.28	4.15	0.24	2.78	0.04	1.65	0.93	1.91	4.53	42	3.7	23	24	53	4.15
Gasa	Hu 2200	Fallow	5.92	4.40	0.34	3.30	0.06	2.60	1.30	1.09	5.05	22	4.9	19	23	58	10.59
Gasa	Hu 2200	Taro	5.98	4.45	0.22	1.06	0.02	2.37	1.24	0.97	4.61	21	3.8	42	34	24	2.77
Ngcamu	Hu 2200	Taro	5.73	4.08	0.29	6.25	0.06	0.50	0.22	4.91	5.69	86	4.1	19	23	58	2.77
		Mean	5.93	4.26	0.27	3.24	0.05	1.93	1.10	2.00	5.09	38	4.0	27	25	48	6.84
		Median	5.93	4.25	0.26	3.04	0.05	2.15	1.17	1.52	5.07	30	3.9	25	24	50	4.15

* ECE C- effective cation exchange capacity (sum of bases + H).

Table 8. Soil chemical properties and particle size distribution of the B horizon of soils from Ogagwini village.

Homestead	Soil form and family	Land use	pH		N	P	K	Ca	Mg	H	ECEC*	Acid saturation	Organic carbon	Clay	Silt	Sand	Microbial activity
			H_2O	KCl	%	mg kg $^{-1}$	cmol$_c$ kg $^{-1}$					%					µg g^{-1} h^{-1}
Z. Mkhize	Hu 2200	Veld	5.80	4.27	0.24	2.35	0.04	2.42	2.20	1.35	6.02	22	3.2	36	22	42	8.69
Z. Mkhize	Hu 2200	Fallow	6.08	4.22	0.20	4.44	0.03	2.11	1.43	1.77	5.33	33	3.3	38	16	46	1.32
Gasa	Hu 2200	Fallow	6.25	4.44	0.27	2.22	0.03	1.99	1.18	1.01	4.21	24	4.5	36	37	27	11.48
Gasa	Hu 2200	Taro	5.93	4.47	0.29	1.90	0.04	3.24	1.57	0.63	5.48	11	4.6	41	42	27	0.34
Ngcamu	Hu 2200	Taro	5.93	4.20	0.30	1.87	0.03	0.84	0.32	2.92	4.11	71	4.0	23	27	50	0.10
		Mean	6.00	4.32	0.26	2.56	0.03	2.12	1.34	1.54	5.03	32	3.9	35	29	38	4.39
		Median	5.96	4.30	0.27	2.29	0.03	2.12	1.39	1.44	5.18	28	4.0	36	28	40	2.85

* ECE C- effective cation exchange capacity (sum of bases + H).

results showed that there are many links between these two systems in terms of land evaluation, ranging from determination of land use to management issues which are critical components of sustainable agriculture. The farmers' soil classification and suitability evaluation, as well as their fertility assessment, correlate with the scientific evaluation. These significant agreements between the approaches imply that there are fundamental similarities between them. These similarities show that these two systems can complement each other to produce a hybrid approach that is highly contextual (an attribute of Indigenous knowledge) and that will help improve the relevance, adaptation and adoption of scientific interventions that provide the in-depth knowledge of soil processes. The challenge remains to achieve such integration between indigenous and scientific approaches at the local level to enable a better understanding of land management systems as applied by small-scale farmers and to ensure the protection of topsoil to maintain sustainable soil quality. This integration could be encouraged by production of an agricultural policy suitable at the farm level for small-scale farmers that utilizes their knowledge to support or perhaps even replace full scientific analysis, in instances where finances are not available. Such a hybrid approach could give direction to farmers and encourage them to play a

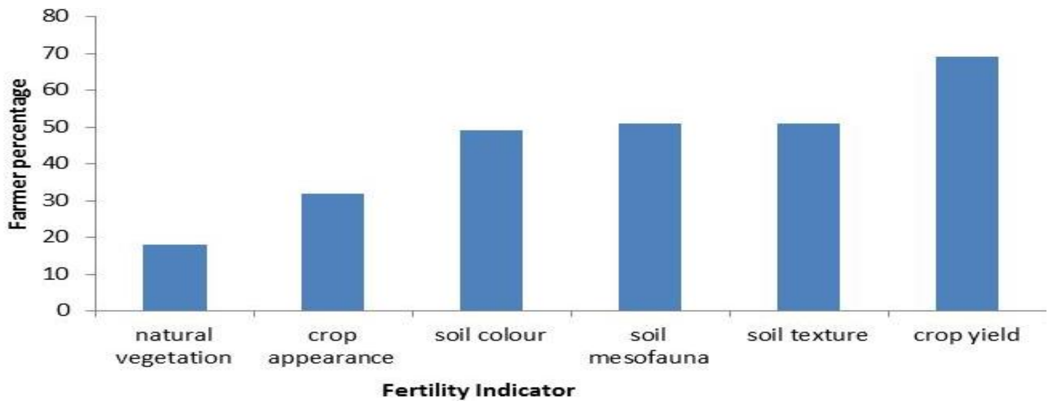

Figure 3. Local indicators identified by farmers for fertility assessment of Ezigeni and Ogagwini soils.

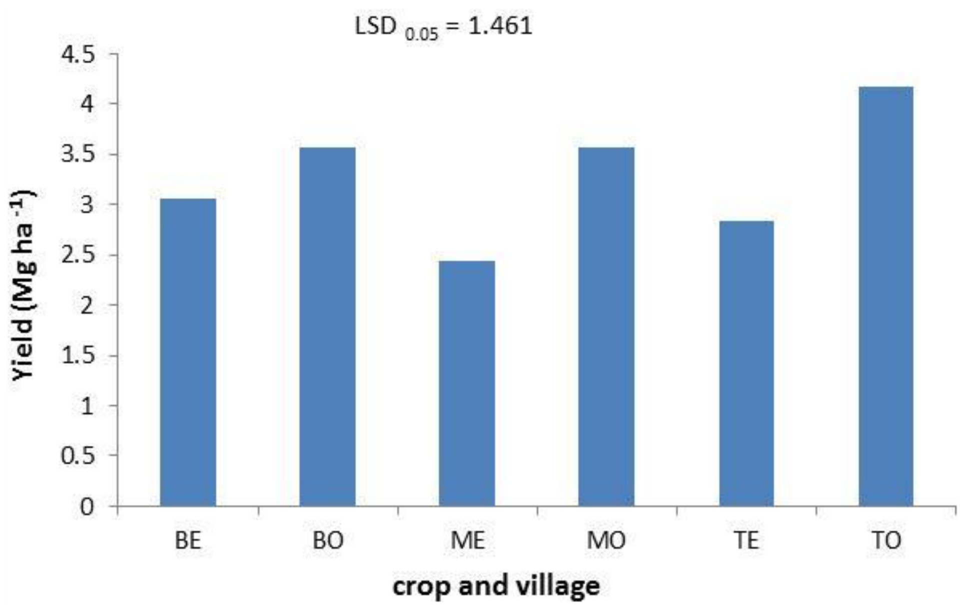

Figure 4. Means for crop yield across locations ($p < 0.05$). (B: Beans; M: Maize; T: Taro; E: Ezigeni; O: Ogagwini).

major role in the future sustainability of their land.

ACKNOWLEDGEMENTS

Financial support from SANPAD under Project 05/32 entitled: "The social agronomy of compound agriculture: A case study of the dynamics of commercialization", and the National Research Foundation of South Africa are gratefully acknowledge. Thanks goes to Ezemvelo Farmers Organisation members, Victor Bangamwabo, Tad Dorasamy, Charity Maphumulo, Karen Caister, Ncebo Zulu, Phesheya Dlamini, Jothan Buthelezi, Ayanda Mthalane, Simphiwe Ngcobo and Vusi Mbanjwa for their assistance.

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