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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Abstract
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 suitability evaluation was compared to scientifically surveyed 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 and texture, and mesofauna were used to estimate soil fertility. Their fertility assessment was found to be more holistic than that of researchers. 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; organic farming.

Introduction
To secure agricultural sustainability in both subsistence and commercial farming, there is a need to reassess our land evaluation systems that have often failed to improve land use, especially in rural areas where knowledge of scientific logic is lacking. The challenge for scientists is to integrate indigenous knowledge into the scientific approach to achieve high production without compromising resources. The integrated approach will enable farming practices that will not only improve soil fertility but also ensure sustainability to prevent resource base degradation. Although many studies have investigated the potential of integrating indigenous knowledge with the scientific system to improve agricultural sustainability (e.g. Oudwater and Martin 2003; Gowing *et al.* 2004; Cervantes-Gutiérrez *et al.* 2005) there is almost no literature referring to indigenous knowledge of soils in South Africa. The main objectives of this study were therefore to (a) explore indigenous and scientific knowledge systems in terms of land evaluation; (b) compare indigenous and scientific land evaluation; and (c) test farmer soil fertility management and assessment systems using scientific 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' 0" South, 30° 42' 0" 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's 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.

Methods
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. 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 and capability based on soil form, depth and drainage (Davidson 1992).

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 and dry beans.

Results and discussion
Farmers' indigenous knowledge
There was no significant effect of age and education on the knowledge elicited showing that these farmers provide a platform for efficient and easy transmission of knowledge from old to young people. Farmers in both villages, with a few exceptions, own livestock and practice 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. Farmers use kraal manure, stubble mulch and fallowing to replenish depleted nutrients.

Famers' soil classification
Farmers recognized 10 soil types (Table 1).

Table 1. 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

Farmers were only concerned with the topsoil as they use this part of the profile for their agricultural activities. This follows a trend observed for other local classification systems (Sillitoe 1998). The farmers' classification was based on different soil morphological attributes but soil colour and texture were key properties recognized by over 80% of the farmers.

Farmers' land suitability assessment
In common with scientific evaluation, farmers recognized 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 2). 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.

Table 2. Crop suitability 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

Scientific land evaluation

Soil types mapped ranged from highly suitable, deep, well drained soils to the least suitable, shallow soils. 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 the other village. These included 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 2 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 farmers' decisions on land use and those obtained by scientific evaluation and that the two systems share common principles and goals.

Soil fertility indicators

Farmers used a combination of indicators to rate the land as either 'good' or 'bad'. 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. Results showed that farmers' fertility perceptions are more holistic than those of researchers.

Yield

Both scientific and farmer suitability evaluation found Ogagwini village to be more highly suitable than Ezigeni. This was further confirmed by yield measurements taken for beans, maize and taro. There was a significant difference ($p < 0.05$) in yield between homesteads. Considering that most of the differences in soils in both villages are inherent, it is possible that yield is more a reflection of management factors. These may include time of planting, weeding, availability of organic amendments, etc. For example, although kraal manure was widely used in both villages not all homesteads own a herd of cattle. There was 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.

Conclusion

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 shows that farmers are more concerned with soil productivity and food security. The farmers' approach is thus more holistic than the approach of scientists. Despite many differences between the scientific and indigenous approaches, 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 correlates with the scientific evaluation. These significant agreements between the approaches imply that there are fundamental similarities between them. The inclusion of indigenous knowledge into scientific approaches will hence lead to the development of land use plans that are more relevant for small-scale farmers.

References

Cervantes- Gutiérrez V, Gama-Castro JE, Hernández-Cárdenas G, Meave del Castillo JA (2005) The land classification system of the San Nicolás Zoyatlán (S Mexico) Nahuatl Indigenous Community: A basis for a suitable parametric soil use proposal. *Human Ecology Review* **12**, 44-59.

Davidson AD (1992) The Evaluation of Land Resources. (Longman: Harlow, UK).

Dent D, Young A (1981) Soil Survey and Land Evaluation. (George Allen and Unwin: London).

Gowing J, Payton R, Tenywa M (2004) Integrating indigenous and scientific knowledge on soils: recent experiences in Uganda and Tanzania and their relevance to participatory land use planning. *Uganda Journal of Agricultural Sciences* **9**, 184-191.

Gruver JB, Weil RR (2006) Farmer perceptions of soil quality and their relationship to management-sensitive soil parameters. *Renewable Agriculture and Food Systems* **22**, 271–281.

Mäder P, Fließbach A, Dubois D, Gunst L, Fried P, Niggli U (2002) Soil fertility and biodiversity in organic farming. *Science*, *New Series*, **296** (5573), 1694-1697.

Oudwater N, Martin A (2003) Methods and issues in exploring local knowledge of soils. *Geoderma* **111**, 387-401.

Sillitoe P (1998) Knowing the land: soil and land resource evaluation and indigenous knowledge. *Soil Use and Management* **14**, 188-193.

Soil Classification Working Group (1991) Soil Classification: a taxonomic system for South Africa. (Department of Agricultural Development, Pretoria, South Africa).