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Classifying Soils: Points of Convergence in Indigenous Knowledge Engagement with Scientific Epistemologies

Oluwatoyin Dare Kolawole & Garrick Wayne Cooper

Article

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Oluwatoyin Dare Kolawole
https://orcid.org/0000-0002-3977-8747
University of Botswana
Eastern University, USA
tkolawole@ub.ac.bw
toyin.kolawole@eastern.edu

Garrick Wayne Cooper
University of Canterbury, New Zealand

Abstract

While cultures are diverse in nature, there are many similarities between them. This is the case with African and Maōri cultures. Local people largely view their realities in a similar way. The question as to whether there are similarities in the indigenous epistemologies related to farming activities in different regions (such as West Africa, southern Africa, and Oceania) therefore arises. Given that no form of knowledge is mutually exclusive, we attempt to seek the points of convergence between local or indigenous knowledge and scientific modes of enquiry in relation to soil fertility management. In addition to secondary information, qualitative data were purposively obtained from key informants in selected farming communities in northwestern Botswana, the Canterbury province in New Zealand (Aotearoa), and southwestern Nigeria. We hypothesise that local farmers' ways of knowing related to soil fertility and management have commonalities with mainstream science, particularly in terms of soil classification. Our findings show that both scientific and indigenous epistemologies as regards soil fertility are based on certain indicators, including soil morphology, the presence of fauna, plant growth, and so forth. While African farmers used the "principle of mental economy" to determine soil suitability, Māori farmers systematically group various soils, which is an indication of their sophisticated environmental knowledge.

Keywords: Botswana; epistemology; local knowledge; science; soil management; New Zealand; Nigeria

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> … no single form of knowledge is in itself rational; only their collective configuration can be rational. (Sousa Santos 1992, 44)

Introduction

Although cultures are diverse in nature, there are many similarities between them. It is indeed gratifying to know that local community people all over the world largely view their realities in a similar way. African and Maōri cultures exemplify these resemblances. Amongst the Maōri of Aotearoa/New Zealand, for instance, traditions suggest that the first human was made from the earth mother, called Papatūānuku, from *oneone*, or soil, at a location called Kurakawa (see, for instance, Keane 2012). This is similar to the mythology of the Yorùbá people of south-western Nigeria, which establishes that the first man was made out of baked earth ("Terra Cota") in Ilé-Ifè and there and then received the breath of life from Olódùmarè (God, the divine creator) (see Idowu 1982). Interestingly, the Yorùbá accounts of human creation also bear a resemblance to Jewish traditions.[1] For the San people of Botswana, humans and Nature are intricately connected. Having firm beliefs in deities and spirituality, the San people hold the opinion that whatever is taken from the natural environment must meet a specific need, which makes them mindful of the need to carefully utilise natural resources, including the soil (see Thondhlana and Shackleton 2015). Two things emerge from these points: first, the spiritual connection of indigenous people with Mother Earth and, second, the importance and role of soil in people's livelihoods and existence in relation to agricultural production and food security (see, for instance, Minami 2009). It is noteworthy to mention that while science has advanced and developed hydroponics technology in crop cultivation, this cannot match the large-scale land-based crop cultivation approach to food production.

Globally, all indigenous communities are land-orientated; they seek to achieve sustainable livelihoods through fruit gathering, crop cultivation, and hunting. Indeed, local people deploy the experiences they have acquired over the years to meet the challenges peculiar to their immediate environments. They devise means to overcome the vagaries of weather conditions in their localities. They know when to plant and when not to do so. For the sake of safeguarding biodiversity, they know which seeds to preserve and which should not be spared; they are geneticists in their own right. They know which plants or herbs to use to treat certain ailments; they practise pharmacognosy and medicine (see Thondhlana and Shackleton 2015). Grassroots communities use local institutions and sanctions to govern access to and use of natural resources and, through those means, ensure environmental management and sustainability (Mogende and Kolawole 2016; Ostrom 1990). In a bid to conserve forest resources in the land of the Yorùbá people, for instance, there are forests designated as *Igbó Àìwo*, meaning sacred groves or forests. Thus people are prevented (through sanctions) from using flora and

1 The Holy Scriptures vividly captures the story of creation in the book of Genesis (chapters 1–6).

fauna indiscriminately (see Babalola 2011; Ogunade 2005). Although modernisation may have impacted on the survival of these traditional practices (Babalola 2011), they still exist in many places. In practice, the Māori people may place a *rāhui* (restriction) on an area, setting it aside for the conservation or recovery of resources (see Alves 2018).

The question then arises whether there are similarities between indigenous farming epistemologies in different regions of the world. Given that no forms of knowledge—be it science or local knowledge—are mutually exclusive, we attempt to seek the points of convergence between local or indigenous knowledge[2] and scientific modes of enquiry in relation to soil fertility management. We therefore hypothesise that there are distinct similarities between the bodies of knowledge of community peoples. We also hypothesise that local farmers' ways of knowing regarding soil fertility and management share commonalities with those of the dominant knowledge (that is, Western science), particularly in terms of soil classification through soil morphology. It is for this reason that we explore the epistemologies of soil fertility among local farmers in Botswana, Aotearoa/New Zealand, and Nigeria in relation to how Western science addresses the subject matter. We seek to identify the similarities and differences between the ways of knowing of these three groups of people and then compare their bodies of knowledge with the scientific mode of soil fertility management.

Between Science and Local Knowledge: A Theoretical Statement

The emergence of science as a dominant form of knowledge has a clear history. The rejection of theology and then philosophy (in that order) as ways of knowing led to the preference for another form of knowledge. The popular disenchantment with "mere deductive speculations" and the undesirability of an appeal to authority, as evident in the knowledge derived from theology and philosophy, led to the desire for a way of knowing based on "democratic" ideals, which seeks "evidence drawn from the study of empirical reality" (Wallerstein 2007, 130). This way of knowing supposedly allows individuals to produce new insights if they strictly observe and follow the "rules of the game". While other problems exist, one major failing of science is that it is in itself undemocratic, as a few individuals within certain academic traditions have the prerogative to decide what knowledge is and what it is not. The unidirectional and linear mode of human progress proposed by the modernists (see, for instance, Rostow 1960) has been rejected by the postmodernists, thus giving rise to the emergence and recognition of local knowledge (see Escobar 2007; Foucault 1973; Foucault 1980; Sousa Santos 1992; Wallerstein 2007).

The postmodernist movement challenged hegemonic assumptions about the universality of knowledge, and insisted that knowledge is, instead, place-based, context-specific, local, and produced in multiple sites. Unlike Western science, indigenous or local

2 The concept "indigenous" or "local" is used interchangeably to connote the same thing in this article.

knowledge does not follow the formalised, regimented procedural rules of engagement. It emerges naturally from within grassroots communities to address practical problems associated with any given socio-ecological context. It is diffuse and autochthonous in nature. It is also somewhat ambivalent and naturally dialectical (see Andrae-Marobela et al. 2012). Indigenous knowledge is informal but procedural, open and closed, within certain subject matter areas and contexts (Kolawole 2012a). The closed nature of certain indigenous knowledges (with spiritual connotations in most cases) confines them within the reach of certain clans and groups of people, thus making them inaccessible to outsiders. This lack of openness constitutes a major barrier to understanding fully the "machinations" of indigenous knowledge systems (IKSs). Despite this shortcoming, the key roles which indigenous knowledge plays in relevant sectors of environmental management and sustainable development continue to receive approbation amongst the postmodernists and development experts.

Many scholars argue that there are contextual, epistemological, and substantive differences between science and local knowledge (Banuri and Apffel-Marglin 1993; Chambers 1980; Dei 1993; Howes and Chambers 1980; Warren 1989). However, some scholars do not agree that Western science and local knowledge differ, because just as local or indigenous knowledge is not able to solve all problems (as conceived of by scientists), mainstream science also cannot offer a solution in all instances (Agrawal 1995). Nonetheless, attempts to classify the two bodies of knowledge as the same have met with stiff opposition from those who believe that local knowledge is likely to be swallowed up by the dominant knowledge—science—if a distinction is not made between the two (see Brokensha 1996). That differences exist between Western science and local knowledge is a confirmation that "all knowledge is local and total" (Nunes 2007, 58). Whereas positivist science is largely reductionist in its analysis, indigenous knowledges are emergent, and embedded in narratives and multiple realities. The assumption that conventional science is "objective", as opposed to the seemingly subjective nature of local knowledges, may not be entirely correct. The contention that science forms the point of reference, foundation, and framework through which knowledge should be constructed, particularly when other knowledges are investigated, may have resulted in its lack of objectivity in many cases. Thus, this *disguised subjectivity* of conventional science—as we see it—leads to its domineering, "manipulative", and "exploitative" tendencies in the development process (Peters 2010, 76). Although some similarities exist between local knowledges in places with similar ecological features, the fact that knowledges are contextual and place-based cannot be disregarded.

All things considered, procedural issues associated with knowledge production suggest that both science and local knowledge exhibit certain similarities, such as engaging in observation, experimentation, and validation of realities, be they social or natural, in any given interrogative endeavour. To be sure, the general analysis on soil classification and management later on in this article provides examples of the similarities that exist between the two bodies of knowledge. As opposed to indigenous knowledge, science stands out for its formalised regimentation and documentation procedures (Kolawole 2001; Kolawole 2012a; Kolawole 2012b; Kolawole 2013), thus making indigenous knowledge appear as lacking in "conceptual or methodological coherence" (Sillitoe and Marzano 2009, 16). However, the outright assertion that indigenous knowledge lacks "methodological coherence" is inherently problematic, for it immediately closes the door against any methodological configurations that might provide possible scenarios for operationalising indigenous knowledge alongside the scientific mode of enquiry. And the claim by scientists that indigenous knowledge entails trial-and-error experimentation sounds too simplistic, for obvious reasons (see Berkes 2008). The fact that Western science cannot guarantee the certainty and success of any experiment from the outset equates it with what appears to be a trial-and-error endeavour as well. It is common knowledge that not all *a priori* expectations set out in a scientific investigation are met all the time. Indeed, there are many botched experiments that just would not work. As notable Western academics have admitted, cynics would do well if they, in humility, sit down, learn (Chambers 1983), and acknowledge other possibilities by "shed[ding] our assumptions about what is universal" (Wallerstein 2007, 134).

Although local knowledge is truly autochthonous (Kolawole 2012a), this does not amount to inaccessibility and practical use, as Agrawal (1995) once argued, particularly where functional infrastructures embedded in an efficient information superhighway are available (Kolawole 2001). However, while indigenous knowledge may be effective in perpetuating the culture and modest well-being of rural societies, it may not on its own be "sufficient for the profound structural transformation required for sustainable development" (Hamel 2005, 233). Even though indigenous knowledge alone may not be adequate to meet people's needs in extraordinary circumstances or in times of emergency (Sillitoe and Marzano 2009), practical local knowledges (*metis*)—as opposed to analytical and formal knowledge (*episteme*)—will continue to find relevance amongst local communities where and when the need to deploy these infrastructures for addressing context-specific, local challenges arises. Thus, the preference for one's own is always present, particularly in situations where people find it challenging to easily and promptly access external aid in times of need. By implication, then, regardless of the degree to which they have embraced modernity, local peoples continue to utilise their knowledge infrastructures to meet their immediate needs, including those related to soil fertility management (see Kolawole 2001; Kolawole 2012a; Kolawole 2012b; Kolawole 2015). And regardless of the extent to which the world has been affected by globalisation, the perpetuity of indigenous knowledge remains even amongst elites living in urban centres and abroad who, owing to nostalgia for their roots and traditions, go home on a routine basis to celebrate traditional festivals (see Kolawole 2015).

If we accept the reality of the *non-suppressability* of the "rhizomes" and "enthymemes" (Milovanovic 1997), then scientists would do well to find meeting points and commonalities between science and indigenous knowledges when seeking new possibilities in sustainable development research. And as Wallerstein points out, "we shall only get *fortuna* if we seize it" (2007, 134). In practical terms, local knowledges are a form of technical knowledge (*techné*), as they can provide solutions for the technically oriented needs of farmers. Brouwer (1998) refers to this as indigenous technical knowledge (ITK), which expresses itself as "operationalized local thinking" in people's livelihoods and ways of life, such as in agriculture, ethno-medicine, ethno-veterinary medicine, architecture, music, textiles, and the like.

Methodology

We used a comparative research design and a qualitative research approach (see Creswell 2014) to analyse the practices of local farmers in three countries: Botswana, New Zealand, and Nigeria. A qualitative research approach, especially in the context of this study, discourages scientific reductionism and allows the respondents to provide a vivid description of their everyday realities. We therefore stratified the study population by investigating farmers in north-western Botswana, south-western Nigeria, and New Zealand. The sample population in the Okavango Delta of north-western Botswana comprises the HamBukushu, BaYeyi, and BaTawana ethnic groups. While the HamBukushu people are found in the panhandle area of the Delta, the BaYeyi and BaTawana people live in the central and distal areas of the Okavango Delta, respectively. The Yorùbá farmers sampled in southwestern Nigeria are of the Ifè and Oyo ethnic subgroups, inhabiting the tropical rainforest and the fringes of the Guinea savanna, respectively. The Māori population comprises about one hundred tribes; the major tribes in terms of population are the Ngāpuhi, Ngāti Porou, Ngāi Tahu/Kāi Tau, Waikato, Ngāti Tūwharetoa, Ngāti Maniapoto, and Tūhoe, in that order (Statistics New Zealand 2013). The choice of the three countries as the sampling frame is predicated on the similarities in the cultural practices and belief systems of the people.

All the farmers who were purposively selected and interviewed from 2013 to 2014 served as key informants who provided qualitative information. Ten practising/active local farmers (with an average age of 51 years) were interviewed in three Batswana communities (Makalamabedi, Nokaneng, and Mohembo West). Twelve active small-scale farmers, with an average age of 60 years, were interviewed in five Nigerian rural communities (Erèfé, Iyánfowórogi, Àró, Òjo, and Akérédolú). In addition to having a discussion with two notable individuals in New Zealand on the subject, most information on soil fertility management among local farmers in that country was derived via secondary sources.

First, we used a critical review of the literature to contextualise Western and indigenous knowledges. We then used key informant interviews and secondary sources to elicit and analyse data on how small farmers identify and ascertain soil fertility, and how they manage or sustain fertility for agricultural productivity. We further used critical discourse analysis to contextualise the epistemology of knowledge as regards scientific and local modes of enquiry in relation to the findings of our field surveys. In the next section, we focus on indigenous modes of knowing in agricultural practices, with a special emphasis on soil fertility and management.

Epistemology of Soil Fertility: African and Māori Perspectives

Ways of Knowing

There are different approaches to knowing reality. Different academic traditions use different strategies or methodologies and methods (i.e. tools or techniques) to unearth the truth about phenomena. While science largely relies on evidence derived from the study of empirical reality through positivism, the humanities mostly engage in grand or universal narratives and discourse analyses to produce knowledge. Even amongst and within academic traditions, different strategies are employed in generating knowledge. In the natural sciences, for instance, chemistry relies heavily on laboratory experiments to test hypotheses on how atoms and molecules interact and react to produce new reagents, while physics focuses on the nature of matter and its motion through space and time. In the social sciences, while sociology tests its hypotheses on social (human) dynamics based on the inter-relationships between observable and socially constructed variables within a group of people, the field of psychology pays attention to individual human behaviour, which is studied by contriving certain conditions within a given environment. Thus, while sociology studies the group, psychology focuses on the individual. In another vein, philosophers are perceived as engaging in "deductive speculation" to generate knowledge (see Wallerstein 2007, 130). By immersing themselves in their subjects' cultural activities and environment, anthropologists rely on long-term, close observation to record people's way of life on a day-to-day basis. While some academic disciplines do not have distinct boundaries, others have been rigidly defined. Indeed, some disciplines rely heavily on other academic traditions to form a whole. A good example is the broad-based field of agricultural science, which borrows from both natural and social sciences and the humanities to address environmental, socio-political, cultural, economic, and food security issues in the agrifood system.

Through constant interaction with their immediate environments, indigenous peoples employ different strategies to generate bodies of knowledge that are deemed suitable for meeting their day-to-day needs and aspirations. The dynamism and multiplicity of indigenous knowledges are apparent in diverse contexts; it is interesting to note that the strategies employed now and here may not necessarily apply tomorrow and elsewhere. Similarly, the postmodernists advocated the replacement of grand narratives—the work of the modernists—with meta-narratives, which are knowledges produced for and peculiar to certain contexts (see Gutting 2007; Lyotard 1984). The following subsection therefore addresses the approaches used by local farmers and scientists in generating soil fertility knowledge.

Approaches and Methods Used by Farmers

Soil Morphology

Our findings clearly indicate that local farmers in the study area have and use indigenous epistemologies to discern and identify fertile and infertile soils. It is noteworthy that there are similarities in farmers' opinions (in all the locations) as to the indigenous way of identifying and knowing which soils are fertile and which are not. Amongst others, soil colour, texture, and structure are basic observable attributes of the soil used by local farmers in classifying their farmlands as fertile or infertile. For instance, the Nigerian farmers opined that a dark colour indicates the presence of humus, which in turns suggests fertility. Thus, farmers classify their farmland soils into humus, gravel, clay, and sand. Across the three study areas, black soils which contain an abundance of organic matter is considered humus (known as *Ìlèdű́* or *Ilè dű́dű́* in Yorùbá and *Seloko* in Setswana). Amongst the Batswana and Nigerian farmers, soil that contains many pebbles is classified as gravelly (*Wéré* or *Yoyo* in Yorùbá, *Mokwakwana* in Setswana), while loose, fine soil is considered sandy (*Iyanrì* in Yorùbá, *Mothaba* in Setswana). Sticky, red earth (indicating the presence of clay minerals, particularly ferrous materials) is categorised as clay soil (*Amòn* or *Odo* in Yorùbá, *Sethabana* in Setswana), and north-western Batswana farmers categorise certain fine, sticky, and dark soils as clay as well (locally known as *Seloko*). This is in addition to those soils which are exclusively red in colour. Also, local farmers classify soils based on their textures—whether coarse or fine (see Table 1).

We treat Māori classifications separately because of their richness and diversity (see Best 1925).[3] The general term for soil or earth in Māori is *oneone*. There are many classes and subclasses, but we focus on those we consider more relevant to our comparison exercise in this article. In other words, unlike what obtains in the two countries under study in Africa, where there are limited classifications, probably due to some limitation in language, among the Māori there are subclasses in the four classes earlier identified (loam, clay, sand, and gravel). Beyond that, there are many more classifications outside these four categories, such as specific names for alluvial and silt soils. For example, one of the Māori names for clay is *keretu*. While a stiff clay soil is known as *korematua*, yellow clay is commonly referred to as *kerewhenua*, and white clay is known as *kōtore*. While loam is known as *onematua*, a dark, fertile, and friable soil is called *oneparaumu*. Māori farmers classify a stiff brown soil that is fertile, but which seems to require enhancing through the addition of sand and gravel, as *onetuatara*. This provides an interesting perspective on the soil classification approach of these farmers and how they manage soil fertility in a given area. While, on the one hand, a rich soil consisting of clay, sand, and decayed organic material is known as *onenui*, a light but good soil comprising sand and loam is known as *oneharuru*. This classification is of utmost interest for this article, and we shall revisit it later. Dark soil mixed with gravel or small pebbles is known as *onehanahana*. Amongst the Māori people, sandy soils are categorised into different subclasses: pure sand is referred to as *onepū*; other variants include sandy soils (*onetai*), white soils with sandy volcanic matter (*onetea*), and light spongy soil (*onepunga*). Silt soils are also subdivided into

3 Elsdon Best collected much material on Māori terms for soil types during his time largely spent with the Tuhoe tribe of the Bay of Plenty at the turn of the 20th century. This knowledge was published in his book *Maori agriculture*. Many distinct soil types were known, especially those that were good for cultivating sweet potato (kūmara).

kenepuru or *kerepuru* (which is a kind of silt of fresh alluvial deposit) and *onepārakiwai* or *parakiwai* (pure silt). Alluvium and alluvial soils are known as *oneparahuhu* (or *parahua*) and *kōtae*, respectively. Gravel, or a very gravelly soil, is known as *onekōkopu* or *onepākirikiri* elsewhere among Māori farmers. While fertile brown soil is known as *kirikiri tuatara*, brown, friable, fertile soils are known as *tuatara wawata*. Other friable soils are referred to as *onetakataka*. Soils found in wet places, known to the Māori as *onekopuru*, bear a resemblance to those classified as *Àkùrò* (marshy soil) by the Yorùbá people of south-western Nigeria. A reddish, poor soil referred to as *onekura* is similar to that which is classified as *Amò* or *Odo* by the Yorùbá people, noted for its plasticity due to the abundance of clay minerals.

It is instructive to note that farmers' ability to distinguish between different types of soils, and in so doing classify and name them, provides the cultural and human capital necessary for environmental protection and preservation. These empirical observations offer survival values (Berkes 2008) for the ecosystem in general.

Table 1: Soil classification among farmers in Botswana, Nigeria, and New Zealand

Country	Classification based on color	Classification based on structure	Classification based on texture
Botswana	Humus/loam: black Clayey soil: red or black earth Sand: white Gravel: any	Humus/loam: fairly fine Clay: sticky and fine Sand: loose Gravel: stony	Humus/loam: fairly fine and fluffy Clay: fine Sand: fairly coarse Gravel: rough and coarse
New Zealand	Humus/loam: black Clay: red, yellow or white earth Sand: white Gravel: any Alluvial Silt	Humus/loam: fairly fine Clay: sticky and fine Sand: loose Gravel: stony Alluvial Silt	Humus/loam: fairly fine and fluffy Clay: fine Sand: fairly coarse Gravel: rough and coarse Alluvial Silt
Nigeria	Humus/loam: black Clay: red earth Sand: white Gravel: any	Humus/loam: fairly fine Clay: sticky and fine Sand: loose Gravel: stony	Humus/loam: fairly fine and fluffy Clay: fine Sand: fairly coarse Gravel: rough and coarse

Presence of Fauna

The presence and abundance of soil-enriching fauna has a direct correlation with favourable ecological conditions and soil fertility. Sighting these types of fauna thus signifies soil health and, potentially, productivity. According to the Nigerian farmers, seeing earthworm vermicast (locally known as *Erinko*) in large amounts in any field is an indication of soil fertility. This corroborates Māori farmers' biological characterisation of soils, in which the presence of "desirable invertebrates" and the "rate of organic decomposition" (Peters 2010, 20) are indicators of fertile soil. According to local farmers, the presence of earthworms and other soil health-enhancing fauna engenders good soil aeration and water capillarity and enhances fertility through burrowing and the pushing of fertile layers of soil to the surface for easy nutrient uptake by crop plants. It is noteworthy that the ecological features of tropical rainforests, which are commonplace in southern Nigeria, include the presence of earthworms as an index of soil fertility in the area. Amongst the Māori, Batswana, and Nigerian farmers, another way of discerning good quality soils is through smelling (Peters 2010). This corroborates Kennedy and Papendick's (1995) findings that local farmers assess soil health through smell: a "sour chemical" or "off" smell suggests poor quality soils, while a "pleasant, earthy" smell is an indication of good quality soils.

Plant Growth and Presence of Other Vegetation

Plant growth and the presence of certain wild plants are common indicators which local farmers use to determine the soil type when selecting soils for cultivating certain crops. For instance, the Batswana farmers opined that the presence of certain woody vegetation such as *Acacia erioloba* (locally known as *Mogotho*) and *Ziziphus macronata* (*Mokgalo*) and grasses such as *Urochloa mosambicensis* (*Phoka*) and *Cynodon dactylon* (*Motlho*) and typically black soils with loose structures are indicators of soil fertility. Conversely, soil is perceived as infertile where a tree species known as *Acacia herbaclada* (*Sechi*) is spotted. In addition to this, unusual colourations of crop plants and poor growth are immediately associated with soil infertility amongst the Batswana farmers. According to the Nigerian farmers, the presence or abundance of shrubs like Siam weeds (*Chromolena odoratum*), which facilitate the volume and availability of decomposed leaves in the fields, indicates that the soil is extremely fertile. Also, wild vegetables (such as *Amaranthus*) thrive on fertile lands in both Botswana and Nigeria. The use of certain flora as indicators of soil fertility is found among Māori farmers as well (see Peters 2010, 25). Māori farmers who engage in animal husbandry use grass growth and vigour as indices of soil health (see Peters 2010). Through cursory observation, soil which is almost bare or which harbours unhealthy or stunted plants is largely judged infertile by the Nigerian farmers.

Choice of Crops

For the Batswana farmers, the choice of crop—like beans, pumpkin, millet, or maize—for cultivation is determined by the indicators already identified in the preceding subsections. For example, farmers in the three communities in Botswana opined that while clay-loam (locally known as *Mokwakwana*) is good for cultivating crops like maize, pumpkins, melons, sweet reed, and sorghum, sandy soil (known as *Sethabana*) is good for beans, millet, melons, and groundnuts. As for the Nigerian farmers in the tropical rainforests and on the fringes of the Guinea savanna, the cultivation of staple crops such as yam, cassava, and maize is appropriate on any plot on which a large amount of Siam weeds can be spotted. For the Māori farmers, brown, friable, fertile soil, known as *tuatara wawata*, is very good for the cultivation of sweet potato (*Ipomoea batatas*), which is locally referred to as *kūmara*. Cocoa farmers in south-western Nigeria establish large plantations on this type of soil.

How Small Farmers Enhance Soil Fertility

Local communities have age-old strategies for achieving their goals, including the enhancement of soil fertility. For example, the Nigerian farmers indicated that they ensure the fertility of their farmlands in several ways. These include the application of compost and farmyard manure, bush fallow, and a specially prepared bean meal seasoned with red oil (locally known as *ékuru oko*). The bean meal attracts insects, which enhances the rapid decomposition of biomass, leading to the production of humus/organic matter in the field. These insect use practices confirm the findings of Lobry de Bruyn and Conacher (1990) on the role of termites and ants in soil modification. In another vein, local farmers in south-western Nigeria indicated that they enhance soil fertility by slicing the pods of *Kigelia africana* (locally known as *Páándòrò*), which they then plough into the soil; it is believed that the fertility of the soil is enhanced when the pods eventually decay. The efficacy of this approach could be attributed to the chemical constituents and active ingredients in the fruit. Laboratory analyses of the fruit have been undertaken to ascertain its efficacy in terms of traditional medicinal uses and to identify compounds for pharmaceutical use (for example, Grace et al. 2002; Khan and Mlungwana 1999; Saini et al. 2009), but we do not currently have an understanding of the effects of the fruit on soils. Although African farmers do not know the science behind the amelioration of the low cation-exchange capacity (CEC) of soil solely through organic soil amendments, it is interesting to mention that they are naturally accustomed to employing local strategies to replenish their soils (see, for instance, Fairhead and Scoones 2005; Lobry de Bruyn and Conacher 1990; Mando, Van Driel, and Prosper Zombré 1993). The choice of an organic approach to soil management by the African farmers is superior to the chemical fertilisation approach commonly advanced by Western science. The right combination of both organic and inorganic mineralisation, as argued by various scholars (Kolawole 2013; Scoones and Toulmin 1999), is a plausible concept for sustainable land management.

The Māori farmers altered the composition of certain soils which they considered as not suitable for agricultural production through deliberate soil modification processes. For example, brown, stiff but fertile soils (known as *onetuatara*) could be augmented with sand and gravel, perhaps to enhance aeration and capillarity (see Best 1925). A Māori informant—an old Ngati-Haua chief in Waikato—told Edward Shortland in 1842 that gravel obtained from adjacent pits was strewn on some soil surfaces in order to enhance the growth and the adaptability of tropical *kūmara* to the temperate New Zealand climate (Clark 1977, in Walton 1978). Dressings of ash were applied to maintain soil fertility (Cameron 1964). Working the soil to achieve specific farming objectives without jeopardising the ecosystem is thus characteristic of local farmers' knowledge and practices.

Commenting on the traditional mode of soil fertility management compared to the current practice in north-western Botswana, local farmers (Personal communication with farmers, Nokaneng, April 9, 2014) were unanimous:

> … shifting cultivation was commonly practiced before the government started to place restrictions on land use. When a farmer noticed that the fertility of his farmland had begun to decline, he would leave the land fallow for two to three years by opening up a virgin land for subsequent cultivations in a given period of time, after which he would then return to the original fallow land, when the soil had regained its fertility … But nowadays, the use of fertilisers has become popular, although the products are very expensive and not affordable for subsistence farmers like us.

Similarities and Differences between Local Knowledge and the Scientific Mode of Knowing

In this context, we focus on how science and local knowledges are applied in determining soil fertility management in the three countries. Without a doubt, similarities exist between scientific findings and indigenous knowledge in soil fertility management. A good case in point is the inducement of termite activity by farmers to enhance the rapid decomposition of organic materials, as described by Lobry de Bruyn and Conacher (1990).

Basic scientific soil texture classifications, based on the combination of different soil particles that constitute a given soil type, are similar to the approaches that farmers use in the classification of soil. Primary particles such as sand, silt, and clay naturally form aggregates, forming what is known as peds. The four principal forms of soil structures are platy-, block-, prism- or pillar-, and sphere-like (spheroidal or granular) structures. On the one hand, platy-like or platy soils are classified as either thick or thin; on the other, structural types (such as sand, silt, and clay) are classified as fine or coarse based on their particle sizes. Amongst the three classes of soil structure, sand, which is gritty in nature, has the largest particle size. Scientifically, sand ranges from very fine (0.05 to 0.10 mm) to fine (0.10 to 0.25 mm), medium (0.25 to 0.5 mm), coarse (0.5 to 1.0 mm), and very coarse (1.0 to 2.0 mm). While silt particles, with smooth or floury textures, are moderate in size (0.002 to 0.05 mm), clay has the smallest particle size (less than 0.002 mm) and is sticky (see USDA 1987, 5). Particles that have a diameter of 2 to 75 mm are classified as gravels, while those with a diameter greater than 75 mm are classified as rocks. While science identifies soil textures through (laboratory) measurements and feel, local farmers engage in the same procedure using sight and feel.

The major procedural difference between science and local knowledge in soil texture categorisation lies in the in-depth classification carried out by soil scientists as informed by the soil textural triangle (STT) model (Figure 1). Soil classification as visualised by science somewhat varies from the approach employed by local farmers. While scientists use the STT to come up with different derivatives of soil types (e.g. silty clay, silty clay loam, sandy clay, silt, loam, etc.) based on the percentages of the particles in a given soil sample (Figure 1), local farmers' classification (particularly those in Africa) might not go beyond the four basic categorisations of sand, clay, loam, and gravel soil types. Based on the triangle, for instance, a sandy loam soil has 60 per cent sand, 10 per cent clay, and 30 per cent silt. A clay soil has 10 per cent sand, 60 per cent clay, and 30 per cent silt. Very close to this scientific procedure are the Māori people's *onenui* and *oneharuru* soil type classifications. *Onenui* refers to a rich soil consisting of clay, sand, and decayed organic material, while *oneharuru* refers to a light, good soil comprising sand and loam. This suggests that Māori farmers are adept at soil classification.

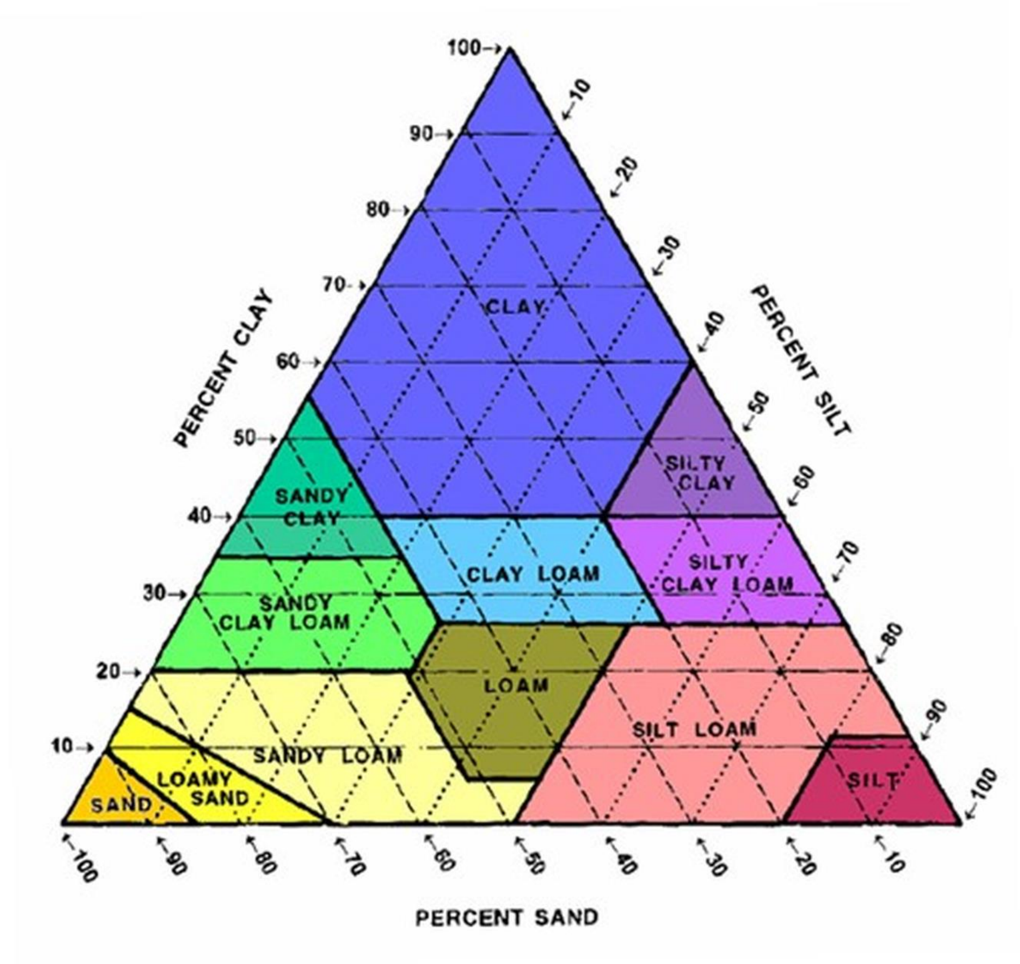

Figure 1: The soil textural triangle (USDA 1987, 9)

Most cultural practices in soil fertility management which are supported by scientific studies are rooted in indigenous knowledge. A few examples will suffice. Mulching, crop rotation, shifting cultivation, mixed cropping (a form of crop intensification), mixed farming (as seen in traditional animal husbandry), heap making or ridging, and agro-forestry are all age-old, common practices amongst local farmers which were eventually validated by soil science and improved upon in various forms. As farmers engage in problem-solving and adaptation experiments driven by curiosity (Rhoades and Bebbington 1995) and peer pressure experiments (Millar 1994), they interact with their surroundings, with the aim of overcoming the challenges posed by the peculiarities of the farming environment.

Contextualising Knowledge and the Way Forward

Clearly, ecological variations influence the mode of knowledge production in local communities. This explains the contextual nature of indigenous knowledge itself. It implies that the solution to a problem in one location may not necessarily be appropriate in another. That Western science cannot find answers to some problems in certain localities points to its limitations in terms of universal applicability (see, for instance, Hountondji 1997). Not only have many "western technically oriented solutions failed because they did not recognize the imperatives entailed by different socio-political-cultural contexts" (Agrawal 1995, 3–4; see also Kolawole 2010; Rogers [1962] 2003), the failings of Western science may also have been anchored in its failure to recognise the geographical and ecological peculiarities of certain places, aspects on which local knowledges inherently hinge. This again buttresses the claim of the postmodernist scholars (such as Lyotard, Foucault, Wallerstein, etc.), who argue that rather than glorifying the master or grand narratives, which in their analyses assume phenomenal sameness across cultures and societies, meta-narratives—bits and pieces of small stories, anecdotes, and experiences here and there—are more suitable for addressing the complex and ever-dynamic natural world.

It is presumptuous to assume that knowledges generated outside the university and research institutes are mere *enthymemes* and disturbing, incoherent noises, as evidence suggests that indigenous or local knowledges are as relevant as the dominant knowledge. Rogers's ([1962] 2003) account of a local farmer in Iowa, whom he had labelled a laggard in his diffusion study of 1954, provides an interesting anecdotal exposition. The farmer had rejected the adoption of agro-chemical fertilisers and herbicides (introduced by the US Department of Agriculture to American farmers at the time) on the grounds that they "kill earthworms and songbirds in his fields" (Rogers [1962] 2003, 194). For his non-conformist posture, the man was profiled as a "laggard farmer" in Rogers's PhD dissertation. Years later, however, Rogers, in his own words, acknowledged that "by present day standards [the farmer] was a superinnovator of the then-radical idea of organic farming" (Rogers [1962] 2003, 194; see also Kolawole 2012b; Kolawole 2017). Stereotypes and stigma, which are social constructions often created from a distance by the "expert", create insurmountable barriers that prevent researchers from making a truly informed "judgement" about the people being studied. These walls continue to impede (rural) development efforts. Unless researchers and science advisors dismantle these barriers and move away from the academic orthodoxy in which we have all been immersed, we may continue to promulgate the same conclusions that serve no useful purpose.

Cultural relativism suggests that variations exist from place to place in people's way of life (see Pickering 1992). This, however, does not imply that there are no commonalities across cultures in relation to the cultural traits and practices of local people. This is evident in the similarities between indigenous epistemologies of soil fertility across cultures in the three countries analysed in this article. Although it appears in some instances that African farmers have a less refined system of soil classification, this does not suggest that they are unable to distinguish between various soil types, as the Western scientists might assume; "it [only] reflects a principle of mental economy in traditional cultures" whereby attention is paid to certain natural resources (soils in this case) which farmers consider significant to their livelihoods (Hunn 1993, 19). Beyond that, the rich and in-depth classification of soil types by the Māori people provides evidence that local farmers are ethno-agronomists who go beyond superficial modes of soil nomenclature and are able to identify the details of specific soil types within their environment and name them accordingly.

These similarities between knowledges in many contexts (as shown in this article) thus provide a platform for developing an appropriate conceptual or theoretical model which would seek to further validate indigenous ways of knowing, at least in terms of ecological knowledge and environmental governance, and that would partly address the subject on which we have focused in this article—soil fertility and management. Admittedly, many efforts are already underway to ensure that it is not "business as usual" in the knowledge industry and among knowledge industrialists. Nonetheless, power relations and the multiplicity of interests among stakeholders remain unresolved. Given the enormity of the problem, the lack of ethics inherent in many knowledge industries, and the intricacies involved in the interconnectedness of peoples and nations, there can be no greater injustice done to the human population and the planet than the continued fragmentation of knowledge infrastructures. The divisions and attritions between the dominant knowledge and the "underdog", between various contenders and harbingers of knowledges who wield unbalanced levels of power, can only perpetuate unprofitable chaos, and further deepen and aggravate our common and global challenge. That said, it is indeed gratifying to know that knowledge amalgamation will most certainly produce chaotic scenarios from which order will eventually emerge in the long run (see, for instance, Wallerstein 2007).

Implications for (Agricultural) Education

The beginning of people-oriented development theory and praxis is a response to the need to sustain the push for the identification and documentation of indigenous knowledge infrastructures. For local knowledge to gain wider acceptance, particularly amongst sceptics, it may be necessary to validate them, add value to them, and then further document them. This would be necessary for the proper recognition of those who own the knowledges and for apportioning their associated rewards. Going further to create sophisticated archives in national libraries, universities, colleges, and research institutes, where vital information on indigenous agricultural practices can be stored and accessible to all stakeholders (including students undertaking training in agricultural sciences) will have implications for the mainstream global education system (Kolawole 2001; Kolawole 2014).

Conclusion

This article outlined the similarities and differences between the ways of knowing amongst indigenous farmers in Botswana, New Zealand, and Nigeria, and compared their bodies of knowledge with the scientific mode of enquiry in soil fertility management. While variations exist between and across cultures—and for this reason a unilineal approach to solving development problems across the board is discouraged (see Kolawole 2019)—there are many commonalities between agricultural practices in different cultures. Specifically, both scientific and indigenous ways of knowing as regards soil fertility are based on certain indicators, such as soil morphology, the presence of fauna, plant growth, and the presence of other vegetation, and the choice of crops is guided by these indicators. Unlike African farmers, who may have used the "principle of mental economy" to concentrate on soils they considered important for their livelihoods, the dexterity with which the Māori people systematically and painstakingly group various soils attests to these local farmers' sophisticated environmental knowledge and their ability to recognise and provide details of specific soil types in their localities.

Acknowledging that local farmers are ethno-pedologists and microbiologists has huge implications for mainstream science and policy engagement in environmental education and soil conservation issues. As Sousa Santos observed, "… no single form of knowledge is in itself rational; only their collective configuration can be rational" (1992, 44). To give credence to farmers' knowledge is to attenuate the hegemonic and arrogant posture of Western science in the eyes of those for whom development is meant.

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