

Soils, people and policy: land resource management conundrum in the Okavango Delta, Botswana

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Abstract: The multi-faceted aspects of natural resources governance underscore the complex nature of the subject. The intricacies associated with the skewed power relations between those who allocate these resources (land, in this case) and those who access and use them *vis à vis* environmental conservation make the subject a daunting one. Based on preliminary field observations and farmers' opinions on soil health conditions in the Okavango Delta, the paper assesses the nutrient status of selected farmers' fields and how the smallholders and government respond to this peculiar ecological environment. It specifically analyses small farmers' perceptions on the political ecology of soil management in the area. We used a multi-stage sampling procedure to sample 228 smallholder farmers. The smallholders were interviewed using interview schedules. Key informant interviews were used to collect qualitative data from farmers as well. Thirty-three (33) composite soil samples were collected from 30 farmers' plots in three farming communities (Makalamabedi, Nokaneng and Mohembo). Laboratory analysis shows that most soils in the wetland and its dryland surroundings are generally acidic, low in essential nutrients as well as in *cation-exchange-capacity* (CEC). However, the results of a one-way analysis of variance (ANOVA) conducted shows significant differences in soil nutrient levels in different locations within the Delta. While farming remains an important livelihood of rural communities, policies on natural resource governance particularly along the river channels delimit local farmers' ability to engage in meaningful soil fertility management. The low CEC of the soils is an indication that holistic cultural practices, which are beyond mere chemical fertilizations are critical and more desirable for improved soil health and sustainable rural livelihoods in the Delta.

Keywords: *Environment, natural resources, policy, rural development, soil fertility, smallholders*

Introduction

One major peculiarity of tropical Africa's soils is their low fertility, which among other factors, may have been largely influenced by low cation exchange capacity (CEC). This constitutes a serious barrier to plant nutrient uptake even where inorganic mineralization has been effectively carried out (Scoones and Toulmin, 1999: 56). Indeed, the peculiarity of Africa's soils (including those in the Okavango Delta) demands that management strategies are addressed contextually by de-emphasising a one-size-fits-all approach to soil fertility management. As pointed out by Nandwa and Bekunda (1998), '[z]one specific and crop specific fertilizer recommendations, if adopted can mitigate nutrient depletion...' Although plausible, Nandwa and Bekunda's recommendation may have a limiting effect on soil productivity if there is no conscious effort to incorporate organic mineralization in the entire soil management practices in a scenario where low CEC is a peculiar problem.

That said, the choice between eco-tourism and farming-related livelihood strategies in the Okavango Delta remains a controversial issue. The need to conserve flora and fauna in a peculiar natural environment at the expense of traditional farming practices and other related rural livelihoods poses a rural development conundrum yet unresolved amongst stakeholders. Clearly, the policy choice between tourism, agriculture and food security poses significant challenges to decision-makers in actualising real development in the area.

Indeed, the major problems associated with land use and soil fertility management in the Okavango Delta are twofold. First, small farmers' usufruct to land affects the management of land resources in the area. The promotion of biodiversity conservation and eco-tourism over agricultural production presents a major problem yet to be resolved in relations to local community preference and needs, and national economic development policy. Although the government gives a tacit approval for traditional farming activities along the river channels (see Magole and Thapelo, 2005), riparian smallholder farmers are faced with many production constraints. While there are many local farmers operating flood recession agriculture (locally known as *Molapo* farming) in the area, they do not have 'modern use rights' (VanderPost, 2009) due to government refusal to issue them usufruct certificates (through the Land Board), which should have enabled them acquire the legitimate right to land resources. Although the state policy is meant to discourage indiscriminate use of chemical fertilizers and prevent the pollution of river channels, this restriction constitutes an impediment to land management in the Delta area. Second, the lack of access to necessary production inputs by most upland farmers have also contributed to the problems of soil fertility management in the Okavango Delta.

This paper, therefore, investigates farming communities in the wetland and dryland surroundings in the area (as both environments are directly inter-linked). The

research specifically verifies the health status of the soils in the area by undertaking some laboratory and comparative analyses of essential nutrients and CEC of selected farmlands. The paper also analyzes smallholder farmers' perceptions in relation to the existing political ecology of soil management in the area.

Theoretical underpinning

This paper is rooted in the political ecology theory. The subject of political ecology derives its name from the amalgam of critical issues in 'ecology and a broadly defined political economy' (Blaikie and Brookfield, 1987: 17) of natural resources (NRs) management. Simply put, political ecology underscores the analysis of the complex associations or relationships between Nature and society as they influence NRs governance; how people access and control the use of these resources in relation to '...environmental health and sustainable livelihoods' (Watts and Peet, 2004: 4; see also Robbins, 2006: 6-7). Elsewhere, Robbins (2012: 3) emphasises the inextricability of both politics and ecology as he points out that 'politics is inevitably ecological and that ecology is inherently political'. In other words, both concepts are inherently enmeshed and not in any way mutually exclusive. Thus political ecology emphasizes the existing power struggles associated with the access to and control over NRs; it explains the power relations in the unequal allocation, distribution of costs and benefits of NRs in a given social-ecological and political milieu (Forsyth, 2003; Watts and Peet, 2004). The skewed power relations and unequal access to NRs (e.g. land) between the elite and poor aggravate conflict situations between these stakeholders (Kolawole, 2013; Watts and Peet, 2004; Forsyth, 2003; Bryant and Bailey, 1997; Blaikie, 1985).

Thus politics and economics have implications for the sustainability of the bio-physical environment. Political ecology focuses on the dynamics of environmental change, which in itself is a product of the interplay between politics and the economy. While, for instance, environmental change such as soil erosion makes some actors wealthier (through rent seeking, contractual activities), it further impoverishes others in a 'politicised environment' (Bryant and Bailey, 1997; Blaikie, 1985; Watts and Peet, 2004: 1-40). Clearly, the rise of capitalism and modernity has been associated with environmental degradation as reflected in climate change, soil erosion, etc. for which the poor is largely made to suffer (e.g. Forsyth 2003; see also, Kolawole, 2013). Power and politics invariably play prominent roles in enhancing [poor] people's ability to access NRs (including land assets) and altering existing structures and processes (see Ashley and Carney, 1999). The field of political economy, which is partly encapsulated in political ecology (that is, the governance of ecological resources including land) 'is concerned especially with who gains and who loses' (Chambers 1983: 185). Acknowledged that it may not necessarily be so all the time, there is the tendency to appropriate NRs (land resources inclusive) in such a manner that warrants making

the gains of one individual to amount to the losses of another (see Chambers, 1983). And taking a recourse to the earlier words of Forsyth (2003) on the fate of the hapless poor people, those who advertently or inadvertently take such decisions on resource allocation and use, if they were to be discerning, should have known beforehand that it is the poor who would eventually be the loser (see Chambers, 2003).

So many policy shifts on land management have thus evolved over the years. The series of paradigm change, which soil fertility management research and development efforts in sub-Saharan Africa (SSA) have undergone from 1960 to date are captured by Vanlauwe *et al.* (2006: 259). This range from the soil fertility management paradigm of 1960s and 1970s, which placed emphasis on external input but with little or no significant recognition accorded the role of organic resources; the push for biological management of soil fertility as part of low-external input (LEI) sustainable agriculture in the 1980s; the second paradigm for tropical soil fertility research and remediation, which advocated for a combination of organic resources and inorganic fertilizer (Sanchez, 1994); and to the current paradigm, which focuses on the social, economic and political dimensions of soil fertility, known as integrated soil fertility management (ISFM).

ISFM is thus a set of locally adapted agricultural practices, which combine the use of both organic and inorganic fertilizers with the ultimate goal of maximizing nutrient and water use efficiency for increased and sustainable agricultural productivity. Buttressing the appropriateness of integrated nutrients management (INM) in conservation agriculture, Palm *et al.* (1997) indicate that a combination of inorganic and organic fertilizers in eastern and southern Africa has proved effective where an optimum combination ratio of 50% organic (e.g., *Tithonia* and *Sesbania*) and 50% mineral N sources (e.g., urea) are carried out. Elsewhere, Nandwa and Bekunda (1998) and Jama *et al.* (1997) have also reported Qureshi (1987) and Swift *et al.* (1994) field trials where there are similar cases of increased and sustained crop yields resulting from the conscious effort to integrate mineral fertilizers and farm yard manure (FYM) in crop fields. This implies that government policies on land management may find relevance in enhancing local people's livelihoods and wellbeing by strictly pursuing a similar model in the Okavango Delta.

Methodology

Study Area

The choice of the Okavango Delta in north-western Botswana is influenced by the peculiarity of the socio-ecological environment and its importance to Botswana's national economy. The area comprises the Ngami and Okavango sub-districts. There are about 50 villages and other farming communities in the Delta. While majority

(75%) of the farming activities in the area rely on rain-fed agriculture, 25% of crop production activities are carried out in inundated flood plains known as *Molapo* fields (VanderPost 2009). Ethnic groups including the San and Herero people of the Xai Xai community are the inhabitants of the Okavango Delta. They engage in cattle rearing, gathering and hunting veldt products and game. Crop failure is commonplace particularly under the rain-fed farming system. The long-term average yields in the study area are 162 kg/ha for maize, 121 kg/ha for sorghum, 144 kg/ha for millet and 28 kg/ha for pulses. While variations exist from year to year due to the degree of annual flooding, crop yields under *Molapo* farming are generally higher than those under rain-fed system and could be as high as 1800-2900 kg/ha for sorghum (Bendsen, 2002), which is a major staple crop in the area. As most of the farmers practise upland farming and whose yields are relatively lower than their counterparts' under the *Molapo* farming system, there is need to critically devise means of improving soil fertility, particularly as they relate to access to and use of agricultural inputs. Besides agriculture, another major source of livelihoods in the Delta area is community-based tourism (EIA, 2004).

Sampling procedure and sample size

A multi-stage sampling procedure was used to select small farmers: A purposive sampling of all the three main geographic areas of Ngamiland District was carried out. The geographic area comprises the panhandle, the mid-Delta and distal area of the Okavango Delta river basin. Mohembo West and Kauxwi were selected in the panhandle; Nokaneng and the surrounding satellite villages in the mid-Delta area; and Chanoga, Xana and Makalamabedi in the distal area. While the panhandle area is mainly inhabited by the HamBukushu farmers, the mid-Delta is inhabited by BaYeyi and Batawana farmers who are commonly found in the distal end of the Delta. Also based on the available population data from the Central Office of Statistics (CSO, 2011), farmers' populations were selected proportionately from each of the communities. Finally, a random sampling technique was then used to select a total of 228 farmers in Makalamebi, Nokaneng and Mohembo (including all the surrounding satellite villages) (Figure 1).

Through our initial interactions with 228 small farmers in the three geographic locations, a number of active farmers were identified and from which 10 smallholders were randomly selected (from the panhandle, mid-Delta and distal area of the Okavango Delta) for the purpose of taking soil samples from their farms.

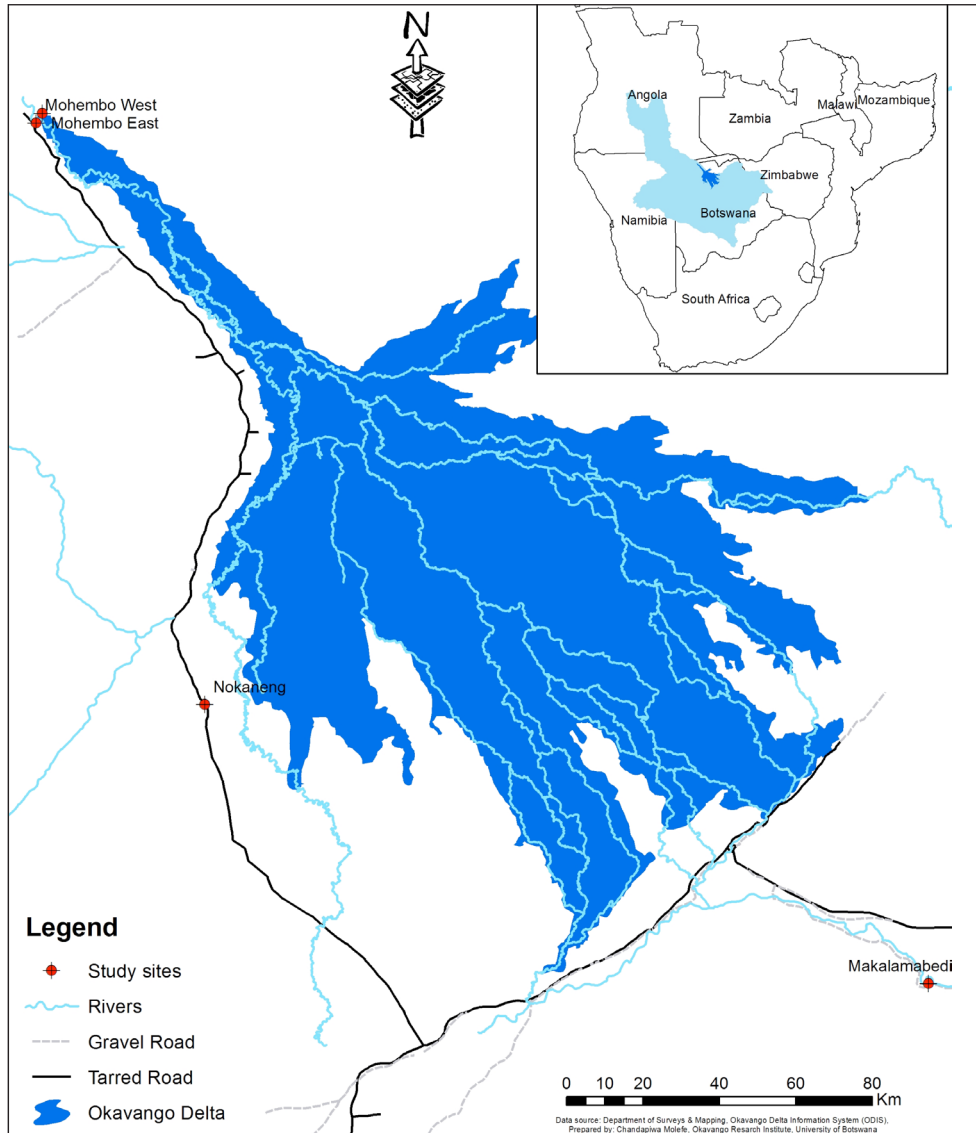


Figure 1 - A map showing the Okavango Delta and communities studied (Courtesy: Chandapiwa Molefe, GIS Laboratory, Okavango Research Institute, University of Botswana).

Social survey instruments

Pre-tested, open and close ended interview schedules were used to obtain quantitative data from the farmers. Close and open ended questions, which addressed explanatory variables ranging from demographic/economic, psychosocial, institutional and environmental issues in relation to soil management, were constructed in the interview schedules. Demographic/socio-economic variables included income, education level, etc. and psychosocial variables included those relating to farmers' perceptions about institutions and political ecology of soil management (comprising power relations, decision-making on knowledge production, policies, regulations, etc.). To measure respondents' perceptions about the political ecology of soil management, 8 Likert items/statements were constructed based on field observations and literatures (see for instance, Bryant and Bailey, 1997; Blaikie, 1985; Watts and Peet, 2004: 1-40; Forsyth, 2003). The items were then placed on a 5-point rating scale of strongly agree (5 points); agree (4); undecided (3); disagree (2); and strongly disagree (1). Most questions, including farmers' perceptions about political ecology, were therefore constructed and measured using a 5-point rating scale. The instruments (i.e. interview schedules) were translated from English to Setswana by a professional translator. To obtain qualitative data, key informant interviews and 3 knowledge validation [participatory] workshop sessions were organized for farmers representatives and other stakeholders who converged in Makalamabedi and Nokaneng and Mohembo communities in August, September and October 2012, respectively.

Soil sample collection and laboratory analysis

Site description

The sampling area is situated within the Okavango Delta in the North West District of Botswana. The parent materials from which the tropical soil series in the Okavango are formed include lacustrine, aeolian and alluvial deposits (Staring, 1978). The area is flat with silty sands and very low fertility (FAO, 2006). In summer, average daytime temperature range is normally 30-40 degrees Celsius and annual rainfall average is 450mm.

Soil sampling and chemical analysis

Soil sample analyses were carried out to verify and complement smallholder farmers' viewpoints on the poor health status of the soils in the study area. Thus

Makalamabedi (and its satellite villages), Nokaneng and Mohembo communities¹ located along the western side of the Okavango Delta were chosen for the study (Figure 1) as a result of their active engagement in farming activities, which serve as the people's foremost livelihood strategies. Thus thirty-three (33) composite soils samples taken at the depth of 300 mm were obtained from randomly selected farmers' plots in the three communities. These were active farmers, who also constituted a part of the 228 farmers randomly selected for the initial social survey. Each sample number represents a farmer's plot. Farmers' fields/plots were selected on the basis of (i.) location; (ii.) farmers' participations in social surveys conducted and our series of knowledge validation workshops; and (iii.) farmers' willingness to allow the collection of soil samples from their plots.

The sampling plots were first visually evaluated for differences in soil type and topographic sloping before soil samples were collected. All farms were observed to have homogenous soils except for three, which had differences in soil types. As such, three sub-samples were collected from each of the 27 farms with the same soil type, and mixed together to make a composite sample, which was then transferred to the laboratory for analysis. From the farms with two different soil types, two separate composite soil samples were also collected for analysis in order to ensure that management of the areas is appropriately targeted for each specific soil type. Thus two composite soil samples were collected in one of the farmers' plots at Makalamabedi, i.e. site MA-4, where the second composite soil sample from a different location in the same plot represented MA-5 (Table 1). Also, two different composite soil samples were collected at site MOH-22 in Mohembo because of the heterogeneity of the field's soil physical property. The first composite sample was tagged MOH-22 and the second, MOH-23 (Table 1). Elsewhere in Mohembo, two different composite samples were collected at another site (MOH-24). In other words, two different composite soil samples from two different parts of the plot were derived from MOH-24 and MOH-25 (Table 1). Thus, a total of 33 composite soil samples were collected from 30 purposively selected farmers' fields in October, 2012 at four different occasions in Makalamabedi and its environ (11 samples), Nokaneng and its environ (10), Mohembo West and Mohembo East (12). Soil samples were then taken for analysis to assess the nutrient status. Laboratory data were further subjected to a one-way analysis of variance (ANOVA) to determine whether there were significant differences in soil nutrients and chemical compositions in all the three locations; in this case, location is the factor. The assumptions guiding the use of ANOVA (i.e. those of random selection, sample independence, normal distribution and commonalities in attributes) were strictly observed (see Zaiontz, 2014).

¹ Communities, sites and locations are used interchangeably to mean the same thing in the soil sample analysis carried out. Makalamabedi and Nokaneng have other small settlements or satellite villages, which are grouped with the two major communities, accordingly.

Laboratory analysis

Soil samples were air-dried for about 5 days and then sieved through a 2mm sieve and kept in sealable plastic bags ready for chemical analysis. Samples were then analyzed for phosphorus (P), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and CEC, and pH. Exchangeable cations (Ca^{2+} , Mg^{2+} , Na^+ , and K^+) were extracted with neutral ammonium acetate and then measured by Atomic Absorption Spectrometer (Ca^{2+} and Mg^{2+}) and Flame photometer (Na^+ and K^+). Phosphorus (P) content was analyzed using Bray II, extracted with ammonium fluoride and measured by colorimetric method (Houba *et al.*, 1988).

Results and discussion of laboratory analysis

Findings from literature show that the soils in this area are deep sandy soils with low fertility (FAO, 2006). The pH ranges between 4 and 7 in all the three areas, indicating acidic and neutral soil conditions. Phosphorus levels are too low in all the sites, mostly below 5 parts per million (ppm), which is far below the optimal level of 10 ppm. CEC, which is a measure of the nutrient holding capacity of a soil, is generally low; low CEC means that the soil cannot hold essential soil nutrient reserves (i.e. exchangeable cation ions like Mg^{2+} , K^+ , Ca^{2+} and Na^+), or release them for plant uptake when needed. For instance, high concentration of Al^{3+} and H^+ in a typical acid soil will most likely prevent the effective absorption of essential nutrients like those mentioned above as a result of certain 'antagonistic relationship' occurring between the mineral elements and saturation of exchange sites with these two cations. Thus the reaction between the plant root hairs and soil colloids has an important influence on whether essential nutrients are tied down or made available for plant root absorption. More importantly, a soil that is low in organic matter content and clay materials is prone to leaching and unable to hold essential nutrients needed for plant growth (see for instance, Hardy *et al.*, 2012; Astera, 2008; WSU, 2004). The texture of a given soil type determines its CEC level. For example, while sands (light-colored) have a CEC value of between 3-5 meq/100g soil, sands (dark-colored) have between 10-20 meq/100g soil. While loams and silt loams have a CEC value of 10-15 and 15-25 meq/100g soil, respectively, clay and clay loams have a CEC value of 20-50 meq/100g soil. Nonetheless, organic soils have 50-100 meq/100g soil (WSU, 2004). Please note that the SI units or International System of Units uses cmol/kg as a measure for most of the soil chemistry parameters. For instance, 10 meq K^+ /100g = 10cmol (K^+) kg^{-1} (Reganold and Harsh, 1985).

Mohembo (MOH) soils are very acidic with an average pH of 5.1, low exchangeable cations and low P level. Although a grand average of 2.90 ± 3.58 of CEC level was obtained in Mohembo, the values for the majority (66.7%) of soil samples in the

plots analyzed for the location is below 2.5 cmol/kg, the optimal level required for minimum crop yield. This explains the relatively high level of dispersion between the individual and grand mean scores for Mohembo. However, the CEC value in Makalamabedi soils (MA) is on the border-lines (averaging ~ 3 cmol/kg) but relatively good in Nokaneng (NOK), ranging between 5-30 cmol/kg). The CEC values obtained in Nokaneng show that the soils in the location range from light sands (light-colored), sands (dark-colored), silt loam to clay/clay loam. There are virtually no organic soils in all the locations.

Determining variations in soil nutrient levels in different localities

We carried out a one-way ANOVA to determine whether there were variations or differences in nutrient levels in relation to location. The results show that the pH levels within the three communities indicate no significant difference ($F(2, 27)=2.658$; $p \leq 0.087$). Nonetheless, all other parameters indicate a significant difference in the levels of soil essential nutrients in the three locations and their surrounding satellite villages. For instance, the levels of P ($F(2, 27)=8.569$; $p \leq 0.001$); Na ($F(2, 27) = 18.573$; $p \leq 0.000$); K ($F(2, 27)=12.821$; $p \leq 0.000$); Ca ($F(2, 27)=11.217$; $p \leq 0.000$); Mg ($F(2, 27)=10.058$; $p \leq 0.000$); and CEC ($F(2, 27)=13.279$; $p \leq 0.000$) were significantly different at 99% confidence level. It is, however, instructive to note that while variations exist in soil nutrient levels between the three locations, the poor trend of low level of essential nutrients is more or less the same in all of the sites (Figure 2). But even so, these noticeable spatial variations warrant the need to objectively view soil management problems through a special lens, which Blaikie and Brookfield (1987: 17) referred to as 'regional political ecology'.

Thus soil analysis revealed that most of the soils in the three sites are of low fertility and acidic in nature. Whereas the average soil pH in the three geographic locations ranges between 5.1-5.7, it is instructive to note that most field crops perform best at soil pH of between 6.0 - 6.8 and the optimal pH for most crops grown on mineral soils is 5.8 - 6.2 (Crozier and Hardy, 2003; Mamo *et al.*, 2003). Naturally, sandy soils have low nutrient level, low organic matter, poor soil structure and low water holding capacity, which are a big challenge for agricultural production (FAO, 2005). The removal of cations (such as Ca^{2+} , Mg^{2+} , K^+ , and Na^+) through leaching and erosion in poorly structured soils (like sands) would normally result in acidity. Leaching, which is naturally associated with sandy soils, and the high volatility of nitrogen (N) particularly in an arid environment where the Delta is situated, may have probably engendered the zero values obtained in the analysis for available N in the

soil samples. The nutrient level is, therefore, generally poor² especially in Mohembo and Makalamabedi areas where most minerals and CEC are below the optimal levels required for plant growth (Table 1 and Figure 2). Phosphorus is also a serious limiting factor in all the three sites. Better soil quality in Nokaneng (a community situated in the mid-Delta) may have been influenced by the variations in water surge/flood pulse of the Okavango River as it enters Mohembo (an upstream community) and probably determining the amount of rich alluvial deposits at different points along the river channels; alluvial erosion is likely to be significantly higher in Mohembo as compared to the mid-Delta and the distal area, which is far removed from the Delta (Figure 1).

Barring a few cases, the averages computed for all the parameters analyzed in the study throughout show a relatively slight dispersion from the mean within both intra- and inter-locations particularly for pH, P, Na and K (see Table 1). The pH mean value in Makalamabedi, Nokaneng and Mohembo is 5.7 ± 0.28 , 5.1 ± 0.22 and 5.1 ± 1.21 , respectively. Phosphorous mean value is 0.51 ± 0.52 , 2.45 ± 1.29 and 1.16 ± 1.31 for Makalamabedi, Nokaneng and Mohembo, respectively. The mean value for Na is 0.06 ± 0.07 ; 0.16 ± 0.08 ; and 0.02 ± 0.02 in the order in which the sites/communities occur above. The average for K in the three locations is 0.20 ± 0.15 ; 0.55 ± 0.33 ; and 0.11 ± 0.09 also in that order. The mean computed for Ca is 2.21 ± 2.13 ; 9.15 ± 3.68 ; and 3.36 ± 4.45 in the three locations. While the mean score of Mg in Makalamabedi, Nokaneng and Mohembo is 0.76 ± 0.87 ; 1.88 ± 1.06 ; and 0.38 ± 0.37 , respectively, the mean value computed for CEC in the three locations is 5.35 ± 6.81 ; 15.92 ± 7.78 ; and 2.90 ± 3.58 . As earlier observed, the variations existing between intra- and inter-locations in relation to the individual plots and grand averages and between locations are minimal except for P that is slightly higher in Nokaneng and Mohembo. Also, there are significant variations in the Ca levels in the three locations. The average level of the Mg is slightly higher in Nokaneng than in Makalamabedi and Mohembo. Also, the average for CEC level in Nokaneng is far beyond the values obtained in the two other locations.

Generally, the soil fertility status in the study area poses a challenge for a meaningful agricultural productivity and sustainability³. Whereas appropriate recommendations on chemical fertilizer use may have been jeopardized by the seemingly 'strict'

² One of the primary intentions of this paper was to determine and compare the nutrient levels of the soils in different locations in the study area. The poor condition of the soils is as a result of a combination of many factors (i.e. physical, biological, chemical, socio-economic and anthropogenic), some of which have already been identified in the paper.

³ Based on these findings, the standard soil analysis report, which was produced by the Soil Analytical Laboratory at the Department of Agricultural Research, Gaborone, suggests that agricultural lime needs to be applied at 1 ton/ha of farmlands in order to address the low pH level in most of the sites except for sites 2, 5-6 and 25-27 (Table 1) where the 'pH is fine'. Please note that the Botswana's Ministry of Agriculture (MoA) recommends liming for the country's sandy soils at any pH, which is less than 6.

Table 1 - Soil nutrients levels in Makalamabedi, Nokaneng and Mohembo communities.

SAMPLE/SITE NUMBER	pH	P (mg/kg)	Na (cmol/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	CEC (cmol/kg)
MA-1	5.4	0.20	0.00	0.02	1.17	0.38	3.40
MA-2	6.0	0.60	0.20	0.24	1.44	0.88	1.00
MA-3	5.9	0.00	0.12	0.21	1.81	0.74	1.80
MA-4	5.9	1.60	0.07	0.15	2.12	0.40	2.40
MA-5	6.2	1.21	0.06	0.42	5.03	1.17	7.20
MA-6	6.0	0.02	0.01	0.15	1.34	0.37	2.00
MA-7	5.6	0.28	0.01	0.15	0.93	0.37	0.62
MA-8	5.6	0.79	0.01	0.15	1.27	0.35	23.80
MA-9	5.6	0.64	0.01	0.07	0.67	0.14	3.40
MA-10	5.3	0.04	0.01	0.12	1.02	0.33	2.40
MA-11	5.6	0.24	0.13	0.51	7.54	3.21	10.80
MA-Mean	5.7±0.28	0.51±0.52	0.06±0.07	0.20±0.15	2.21±2.13	0.76±0.87	5.35±6.81
NOK-12	5.3	3.39	0.13	0.76	10.60	1.25	23.60
NOK-13	5.2	3.06	0.15	0.65	9.99	2.55	15.60
NOK-14	5.3	0.20	0.19	0.22	13.78	3.37	18.00
NOK-15	5.5	1.44	0.16	0.83	14.11	3.25	22.00
NOK-16	5.3	0.95	0.07	0.35	5.57	1.07	7.60
NOK-17	4.9	3.57	0.04	0.22	3.47	0.43	5.80
NOK-18	5.0	4.18	0.29	1.27	12.87	3.04	30.80
NOK-19	4.9	2.88	0.14	0.41	6.51	1.23	10.40
NOK-20	4.8	3.31	0.24	0.28	7.59	1.30	13.20
NOK-21	5.1	1.81	0.23	0.49	7.01	1.28	12.20
NOK-Mean	5.1±0.22	2.45±1.29	0.16±0.08	0.55±0.33	9.15±3.68	1.88±1.06	15.92±7.78
MOH-22	4.0	0.9	0.01	0.02	0.15	0.06	0.20
MOH-23	4.3	1.2	0.01	0.05	0.60	0.14	0.20
MOH-24	4.3	0.1	0.01	0.06	0.85	0.16	0.40
MOH-25	6.5	1.1	0.02	0.23	5.73	0.41	4.00
MOH-26	6.4	0.6	0.01	0.18	1.96	0.39	4.00
MOH-27	6.8	3.9	0.03	0.16	11.90	0.76	2.00
MOH-28	7.0	3.5	0.07	0.30	12.22	1.22	13.40
MOH-29	4.4	0.0	0.02	0.15	4.82	0.82	1.80
MOH-30	4.2	0.0	0.01	0.06	1.08	0.37	2.10
MOH-31	4.5	0.6	0.01	0.05	0.62	0.14	3.40
MOH-32	4.2	0.2	0.01	0.03	0.25	0.07	1.40
MOH-33	4.0	1.8	0.01	0.04	0.13	0.07	1.40
MOH-Mean	5.1±1.21	1.16±1.31	0.02±0.02	0.11±0.09	3.36±4.45	0.38±0.37	2.90±3.58

Source: Laboratory analysis (2013). Key: MA – Makalamebedi; NOK – Nokaneng; MOH - Mohembo

regulations in the Molapo farming system, which constitutes only 25% of the total farmlands in the Delta, their right combination with organic fertilizers in the surrounding upland farms, where CEC is low could prove worthwhile for soil optimal performance (Scoones and Toulmin, 1999: 56) in a peculiar ecological environment such as the Okavango Delta.

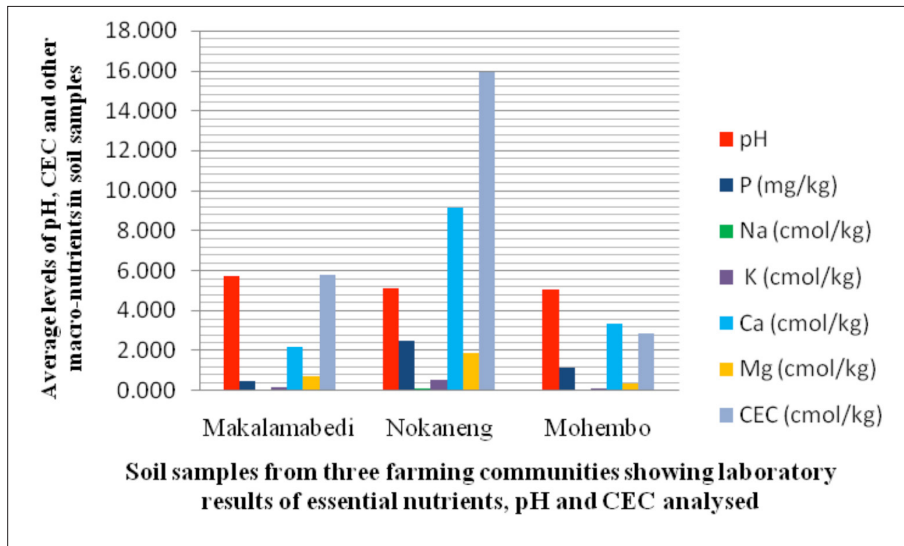


Figure 2 - Average values of pH, essential macro-nutrients' levels and CEC in Makalamabedi, Nokaneng and Mohembo communities in north-western Botswana.

More importantly, Figure 2 above shows the general trends in soil chemical composition and quality in the Delta and the surrounding environment. A cursory look at the bar graphs suggests that the trend is similar in all the three areas but with a better outlook in Nokaneng, which is a community situated in the mid-Delta. As earlier observed, it could probably be inferred that alluvial deposits induced by the flood pulses entering Botswana at Mohembo may have accumulated more in the mid-Delta area than in the flood pulse entry point up north as well as in the distal area, where Makalamabedi is situated (Figure 1). Although not totally fault proof, Botswana government - in its bid to protect the pristine environment of the Okavango Delta - tends to strictly regulate the use of agricultural chemicals in the area. Information made available by the Department of Crop Production indicates that fertilizer applications are not allowed in farms situated along the river banks. However, only farmers who registered under the government's Integrated Support Program for Arable Agricultural Development (ISPAAD) (also known as President's Initiative), and who also have and or use planters/machineries are provided fertilizers

to enable them (farmers) apply the agro-chemicals in rows and not in a haphazard manner. These are upland farmers whose farms are situated in relatively far distances away (~200 meters or more) from the river courses. Acknowledging the minimal use of agricultural chemicals in the Delta, Masamba (2009) points out that farmers use livestock manure in some cases to replenish their soils. Whereas, the acidity of the soils in the area could easily have been linked with continuous fertilizer applications if this were to be the case, the natural occurrence of this phenomenon appears to be a daunting challenge - a catch-22 situation. Although available in abundance, farmers in some locations do not appear to have any strong inclination towards the use of cow dung in enhancing the fertility of their farmlands. For instance, in the series of interactions with farmers during our workshops and key informant sessions, the smallholders in Makalamabedi said they stopped using cow dung because they perceived that its use induces the growth of new weed species in their fields. This is probably due to the mode of seed dispersal via the dung of locally herded cattle, which naturally eat different fodders and wild plants.

Results and discussions of social survey

Farmers and scientists' socio-economic and demographic attributes

Data in this section show the distribution of farmers by some of their socio-economic characteristics. Most (65.4%) of the farmers in the Okavango Delta are women. The average age of the farmers was 51 years with a standard deviation of ± 16.18 . While only 6.6% of the farmers aged below 26 years, some 23.7% of them were within the age bracket of between 41-50 years. About 19% of the population aged between 51-60 years. A substantial percentage (22.4%) of the farmers were above 65 years. This indicates that about 41% of the farmers were 50 years and above. And based on the average, majority of the farmers were able bodied men and women. About 40% of the farmers neither had formal nor non-formal education at all. While some 16.7% of farmers had secondary education, barely less than 1% of them had post-secondary education. The analysis shows that a majority of the farmers in the study area did not acquire substantial Western education.

Farmers' perceptions on the political ecology of soil fertility management

Resolving soil management issues would mean putting those who manage soils (e.g. farmers, pastoralists, etc.) at the 'centre stage' in an effort to 'learn from the land managers' perceptions of their problems' (Blaikie and Brookfield, 1987: 16). In this sub-section, we analyze farmers' perceptions on the political ecology of soil fertility management in the study area. While the highest point was assigned to a farmer who

strongly agreed with each of the statements, the lowest point was assigned to a farmer who strongly disagreed with anyone of them. Over all, the maximum score, which a farmer could obtain, was 40 points, and the minimum was 8 points from which his or her average is computed based on the farmer's responses on the Likert items (in this case, 8 statements) measured on the Likert scale. The sum total of the points acquired for all the Likert items comprising each construct is a measure of the variable under analysis (see for instance, Carifio and Perla, 2007; Glass *et al.*, 1972; Likert, 1932). The average score of the farmer was calculated based on his or her total scores derived from all the responses on the Likert items (in this case, 8 statements) measured on the Likert scale.

As the responses of farmers on the subject are considerably similar in all the three geographical locations, the average of the entire population was therefore computed. Thus data analysis shows that the average score of the farmers was 3.26 with a standard deviation of ± 0.98 . Data indicate that half (50%) of the farmers either agreed or strongly agreed that '[i]ndustrialists⁴ have taken a fair share of the community land, therefore, leading to lack of attention to soil management' by the government. The pervasiveness of tourism industry and the priority given to the sector over agriculture in the Okavango Delta may have influenced lack of 'political will' on soil fertility management. However, 47.4% of them held a contrary opinion on the issue. While 49.1% of the farmers felt that '[s]oil erosion problem has been largely caused by continued deforestation as a result of industrialisation', 38.1% of them felt otherwise. Also, 59.3% affirmed that '[s]oil erosion problem has not been given any serious attention by the government except when it affects the powerful elite'. Nonetheless, 28.5% of the farmers held a contrary viewpoint on the matter. While most (61.4%) of the respondents agreed that '[e]nvironmental degradation resulting from the unwholesome activities of the industrialists may have had negative impacts on smallholder agricultural production in my area', only 24.6% of them had different opinions. Thus the incessantly passive and or full blown conflicts over the use of land between '...small farmers and the state, developers and concerned landholders' (Blaikie and Brookfield, 1987: 4) are pervasive. Elsewhere, almost half (~50%) of the farmers felt that '[t]he riverine nature of my area and its inaccessibility may have discouraged extension personnel and other agricultural workers from accessing my community for any meaningful soil fertility intervention'. Nonetheless, 37.3% of the farmers did not agree with the statement. Those who disagreed may have been the farmers who are situated in the hinterland and who engage in dryland agriculture. While a significant 68.8% of the respondents perceived that '[a]ny government intervention on land management is only felt when the powerful elite

⁴ Given that the most prominent industry in the Okavango Delta is tourism, industrialists in this context are mainly the tourism business operators.

farmers are affected in my area, 22.4% of them did not see the issue in the same light. The ISPAAD provides an example of the platform through which the government provides farmers with access to farming inputs. Under the program, only farmers who registered under the President's Initiative and those who at the same time have acquired and or used planters/machineries could only access free fertilizers from the government, thus providing the legitimacy to use the product in the Delta area. As earlier indicated, however, those whose farms are about 200 meters away from the river channels are eligible to access fertilizers. Further finding shows that the Government of Botswana does not issue certification to the farmers who traditionally engage in flood recession (Molapo) farming in the Delta, through which they could otherwise have been eligible for fertilizer subsidy. While the government does not give any legitimacy to the practice of Molapo farming, it only allows farmers to perpetuate this age-long livelihoods practice (Magole and Thapelo, 2005) but with the proviso that no agricultural chemical inputs are used. This policy is enacted to prevent the acidification or pollution of the Okavango Delta rivers. Also, while a about 66% of the respondents felt that '[p]opulation pressure has continued to reduce access to land use and its management', some 30% of them had different opinions. As about 47% of the farmers either strongly disagreed or disagreed that '[t]he development of infrastructure such as road building and the like may have impacted negatively on the available fertile land in this area/community', about 46.5% of them either strongly agreed or agreed with the statement. Only about 7% of the farmers had no opinion on the matter. It is therefore deduced that certain community people/farmers perceived that they have been directly affected and somewhat negatively impacted by infrastructural development projects. Essentially, the relatively high average score (3.26 ± 0.98) of the farmers indicates that they had negative perceptions about government regulation/policy on the use and management of natural resources in relation to the implementation of soil fertility management.

Government agricultural policy and initiatives

Policies are a set of guidelines, which are developed to achieve certain objectives in government bureaucracies and private-oriented concerns. Policy reforms, on the other hand, are meant to bring about improvement in the way government services are delivered to members of the public. Thus reforms 'are deliberate efforts on the part of government to redress perceived errors in prior and existing policy and institutional arrangements' (Grindle and Thomas, 1991: 4). Depending on how they view and define the existing problem, a range of policy options exists from which decisions makers have the prerogative to choose. As such, the content of any policy

Table 2 - Percentage distribution of farmers by their perception on the political ecology of integrated soil fertility management ($n = 228$) ($M = 3.26 \pm 0.98$).

SN	Item*	SA(5)	A(4)	U(3)	D(2)	SD(1)
i	Industrialists have taken a fair share of the community lands, therefore, leading to lack of attention to soil management	60 (26.3)**	54 (23.7)	6 (2.6)	49 (21.5)	59 (25.9)
ii	Soil erosion problem has been largely caused by continued deforestation as a result of industrialisation	29 (12.7)	83 (36.4)	29 (12.7)	37 (16.2)	50 (21.9)
iii	Soil erosion problem has not been given any serious attention by the government except when it affects the powerful elite	61 (26.8)	74 (32.5)	28 (12.3)	22 (9.6)	43 (18.9)
iv	Environmental degradation resulting from the unwholesome activities of the industrialists may have had negative impacts on smallholder agricultural production in my area	56 (24.6)	84 (36.8)	32 (14.0)	25 (11.0)	31 (13.6)
v	The riverine nature of my area and its inaccessibility may have discouraged extension personnel and other agricultural workers from accessing my community for any meaningful soil fertility management intervention	42 (18.4)	71 (31.1)	30 (13.2)	36 (15.8)	49 (21.5)
vi	Any government intervention on land management is only felt when the powerful elite farmers are affected in my area	73 (32.0)	84 (36.8)	20 (8.8)	25 (11.0)	26 (11.4)
vii	Population pressure has continued to reduce access to land use and its management	52 (22.8)	99 (43.4)	11 (4.8)	36 (15.8)	30 (13.2)
viii	The development of infrastructure such as road construction and the like may have impacted negatively on the available fertile lands in this area/community	44 (19.3)	62 (27.2)	15 (6.6)	58 (25.4)	49 (21.5)

Source: Field survey, 2012

*Multiple responses

**Percentages are in parenthesis ()

SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree

initiatives is determined by how policy elites perceive the problem at hand (Grindle and Thomas, 1991: 9), in this case environmental degradation and food insecurity. While domestic policy choices and reforms are determined by internal and external factors, 'political perspectives', 'economic pressures', 'strategic choices of state reformers' and 'international financial institutions' (IFIs) are four major influencers of reforms (Heredia and Schneider, 2003). There are a number of initiatives put in place to achieve government policy objective on agricultural development

in Botswana. These include the Arable Land Development Program (ALDEP); Accelerated Rain-fed Arable Program (ARAP), Drought Relief to Arable Farmers (DRAF) and Integrated Support Programme for Arable Agriculture Development (ISPAAD) also known as the President's Initiative. However, the ISPAAD seems to be the most popular amongst them. Introduced in 2008, the program is considered as one of the major schemes established for the purpose of enhancing agricultural support mainly for Botswana smallholder farmers. By design, the initiative is meant to address challenges facing the arable sub-sector in relation to farmer's poor technology adoption and low productivity. The primary objectives are tailored towards increased grain production; promotion of food security at household and national levels; commercialization of agriculture through mechanisation; facilitation of access to farm inputs and credit; and improved extension outreach. To achieve the scheme's objectives, key thematic areas include cluster fencing; provision of potable water, seeds and fertilizers; facilitation of access to credit; establishment of agricultural service centres; and draught power provision (MoA, 2011).

Paradoxically, while ISPAAD, by design, is established to benefit all small farmers across all regions, it is bedeviled by a number of factors including poor awareness, policy regulations which disfavor a group of farmers based on where they are and what they have. For instance, farmers who are not certified or do not have officially allocated or leased land are not qualified to participate in the program (MoA, 2011). Key informant interview conducted in Makalamabedi, Nokaneng, Mohembo and Danega communities indicate that while some farmers benefited from the government initiative, poor coverage and lack of awareness by many farmers are a major problem. Smallholder farmers who had awareness of the program remarked:

Some of us have planters. Government has, through compensation, assisted some of us to plough our farmlands because the farms are free of tree stumps... Those who benefit also receive free seeds. Although most of us wish to benefit from the government initiative, some individuals do not qualify to partake in it because they lack machineries like planters, which are a basic requirement (Small farmers in Mohembo, Nokaneng and Makalamabedi, August 2013).

Smallholders who lacked awareness of the scheme also remarked:

We only heard about the initiative through the radio and television but have little information and knowledge about it. The agricultural extension people (Balemisi) are yet to educate us on the procedures for participating in the program. More importantly, we are all interested in the scheme if we are availed the opportunity in our community (Small farmers in Mohembo and Makalamabedi, August 2013).

It is noteworthy that five years after the commencement of ISPAAD, many farmers

indicated they were yet to be personally reached and educated on how to participate in the initiative. Aside the policy which discourages those who farm close to the river channels to not participate in the program, extension personnel are yet to reach out to farmers in many remote villages and educate them on how they could benefit from the initiative.

Conclusions and policy implications

The paper determined the nutrient levels of selected farmers' fields in the Okavango Delta [section 1]; and analyzed the perception of small farmers about the political ecology of soil management and how this has impacted the smallholder and their socio-economic well-being [section 2]. Laboratory analysis showed that all the soils in the three farming communities are acidic, low in CEC, sandy and generally poor in nutrient levels. Further analysis indicated that there are significant differences in the nutrient levels in the three locations but the trends are the same, although Nokaneng soils seem to be the most promising for crop production. However, the prevalent problem of soil infertility constitutes a serious concern for agricultural productivity and sustainability in the Okavango Delta. Overall, the soil analysis achieved two things. First, the exercise validated observational evidences and farmers' observations that the soils in the Okavango Delta are poor. Second, it points direction to the urgent need for a pro-active policy formulation and management strategy, which are designed to improve agricultural lands in the Delta. More importantly, the ANOVA results, which showed variations in soil nutrient levels in different locations within the Okavango Delta, underscore the need to de-emphasize the deployment of a straight-jacket approach to land management issues in the area and other similar ecological contexts in southern Africa, and beyond. Indeed, taking 'account of environmental variability and the spatial variations in resilience and sensitivity of the land, as different demands are put on the land through time' (Blaikie and Brookfield, 1987: 17) further buttresses the need to not treat soil management issues in a simple, linear fashion. As such, land management policies that are exclusively designed and implemented to meet the specific needs of different localities are deemed plausible.

Although loophole exists in its implementation, government policy on non-issuance of certification to certain categories of farmers - who do not have and or use planters/machineries, and are not registered under ISPAAD - is a reflection of the political ecology of soil management in the Okavango Delta. Although farmers whose plots are 200 meters or more away from the river banks are allowed to use chemical inputs, including fertilizers, majority of them do not have access to the products. The drive towards biodiversity conservation and eco-tourism development which is prioritized over *Molapo* farming system may have been detrimental to people's livelihoods. While farming remains an important livelihood strategy of

rural communities, policies on natural resource governance particularly the aquatic environment delimit local farmers' ability to engage in meaningful soil fertility management. The need to achieve food security in rural households without adequate mechanisms for attaining the goal *vis à vis* the existing policy regime of environmental conservation in the Delta presents a rural development conundrum yet to be resolved. The low CEC of the soils is an indication that holistic cultural practices, which are beyond mere chemical fertilizations, are critical and more desirable for improved soil health and sustainable rural livelihoods in the area. Although environmental conservation is a key component in the drive towards sustainable development, there is need to provide suitable cultural and environmental-friendly alternatives to any conventional approach in the Okavango Delta (see also, Kolawole, 2013). This will enable farmers operate freely and thrive within the current policy regime.

The relatively high average perceptual score of the farmers indicates that they had a negative viewpoints about government policy on soil fertility management in the Okavango Delta. Given the ecological peculiarity of the area and recognizing the need to devise pro-active strategies in enhancing soil fertility, relevant field trials (in collaboration with small farmers) are proposed. To fill the present gap between farmers and their access to the use of appropriate agricultural inputs in most parts of the Delta, such recommended trials need to focus on the identification, development and use of appropriate organic products. Ultimately, policies that encourage and enhance this process will be an imperative for meaningful environmental conservation, and sustainable agricultural and rural development.

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