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Farmers Knowledge on Indigenous Soil Types: A Review

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ABSTRACT
This review explains the significance of smallholder farmers' understanding of soil types as a dependable basis for subsistence crop production. The data presented in this review was sourced from literature on subsistence farming, indigenous soil nomenclature, and the suitability of various soils for different crop varieties. The review findings revealed four primary soil classifications, specifically loam, clay, sandy, and rocky, each exhibiting distinct variations in texture and colour. Farmers utilise soil texture and colour as indicators of the suitability of soil for certain crops. For example, black clay soil has high moisture retention and low susceptibility to erosion that mitigates the risk of crop failure. Farmers utilise this knowledge to mitigate the impacts of increasing temperatures and unpredictable precipitation patterns on the planting and management of crops. This type of adaptation mechanism could be incorporated into climate change adaptation policy to foster the use of community-based and innovative mechanisms to mitigate and cope with the negative impacts of climate change on subsistence food production.

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INTRODUCTION
Resilience to the negative effects of environmental change on rain-fed agricultural production is an integral part of indigenous knowledge systems required in decision-making to ensure food insecurity. In addition to the knowledge of predicting the rainy season, preservation of the seeds, and maintenance of the crops, indigenous knowledge of soil names and types is essential in making crop production decisions. Indigenous knowledge of soil could be used to reduce the negative impacts of unpredictable rain on smallholder farming. The transmission of this knowledge throughout generations, from farmer to farmer, and the transfer from scientists to farmers is an essential component of sustainable agriculture. Farmers' knowledge of soils demonstrates the benefits of integrating indigenous soil knowledge with modern soil knowledge to nurture and maintain natural resources. This integration could be an effective strategy for promoting agricultural systems based on traditional ecological knowledge. This review describes indigenous knowledge of soil nomenclature, the types of crops that do well on these soils, and how this knowledge is used to cope with the impacts of erratic rainfall on subsistence crop production.

LITERATURE REVIEW
Over many centuries of rain-fed crop cultivation, small-scale farmers have amassed a wealth of systematic knowledge about soils. Small-scale farmers have extensive, systematic soil knowledge gained over many generations of subsistence rain-fed crop production. In underdeveloped countries, where most farmers lack access to soil analysis and extension services, this foundational knowledge is especially important for the development of agricultural and environmental sustainability.[1] Small-scale farmers' understanding of soil nomenclature is astounding. They can be referred to as pedologists in the sense their knowledge of soil structural

[1] Food and Agriculture Organization (FAO) of the United Nations, "Agroforestry," http://fao.org/forestry/agroforestry/en., 2019.

properties is fundamental to soil use and management.[2] Accordingly, color and texture are important soil properties that farmers use to differentiate and describe the soil.

Surface color and soil texture are important criteria for identifying and describing soils by smallholder farmers.[3] Case studies from Africa, America, Asia, and Europe revealed that soil structure is an essential determinant of soil nomenclature and classification.[4] Additionally, soil structure and color are the basis for many indigenous soil ethnopedology.[5] Similarly, the indigenous soil nomenclature and classification system observed among Vhavenda of Limpopo Province in South Africa is based on surface soil physical properties related to the use of the soils.[6]

Farmer knowledge of soils and their management is critical in developing greater sustainability in agricultural systems.[7] Users' interest in particular soil features led to the development of a taxonomy of local vernacular classification systems.[8] Soil texture and color, for example, are surface properties used by farmers that contribute to evaluating soil productivity.[9] Texture and color are not only visually appealing but are also associated with qualities such as moisture retention and drainage, which may be preferable in the era of erratic rainfall.[10] Additionally, crop-relevant soil features can be inferred from soil taxonomy.[11]

Soil color and texture have been found to be productive soil fertility indicators, while soil stoniness and texture are shown to be unproductive.[12] For instance, because they contain more organic matter, black soils are better for plant growth than their lighter counterparts.[13] Farmers' knowledge of soil, if well researched and documented, could offer long-term adaptation practices to respond to natural disasters.[14] Furthermore, the knowledge may enable farmers to mitigate and cope with harsh climatic conditions such as erratic rainfall and rising temperatures, which are not conducive to crop growth and maintenance.

METHODOLOGY

This review describes indigenous knowledge related to soil taxonomic systems of subsistence crop producers in the Limpopo province of South Africa. To accomplish this, literature on subsistence farming and climate variation on food security was identified and analyzed to describe the indigenous knowledge of soil nomenclature and the types of crops doing well on each soil as a means of coping with erratic rainfall patterns. A description of the smallholder farmers' knowledge of the soils on which they grow their subsistence crops is required, primarily to investigate how this knowledge is used to adapt to the impacts of reduced rainfall due to climate change.

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[2] Paulo Pereira et al., "Soil Mapping and Processes Modelling for Sustainable Land Management: A Review," in *EGU General Assembly Conference Abstracts*, 2017, 3254.

[3] Jari Hinsch Mikkelsen and Roger Langohr, "Indigenous Knowledge about Soils and a Sustainable Crop Production, a Case Study from the Guinea Woodland Savannah (Northern Region, Ghana)," *Geografisk Tidsskrift-Danish Journal of Geography* 104, no. 2 (2004): 13–26.

[4] Louanna Furbee, "A Folk Expert System: Soils Classification in the Colca Valley, Peru," *Anthropological Quarterly*, 1989, 83–102.

[5] Furbee, "A Folk Expert System: Soils Classification in the Colca Valley, Peru"; Basga E Dialla, "The Mossi Indigenous Soil Classification in Burkina Faso," 1993.

[6] L O Nethononda and J J O Odhiambo, "Indigenous Soil Knowledge Relevant to Crop Production of Smallholder Farmers at Rambuda Irrigation Scheme, Vhembe District South Africa," *African Journal of Agricultural Research* 6, no. 11 (2011): 2576–81.

[7] Stewart Kyebogola et al., "Comparing Uganda's Indigenous Soil Classification System with World Reference Base and USDA Soil Taxonomy to Predict Soil Productivity," *Geoderma Regional* 22 (2020): e00296.

[8] Jonathan A Sandor and Louanna Furbee, "Indigenous Knowledge and Classification of Soils in the Andes of Southern Peru," *Soil Science Society of America Journal* 60, no. 5 (1996): 1502–12.

[9] Yoshie Yageta et al., "Comparing Farmers' Qualitative Evaluation of Soil Fertility with Quantitative Soil Fertility Indicators in Kitui County, Kenya," *Geoderma* 344 (2019): 153–63.

[10] Christien H Ettema, "Indigenous Soil Classifications," *What Are Their Structure and Function and How Do They Compare with Scientific Soil Classifications. Institute of Ecology, University of Georgia, Athens*, 1994.

[11] Randall J Schaetzl, Frank J Krist Jr, and Bradley A Miller, "A Taxonomically Based Ordinal Estimate of Soil Productivity for Landscape-Scale Analyses," *Soil Science* 177, no. 4 (2012): 288–99.

[12] Kyebogola et al., "Comparing Uganda's Indigenous Soil Classification System with World Reference Base and USDA Soil Taxonomy to Predict Soil Productivity."

[13] Ellen Taylor-Powell, *Integrated Management of Agricultural Watersheds: Land Tenure and Indigenous Knowledge of Soil and Crop Management* (Soil Management Collaborative Research Support Program, North Carolina State …, 1991).

[14] Kyebogola et al., "Comparing Uganda's Indigenous Soil Classification System with World Reference Base and USDA Soil Taxonomy to Predict Soil Productivity."

RESULTS AND DISCUSSION

Indigenous knowledge of soils

Table 1. Soil types

Soil types	Vernacular	Description and color	Suitable crops
Clay	*Seloko*	Soil may be dark brown, red, grey or black in color. It is favourable in the season of good rainfall as it retains moisture for a longer period. Not erodible.	Maize, sorghum, beans and melons
Sandy	*Sehlaba*	Red to pink, allows easy water penetration. Low fertility and highly erodible	Millet, sorghum, beans and melons
Loam	*Sehlabane*	Reddish, grayish or brownish sandy loam soil. Less erodible.	All crops
Rocky	*Lakuru/ Lekgwara*	Usually white and red. Stoney and erodible.	Maize, beans, sorghum

Subsistence crop production is predicted on centuries of knowledge of the soils on which varieties of crops are grown, managed, and harvested to ensure household food security. As a result, knowledge of soil structure and properties can be considered the foundation of traditional farming systems in which farmers carefully grow seeds on soil whose texture and color retain the amount of moisture required for seed germination and the growth of crops.

Table 1 shows the four major soil types identified by small-scale farmers; clay, sandy, loam and rocky. The Table also details the criteria and principles that form the basis of soil taxonomies used by subsistence crop farmers in Limpopo Province, South Africa. The soils presented in the Table appear in every community of Bapedi studied.[15] A significant observation is the farmers assign names to key morphological features of the soil and determine the types of crops that do well on such soils. Table 1 shows that soil is assigned a name based on its descriptive characteristics, such as texture and color.

One way to evaluate the soil's texture is to rub a little sample of it between one's fingertips to determine whether it is sandy, clay, or loam (between sandy and clay).[16] Color distinctions distinguished black, red, brown, and gray soils. The black soil is thought to be the most fertile, followed by red and white soils. The degree of water penetration is tested by soil texture in which water penetrates immediately into sandy, rocky, and loamy soils, but clay has delayed penetration. Water and moisture retention is proportional to the degree of water penetration, which is greater in clay than in loam, sandy, or rocky soils. The evidence presented above lends credence to the claim that agriculture still plays a crucial role in supplying food and income to rural populations.[17] Subsistence farmers use soil resources daily in their communities; however, they have knowledge of the vernacular names of soils and land types, the appearance properties and uses of the soil, the places where they are found, and the agricultural and management practices.[18]

Farmers describe their soil primarily based on topsoil color, texture, and other criteria such as erodability, drainage, and crop yield. Color and texture are the major soil properties used by farmers at Rambuda Irrigation Scheme to differentiate and describe the soil[6]. Bapedi, like other South African cultural groups such as Vavhenda, distinguishes four types of soil: clay, loam, sandy, and rocky.[6] People's innate understanding of soil allows them to make whatever associations between soil kinds they deem useful.[19] Therefore, indigenous soil knowledge has served as the basis for local soil-crop systems, going much beyond simple soil nomenclature. The texture and color of the soil are important factors in determining crop suitability. In South Africa, where there is a high level of linguistic and ethnic diversity, clay soils are ideal for crops that require more water to grow and mature.[20] Knowledge gained through ethnopedology has the capacity to accurately describe dynamic and complex environments, as well as the lived realities of farmers and rural residents more generally.[21] The applicability of scientific information to the needs of rural people can be greatly enhanced by incorporating

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[15] Hermann Otto Mönnig, "The Pedi," *(No Title)*, 1967; E Jensen Krige and Jacob Daniel Krige, *The Realm of a Rain Queen: A Study of the Pattern of Lovedu Society* (Routledge, 2018).
[16] Mönnig, "The Pedi."
[17] Poppy Hawkins et al., "Dietary and Agricultural Adaptations to Drought among Smallholder Farmers in South Africa: A Qualitative Study," *Weather and Climate Extremes* 35 (2022): 100413.
[18] C Nwankwo, B O Nuga, and J Chukwumati, "Indigenous Description of Soils in Some Communities in Emuoha Local Government Area of Rivers State, Nigeria," *Journal of Agriculture and Social Research (JASR)* 11, no. 1 (2011).
[19] P Sillitoe, "Ethnoscientific Observations on Entomology and Mycology in the Southern Highlands of Papua New Guinea," *Science in New Guinea* 21 (1995): 3–26.
[20] Nkosinomusa Nomfundo Buthelezi-Dube, Jeffrey Charles Hughes, and Pardon Muchaonyerwa, "Indigenous Soil Classification in Four Villages of Eastern South Africa," *Geoderma* 332 (2018): 84–99.
[21] Pereira et al., "Soil Mapping and Processes Modelling for Sustainable Land Management: A Review."

indigenous knowledge of soil as a supplementary body of knowledge with rich contributions from local experiences. The practical importance and contribution to rational and long-term soil management is generally recognized.[22] Berlin's argument that native taxonomies and classification systems can be explained by humans' natural and largely unconscious sense of the inherent lends credence to this discovery.[23]

There is some useful analogy to Weinstock's practical approach to distinguishing between physical and perceptual dimensions of soil nomenclature when linking ethnological taxonomies to indigenous taxonomies.[24] The physical dimension is concerned with the most easily observable criteria that farmers use to differentiate their soils, namely soil characteristics.[25] When comparing ethnological taxonomies to indigenous taxonomies, some helpful parallels can be drawn from Weinstock's practical methods of separating the physical and perceptual elements of soil nomenclature.[26] Soil characteristics are the most readily apparent criteria that farmers use to categorize their soils, and hence fall under the purview of the physical dimension.[27]

Significance of Soil Texture and Color in Coping with the Impacts of Erratic Rainfall

This analysis highlights the significance of soil structure and color in crop productivity, suggesting that these factors can be used to better understand and address challenges and possibilities in this area. Sandy and loam soils are well suited to erratic rainfall. When it rains, the water that falls soaks into the soil, allowing the seeds to germinate and the crop to grow. Though the moisture content does not last long, water penetration is highly valued. Low moisture content allows crops to grow, resulting in poor harvests. Melons, millet, sorghum, and beans are among the most popular crops grown on sandy and loam soils. Clay and rocky soils are ideal for normal rainfall that arrives at the start of the season and continues to fall throughout the season until the crops mature or the fruits ripen. Soil is an essential component of resilient and sustainable agriculture.[28] The healthier the soil, the better and more plentiful the food supply. Soil productivity is also dependent on local soil nomenclature. Soil behavior, long-term observations, and prior familiarity with important morphological qualities like texture and color, are all reflected in the nomenclature criteria.[29] At least on field size, the pedological knowledge and understanding of many rural communities have been found to be just as reliable as that of professional pedologists.[30] The ecosystem's soil fertility, on the other hand, is a determining factor in plant growth and can limit or promote the productivity or success of consumer organisms further down the food chain.[31]

The findings of this review indicate that farmers are "innate pedologists", supported by observations that although the local morphological text does not address pedogenesis, it does embrace its product, i.e. soil morphology.[32] Colombian farmers regard black and brown colours as determinants of good crop sustenance and yields, as opposed to light colours (red, yellow, and white), which are less fruitful.[33] The foundation of soil nomenclature lies in its fertility. Indications of soil properties are important for crop growth.[34] Farmers on a smaller scale typically have a deeper familiarity with their land and the kind of plants that thrive there.[35]

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[22] Fabio Stagnari et al., "Sustainable Soil Management," in *Innovations in Sustainable Agriculture*, ed. M. Farooq and M. Pisante (Cham: Springer, 2019).
[23] Brent Berlin, *Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies*, vol. 185 (Princeton University Press, 2014).
[24] J Weinstock, "Getting the Right Feel for Soil-Traditional Methods of Crop Management," *Ecologist* 14, no. 4 (1984): 146–49.
[25] M A Adewole Osunade, "Identification of Crop Soils by Small Farmers of South-Western Nigeria," *Journal of Environmental Management* 35, no. 3 (1992): 193–203; Shankarappa Talawar and Robert E Rhoades, "Scientific and Local Classification and Management of Soils," *Agriculture and Human Values* 15 (1998): 3–14.
[26] Weinstock, "Getting the Right Feel for Soil-Traditional Methods of Crop Management."
[27] Osunade, "Identification of Crop Soils by Small Farmers of South-Western Nigeria"; Talawar and Rhoades, "Scientific and Local Classification and Management of Soils."
[28] Osunade, "Identification of Crop Soils by Small Farmers of South-Western Nigeria."
[29] Osunade, "Identification of Crop Soils by Small Farmers of South-Western Nigeria"; Talawar and Rhoades, "Scientific and Local Classification and Management of Soils."
[30] Ephraim Nkonya, Alisher Mirzabaev, and Joachim von Braun, eds., *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development* (Cham: Springer International Publishing, 2016), https://doi.org/10.1007/978-3-319-19168-3.
[31] Nkonya, Mirzabaev, and von Braun, *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*.
[32] Michael Pidwirny, "Biology and Physical Geography.," http://www.physicalgeography.net/fundamentals/9s.html, 2006.
[33] Victoria Frausin et al., "'God Made the Soil, but We Made It Fertile': Gender, Knowledge, and Practice in the Formation and Use of African Dark Earths in Liberia and Sierra Leone," *Human Ecology* 42, no. 5 (October 30, 2014): 695–710, https://doi.org/10.1007/s10745-014-9686-0.
[34] Paul Sillitoe, "Indigenous Knowledge in Development," *Anthropology in Action* 13, no. 3 (2006): 1–12; Schaetzl, Krist Jr, and Miller, "A Taxonomically Based Ordinal Estimate of Soil Productivity for Landscape-Scale Analyses."
[35] Jasmine Pearson, Guy Jackson, and Karen E McNamara, "Climate-Driven Losses to Knowledge Systems and Cultural Heritage: A Literature Review Exploring the Impacts on Indigenous and Local Cultures," *The Anthropocene Review* 10, no. 2 (August 15, 2023): 343–66, https://doi.org/10.1177/20530196211005482.

If there is erratic rainfall during the rainy season, farmers with fields on sandy soils will have greater production opportunities because the soil texture allows even smaller amounts of rainfall to penetrate. The type of soil texture is also a good indicator of which plants to grow in a garden or field (Table 1). Color is another important characteristic used by farmers because can indicate the fertility of a type of soil.[36] The farmers recognize fertile soils by their black, gray, and dark brown colors. When compared to other soils, dark brown and sandy loam underlain by clayey soil has a lower water infiltration rate[26].

RECOMMENDATIONS

It is recommended that farmers' knowledge of soil structure be included in climate change adaptation strategies for the benefit of subsistence agricultural producers to build resilience against the negative effects of changing climatic conditions on household crop production. In the future, an understanding of soil structure must be developed, not only through observations but also through guiding philosophies and procedures for the dissemination of information. Farmers should have knowledge of soil structure and properties to mitigate and cope with challenges in agricultural production.

CONCLUSION

The review findings show that farmers have knowledge of the soils on which they grow subsistence crops. Farmers distinguish their soils primarily based on pedological features or surface characteristics. Soil nomenclature is determined by soil morphological features, so soils are described in terms of texture and color. Farmers describe four soil types using local soil nomenclature: *seloko, sehlaba*, loam and *lekuru*. Ethnopedological studies have shown that this knowledge of soil types is crucial for sustainable climate-resilient indigenous farming methods. Precision agriculture is made possible by farmers' ability to recognize variations in soil types.

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