

Political Economy of Integrated Soil Fertility Management in the Okavango Delta, Botswana

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Abstract—Although many factors play a significant role in agricultural production and productivity, the importance of soil fertility cannot be underestimated. The extent to which small farmers are able to manage the fertility of their farmlands is crucial in agricultural development particularly in sub-Saharan Africa (SSA). This paper assesses the nutrient status of selected farmers' fields in relation to how government policy addresses the allocation of and access to agricultural inputs (e.g. chemical fertilizers) in a unique social-ecological environment of the Okavango Delta in northern Botswana. It also analyses small farmers and soil scientists' perceptions about the political economy of integrated soil fertility management (ISFM) in the area. A multi-stage sampling procedure was used to elicit quantitative and qualitative information from 228 farmers and 9 soil researchers through the use of interview schedules and questionnaires, respectively. Knowledge validation workshops and focus group discussions (FGDs) were also used to collect qualitative data from farmers. Thirty-three composite soil samples were collected from 30 farmers' plots in three farming communities of Makalamabedi, Nokaneng and Mohembo for laboratory analysis. While meeting points exist, farmers and scientists have divergent perspectives on soil fertility management. Laboratory analysis carried out shows that most soils in the wetland and the adjoining dryland/upland surroundings are low in essential nutrients as well as in cation exchange capacity (CEC). Although results suggest the identification and use of appropriate inorganic fertilizers, the low CEC is an indication that holistic cultural practices, which are beyond mere chemical fertilizations, are critical and more desirable for improved soil health and sustainable livelihoods in the area. Farmers' age ($t = -0.728$; $p \leq 0.10$); their perceptions about the political economy ($t = -0.485$; $p \leq 0.01$) of ISFM; and their preference for the use of local knowledge in soil fertility management ($t = -10.254$; $p \leq 0.01$) had a significant relationship with how they perceived their involvement in the implementation of ISFM.

Keywords—Access, Botswana, ecology, inputs, Okavango Delta, policy, scientists, small farmers, soil fertility.

I. INTRODUCTION

POLITICAL economy underscores the power relations existing between and amongst stakeholders in the allocation of scarce resources (including production inputs) in any given economy. Better still; the interplay between economic, political and legal institutions in the allocation of natural and physical resources defines the political economy of any human society. It is indeed more of a daunting

challenge in transboundary and international frontiers, particularly where different nations share common resources such as water and the like. To achieve meaningful success in African agriculture would mean that institutional bureaucratic red-tape and personal interests are properly addressed in order to ensure the formulation and enactment of appropriate agricultural and rural development policies. In rural development practice, political economy is about '... who gains and who loses' [1]. Indeed, *politics as usual* or a *crisis* situation plays a significant role in policy formulation and implementation [2] in agricultural reforms. Poor agricultural lands in combination with many other institutional factors in sub-Saharan Africa (SSA) have continued to engender chronic food shortages. As such, land degradation alone has reached a crisis situation in the SSA region where a number of strategies are already devised to address the problem [3]. For instance, the New Partnership for Africa's Development's (NEPAD's) Fertilizer Support Program (FSP) was put in place to enhance the use of fertilizers across Africa [4]. While the Abuja Declaration on Fertilizers for an African Green Revolution advocated for the need to substantially increase the use of fertilizers in Africa by 2015 [5], there was no mention of the peculiarity of the diverse ecological which the SSA is noted for. Well over six years after the meeting, and contrary to the summit's expectations that accessibility, affordability and quality of fertilizers available to African small farmers will be enhanced through a set of supposedly well implemented guidelines and actions, smallholders in the SSA continue to contend with the problems of soil infertility.

Nonetheless, the diversity and peculiarity of different ecological features associated with the African continent demand that a holistic and all-inclusive approach of soil fertility management be devised instead of a one-size-fits all strategy commonly pursued by national governments and international development partners. Of paramount interest is the low cation-exchange-capacity (CEC) noted as a major impediment to the optimal performance of most tropical soils, the category in which the soils in northern Botswana fall. Where this anomaly exists, plant nutrient uptake becomes difficult even where chemical fertilizers are applied [6]. There is therefore the need to ensure the balance in the four major components of the soil in terms of mineral elements, water, air, and organic materials [7] failing which its (soil) optimality becomes compromised in a significant way. It is acknowledged that organic manure application is necessary in ensuring the reversal of the anomalous soil condition particularly so where this does not prove difficult to accomplish [8]. The complexity of soil fertility management

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suggests that a holistic strategy (that encompasses a whole range of factors) needs to be adopted to address the problem of poor agricultural land performance in the sub-continent.

Integrated soil fertility management (ISFM) underscores the adoption of a research strategy that addresses a whole gamut of biological, physical, chemical, social, economic and political dimensions of soil degradation [9]. It thus seeks a balance between the bio-physical and chemical components of soil and water management in addition to improving soil nutrients through the application of a right combination of both organic and chemical fertilizers [10], [11]. The need for the implementation of an all-inclusive ISFM, which apart from addressing the socio-economic, bio-physical, biological, chemical and political factors of soil management should also emphasize its cultural dimension as reflected in the local knowledge of community people, which appears to have been overlooked for too long [3], [12].

This paper is rooted in Karl Marx's [13] production-determining relations in which '...men inevitably enter into definite relations, which are independent of their will, namely relations of production appropriate to a given stage in the development of their material forces of production'. The sum total of the mode of production (i.e. forces of production and property relations) and the relations of production (i.e. the nature of economic roles permitted by the state of development of property relations) constitute the [foundational] economic structure of any society on which the legal and political superstructure is built. Changes in a society's economic structure amount to changes in its social structure, which also translate to changes in the consciousness of its people [14]. There is thus always a class struggle between those who wield and control the means of production and those who use them. Small farmers (both women and men) who are 'vulnerable', 'physically weak', 'powerless', 'isolated', and financially poor [1] are those who are deprived of essential resources in meeting the requirements for their livelihoods; they are the people who also have to contend with unwholesome government policies in agricultural resource allocation and accessibility. A case in point will suffice. In an attempt to prevent the pollution and acidification of the water bodies within the Okavango Delta (which of course is a good environmental conservation ideal), the government of Botswana does not officially approve traditional flood recession farming (locally known as *Molapo* farming) practiced by the riparian communities in north-western part of the country. As such, the Land Board does not issue certificates to the local farmers practicing this farming method, thus making them to have no 'modern use rights' [15] to land for meaningful agricultural activities. Not only are they not officially approved for usufruct, poor farmers' access to fertilizers appear non-existent as government only subsidizes upland farmers and other categories of farmers who are certified and who use machineries in some agricultural operations, including those whose farms are 200 meters or more away from the river channels. Although loopholes in the policy exist, thereby engendering a problem in soil

management, the government continues to drive its environmental policies in the area.

In line with the above, the paper, therefore, seeks to assess the nutrient and CEC status of the soils in some selected farming communities spread across the Okavango Delta; describe the demographic and socio-economic attributes of both farmers and soil scientists in the area; analyze farmers and soil scientists' perceptions about the political economy of ISFM; and analyze the perceptions of farmers about their involvement in ISFM.

II. METHODOLOGY

A. Study Area

The study area is situated in Northwestern Botswana. It comprises the Ngami and Okavango sub-districts. There are about fifty villages and other farming communities. While majority (75%) of the farming activities in this area rely on rain-fed agriculture, about 25 per cent of farming activities are based on the use of inundated flood plains known as Molapo farming [15] in the Okavango Delta, which is '... home to a number of communities including the San and Herero people of the Xai Xai community. These communities survive on a combination of farming, owning small numbers of cattle or by gathering and hunting veldt products and wildlife.' One other means of livelihoods in the Delta area is community based tourism [16].

B. Sampling Procedure and Sample Size

A multi-stage sampling procedure was employed in selecting 2 groups of respondents for the study [small farmers and soil scientists/researchers] viz: A purposive sampling of all the three main geographic areas of Ngamiland District was carried out. The area comprises the panhandle, the mid-Delta and the Delta distal area. Mohembo West and Kauxwi were selected in the panhandle; Nokaneng and surrounding villages in the mid-Delta area; and Chanoga, Xana and Makalamabedi in the distal area. These selections provide a comprehensive coverage of the District as well as the cultural diversity in farming systems. While the panhandle area is mainly inhabited by Hambukushu farmers, the mid-Delta is inhabited by the Bayeyi farmers. However, Batawana farmers are commonly found in the distal end of the Delta. Also based on the available census data obtained from the Central Office of Statistics [17], proportionate sampling of 228 farmers within the selected major farming communities of Makalamebi, Nokaneng and Mohembo (including all the satellite villages) [in the three areas] was carried out (see Fig. 1).

Thus, farmers were randomly selected to participate in the study. By virtue of the activities of the Ministry of Agriculture and other development agencies in the area, it is assumed that most farmers sampled for the study may have adopted/negotiated western (foreign) agricultural innovations, hence, their ability to have negotiated western knowledge on one or more occasions. Some 9 soil scientists were interviewed in states' parastatals and Ministries of

Agriculture/Natural Resources; there are a fewer number of soil scientists working in the study area.

More importantly, a combination of field observations, social survey and laboratory experiments were deemed plausible as the appropriate mixed method of scientific enquiry in this research. While field survey approach was used in eliciting psychosocial and other socio-economic variables from both farmers and scientists, we engaged in laboratory soil analysis to ascertain the veracity of personal and farmers' observations.

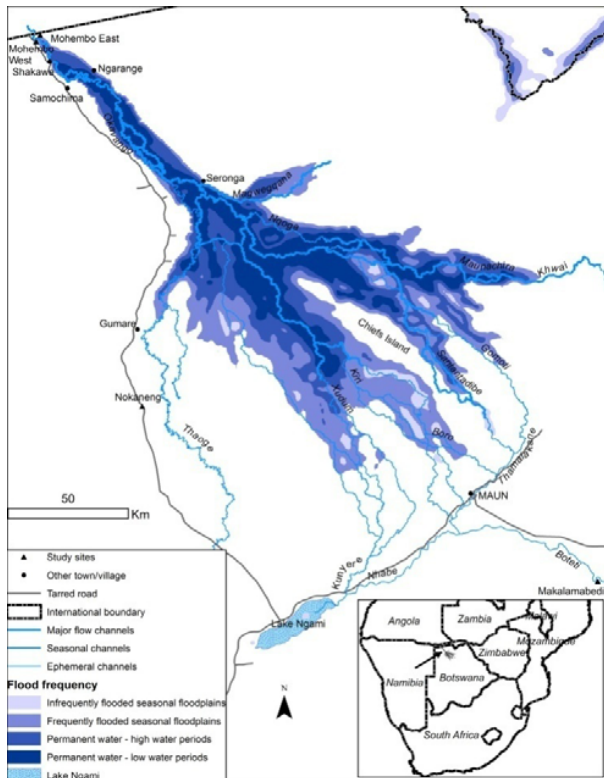


Fig. 1 A map showing the Okavango Delta and communities studied

C. Social Survey Data Instruments

While pre-tested interview schedules were used to obtain quantitative data from the farmers, questionnaires were used to elicit information from the scientists/researchers. Close and open ended questions, which addressed independent variables ranging from demographic/economic, psycho-social, institutional and environmental issues [as they affect ISFM] were constructed in the interview schedules. Demographic/economic and psycho-social variables included age, income, education level, contact with agricultural/extension agencies, knowledge of soil management, negotiation of western innovations, preference for local knowledge, etc. Institutional variables included political economy of soil management (comprising power relations, decision-making on knowledge production, policies, regulations, etc.). Most questions were constructed in the ordinal rating scale. Those addressing farmer's perceptions on his or her relevance and involvement in the implementation of

ISFM were raised [dependent variable] as well. The same set of questions but constructed in questionnaire format were designed for the researchers. To obtain qualitative data, knowledge validation and participatory workshop sessions were organized for farmers' representatives and scientists who converged in both Makalamabedi and Nokaneng communities from September – October, 2012.

D. Soil Sample Collection and Laboratory Analysis

1. Site Description, Soil Sampling and Chemical Analysis

We embarked on a laboratory soil analysis based on three main reasons: (1) Personal observations suggested that the soil health in the area may have been compromised; (2) the preliminary interviews conducted by our research team indicated that small farmers themselves perceived that their farmlands were marginal because of the poor yields they had recorded over the years; and (3) the need to validate our observations and those of farmers through a valid procedure scientific enquiry. Thus the three active and prominent farming sites chosen for this study (Makalamabedi, Nokaneng and Mohembo, and their satellite small communities) were along the western side of the Okavango Delta. Soils samples were obtained from selected farmers' plots in the three communities. Each sample number represents a farmer's plot. Farmers' fields were selected on the basis of (i.) location; (ii.) farmers' participations in our social surveys and knowledge validation workshops; (iii.) willingness to allow the collection of soil samples from their plots; (iv.) their active and sustained engagement in farming activities; and (v) adequate and wide coverage. Thus, a total of 33 soil samples were collected from selected farmers' fields in October, 2012 at four different occasions in Makalamabedi (11 samples), Nokaneng (10), Mohembo West and Mohembo East (12). While 3 sub-samples of soils were collected from each of the 27 fields having homogenous soil physical characteristics in all the 3 locations, 3 sub-samples were also collected from each of the two parts of the plots which had two distinctive soil structures in three farmers' fields (one in Makalamabedi and two in Mohembo). Each of the 3 sub-samples (representing a farmer's plot) was mixed thoroughly to form a composite sample, which was then bagged for analysis. Thus the total number of composite samples taken from the 30 farmers' fields was 33 in all. Soil samples were then taken for analysis to assess the plant nutrient status. A soil test chemically extracts and measures the elements essential to plant nutrition. It also measures soil acidity and pH. These factors are indicators of lime requirement, nutrient availability and the potential of the soil to produce crops.

2. 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 *cation-exchange-capacity* (CEC). Also pH was measured for all samples. Exchangeable *cations* (Ca, Mg, Na, and K) were extracted with neutral ammonium

acetate and then measured by Atomic Absorption Spectrometer (Ca and Mg) and Flame photometer (Na and K). Phosphorus (P) content was analyzed using Bray II, extracted with ammonium fluoride and measured by colorimetric method [18].

III. RESULTS AND DISCUSSION OF LABORATORY ANALYSIS

Results of analysis showed that soils in the three sites are very sandy with low levels of nutrients. The pH ranges between 4 and 6 in all the three areas, indicating acidic conditions. Phosphorus levels are too low in all sites, mostly below 5 parts per million (ppm) which is far below the optimum level of 10ppm. Cation-exchange-capacity (CEC) is a measure of the nutrient holding capacity of a soil; low CEC means that the soil is prone to leaching and cannot hold nutrient reserves [19]. Mohembo soils are very acidic with an overall average pH of 5.1, low exchangeable cations and low phosphorus level. The CEC is also very low in Mohembo, with many sites having below 2.5 cmol/kg - the optimal level required for minimum crop yield (please note that the overall average is shown in Table I). However, it is on the border lines in Makalamabedi (averaging ~ 5 cmol/kg) and relatively good in Nokaneng (ranging between 5-16 cmol/kg).

Averages¹ computed for all the three sites, Makalamabedi, Nokaneng and Mohembo (see Table I and Figs. 2-4) show that the soils in the area are very acidic and sandy in nature with generally poor nutrient level. This is especially the case in Mohembo and Makalamabedi areas where most minerals and CEC are below the optimal levels required for plant growth. Phosphorus is also a serious limiting factor in all the three sites. The soil fertility status in the study area poses a concern to agricultural productivity and sustainability.

TABLE I
SOIL TEST RESULTS SHOWING THE MEAN VALUES OF SOIL NUTRIENT LEVELS AND CEC COMPOSITIONS IN MAKALAMABEDI, NOKANENG AND MOHEMBO COMMUNITIES

Sample/site No	pH	P (mg/kg)	Na (cmol/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	CEC (cmol/kg)
Makalamabedi	5.7	0.51	0.06	0.20	2.21	0.76	5.35
Nokaneng	5.1	2.45	0.16	0.55	9.15	1.88	15.92
Mohembo	5.1	1.20	0.02	0.11	3.36	0.38	2.90

Source: Laboratory analysis, 2012

¹ A fuller detail of data generated from the soil analysis is presented in a working paper on Political ecology of soil fertility management, which is authored by the same team of scientists. Averages for the three locations were computed because the trends in the farms in each location appeared somewhat the same.

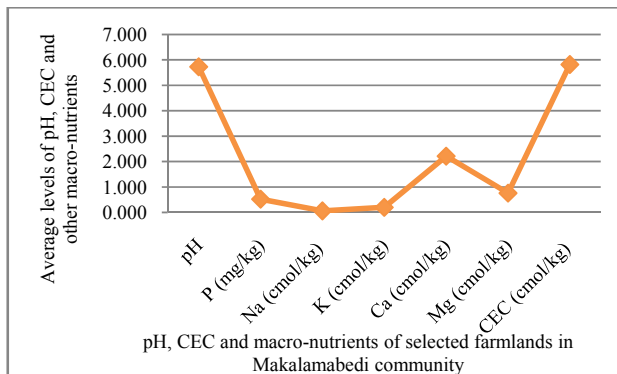


Fig. 2 A line graph showing the average values of pH, essential macro-nutrients levels and CEC in Makalamabedi, northern Botswana

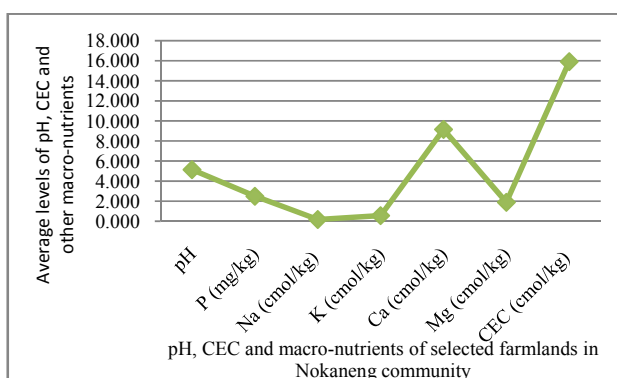


Fig. 3 A line graph showing the average values of pH, essential macro-nutrients levels and CEC in Nokaneng, northern Botswana

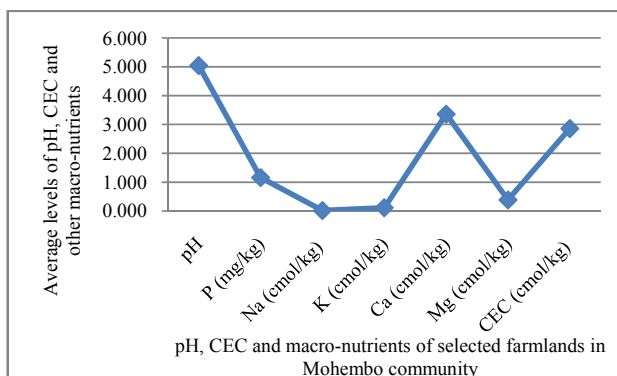


Fig. 4 A line graph showing the average values of pH, essential macro-nutrients levels and CEC in Mohembo, northern Botswana

It is instructive to note that analysis for available nitrogen (N) in the soil samples yielded no results probably because of the leaching nature of sandy soils and the high volatility of N particularly in an arid or semi-arid environment where the Delta is situated. Figs. 2-4 above show the general trends in soil nutrient compositions and quality in the study areas – Makalamabedi, Nokaneng and Mohembo, respectively. The laboratory analysis was primarily conducted to assess the soil

status in the Okavango Delta. The results as shown in the Table I and Figs. 2-4 portray a gloomy situation of the soil conditions in the Okavango Delta. This should, therefore, alert policy-makers in agricultural development and food security about the need to devise pro-poor strategies in enhancing the quality of the soils in the area if only to achieve sustainable agricultural and rural development in northwestern Botswana. While small farmers devise means of alleviating the appalling conditions of their farmlands through the use livestock manure [20] and through other coping strategies, there is need for a change in policy direction in terms of how, who and where to channel agricultural inputs (particularly organic and inorganic fertilizers) and delivery.

IV. RESULTS AND DISCUSSIONS OF SOCIAL SURVEY

A. Farmers and Scientists' Socio-Economic and Demographic Attributes

Data showed the distribution of farmers and scientists by their socio-economic characteristics. While 34.6 per cent of the farmers were males, majority (65.4%) of them were females. This shows that most of the farmers in Ngami and Okavango sub-Districts, Botswana are mainly women. However, while 66.7 per cent of the scientists were males, 33.3 per cent were females. The average age of the farmers and scientists was 51 and 59 years with a standard deviation of ± 16.18 and ± 26.74 , respectively. While only 6.6 per cent of the farmers aged below 26 years, 23.7 per cent was within the age bracket of between 41-50 years. Some 18.5 per cent of the population was aged between 51-60 years. A substantial percentage (22.4%) of the farmers was above 65 years. Based on the average, majority of the farmers were able bodied men and women. Majority (~56%) of the scientists aged between 31 and 40 years just as 33.3 per cent of them aged between 46-55 years. About 40.0 per cent of the farmers neither had formal nor non-formal education at all. While 16.7 per cent of farmers had secondary education, barely less than 1 per cent of them had post-secondary education. All the scientists had post secondary education ranging from Diploma to University Degree levels. This showed that the farmers in the study area were poorly educated. Farmers' other means of livelihoods were trading (9.2%), civil service (6.6%), artisanal work (6.6%), and social welfare program also locally known as *Ipelegeng* (28.9%). Livestock husbandry, fishing, dependence on money repatriated by children, rural telephony, selling of veldt products, etc. accounted for others minor sources (26.8%) from which farmers derived their livelihoods. Analysis on income showed that majority (61.0%) of the farmers earned below BWP 2500.00 per month². While about 30 per cent of them earned between BWP 2500.00 – 5000.00 monthly, only 2.6 per cent earned between BWP 5001.00 – 7500.00 per month. An insignificant percentage (0.4%) of the population earned between BWP 7501.00 – 10000.00 monthly. The average monthly income of farmers was BWP1504.00 with a standard deviation of ± 340 , and that of

scientists was BWP3750.00 with a standard deviation of ± 972 . This showed the financial vulnerability of the farmers in the area. The average household size of both farmers and scientists was approximately 4 persons apiece per household with a standard deviation of ± 1.56 and ± 1.66 , respectively. While 51 per cent of the farmers had between 2-5 household members, 17.5 per cent of them had between 6-7 members. However, about 20 per cent of the farmers had more than 9 persons per household. While about 56 per cent of the scientists had family sizes ranging from 6-9 members, 44.4 per cent of them had only 2-3 household members. Generally, farmers' household size in the area was relatively low, which is a reflection of the low population (~2 million people) of the country itself. This may have impacted on available farm family labor.

B. Farmers' Perception about the Political Economy of Soil Fertility Management

Political economy simply means the power relations existing between the elite and commoners in the allocation, distribution and use of scarce economic resources available within a given socio-political space. Data showed the distribution of farmers by their perception about the political economy of soil fertility management in Ngami and Okavango sub-Districts, Botswana. Farmers were asked to rate their responses on a set of statements placed on a continuum of a 5-point Likert-type scale [21]. While the highest point (5 points) was assigned to a farmer who strongly agreed (SA) with each of the statements, the lowest point (i.e. 1) was assigned to a farmer who strongly disagreed (SD) with any of the statements. Thus agreement with a seemingly negative statement about the role of government in soil fertility management receives higher scores (either 4 or 5 points). Over all, the possible maximum score, which a farmer could obtain, was 40 points and the minimum was 8 points from which his or her average was computed based on the 8 Likert items/statements measured on the scale [22], [23].

Thus, analysis showed that the average score of the farmers was 3.87 with a standard deviation of ± 0.60 . Most (95.5%) of the farmers were affirmative that '[g]overnment has made little investment in soil fertility management in my community/area'. Also, 83.8 per cent of the population unanimously opined that the '[g]overnment has not invested at all in soil fertility management in my community/area'. While about 10 per cent of the population was undecided on the matter, only about 7 per cent was of a contrary viewpoint. Also, a significant 78.5 per cent of the farmers either strongly agreed or agreed that: '[p]olicy on input provision and distribution [such as fertilizers] has not yielded any meaningful result in soil management in my community'. About 53 per cent of the respondents were affirmative that '[o]nly farmers who have connections with political elite have access to fertilizers'. Nonetheless, some 30.7 per cent of them had a contrary opinion on the matter. Available information provided by the Department of Crop Production indicated that farmers who were not registered under the President's agricultural initiative known as the Integrated Support

² At the time of writing this report, BWP 8.56 exchanges for US\$1.00.

Program for Arable Agricultural Development (ISPAAD) and who also did not have and or use planters/machineries were not eligible to access fertilizer subsidy from the government, making them not to have legitimate right to use the product in the Delta area. Although loopholes exist in the implementation of this policy, poor local farmers who traditionally engage in flood recession (*Molapo*) farming in and around the Delta are denied access to fertilizer subsidy. In other words, the Botswana government does not formally give approval to flood recession farming but only allows farmers to perpetuate this age-long livelihoods practice on the condition that they do not use agricultural chemical inputs. This is an attempt to prevent the pollution/acidification of water bodies in the area through haphazard applications. Nonetheless, this policy appears skewed in favor of the seemingly 'powerful' farmers and elite who are somewhat given preferential treatment in government's fertilizer subsidy program. While 57.5 per cent of the farmers had no opinion as to whether or not '[f]ertilizer prices have become exorbitant because of certain middlemen who engage in its distribution and supply', 35 per cent of them were affirmative about the statement. Just as 64.5 per cent of the respondents felt that '[p]oor and dysfunctional institutional arrangements/structures [such as the extension agency] have played a crucial role in poor soil management', 24.6 per cent of them did not have any opinion on the issue. Only 11 per cent of the farmers had a contrary opinion. Interestingly, most (85.6%) of them affirmed that '[t]he agric. extension agency has not offered any strong support in reversing soil infertility problem in my area/community'. Only about 12 per cent had a contrary opinion. While 77.2 per cent of the farmers either strongly agreed or agreed that '[g]overnment policy on land use does not encourage proper and personal investment in soil management', only 16.2 per cent of them had a contrary viewpoint on the matter. Over all, the relatively high average score of farmers (3.87±0.60) depicts that farmers were of the opinion that the political economy of soil fertility management had not favored them in any significant way.

C. Scientists' Perceptions about the Political Economy of Soil Management

Soil scientists were asked to rate their responses on a set of set of statements placed on a continuum of a 5-point Likert scale. While the highest point (5 points) was assigned to a scientist who strongly disagreed (SD) with each of the seemingly negative statements about the role of government in soil fertility management, the lowest point (i.e. 1 point) was assigned to a scientist who strongly agreed (SA) with any of them. Thus agreement with a seemingly negative statement about the role of government in soil fertility management receives lower scores (either 1 or 2 points). Over all, the possible maximum score, which a scientist could obtain, was 40 points and the minimum was 8 points from which his or her average was computed based on the 8 Likert items/statements measured on the scale (see section B).

Analysis showed that the average score of the scientists was 2.97 with a standard deviation of ± 0.92. A significant 78 per cent of them affirmed that '[g]overnment has not invested

much in soil fertility management [either in form of research or its implementation]' in the Okavango Delta. Only 22.2 per cent of them disagreed with the statement. While 33.3 per cent of the respondents affirmed that, '[g]overnment has not invested at all in soil fertility management in some communities,' a fairly significant percentage (44.4%) disagreed with the statement. However, 33.3 per cent of the scientists agreed that the '[p]olicy on input provision and distribution [such as fertilizers] has not yielded any meaningful result in soil management' just as about 44.0 per cent of them felt otherwise. About 90 per cent of the respondents disagreed that '[o]nly farmers who have connections with political elite have access to fertilizers'. This response may have been influenced by the perceived institutional risks to which the scientists might feel they were subjected. While 44.4 per cent agreed that '[f]ertilizer prices have become exorbitant because of certain middlemen who engage in its distribution and supply', about 22 per cent had a contrary opinion. While about 56 per cent of them disagreed that '[p]oor and dysfunctional institutional arrangements/structures [such as the extension agency] have played a crucial role in poor soil management', 33 per cent were affirmative on the statement. A fairly significant number (~56%) disagreed that '[t]he agric. extension agency has not offered any strong support in reversing soil infertility problem in my area/community'. Just as about 44 per cent agreed that '[g]overnment policy on land use does not encourage proper and personal investment in soil management', about 56 per cent of the population sampled had a contrary opinion. Based on their average score (2.97 ± 0.92), the analyses revealed that most scientists were neither here nor there on their perceptions about the political economy of soil management in the Okavango Delta of Botswana.

D. Farmers' Perception about their Involvement in the Implementation of Integrated Soil Fertility Management

Data showed the distribution of farmers by how they perceive their roles and involvement in the implementation of integrated soil fertility management. Farmers were asked to rate their responses on a set of statements placed on a continuum of 5-point Likert scale. While the highest point (5 points) was assigned to a farmer who strongly disagreed (SD) with each of the statements, the lowest point (i.e. 1 point) was assigned to a farmer who strongly agreed (SA) with any of the statements. Over all, the possible maximum score, which a farmer could obtain, was 110 points, and the minimum was 22 points from which his or her average was computed based on the number of Likert items/statements measured on the scale (see also, section B). While high scores were indicative of farmers' favorable perception about ISFM implementation, lower scores suggested otherwise.

Thus, analysis showed that the average score of the farmers was 2.05 with a standard deviation of ± 0.47. A significant proportion (75%) of the farmers either strongly agreed or agreed that: 'I do not know and I have not heard about the initiative on integrated soil fertility management [ISFM]'. Some 22.4 per cent, however, had a contrary opinion on this.

While about 74 per cent of the farmers affirmed that 'I have heard about ISFM but do not know what it entails', 90.4 per cent of them admitted that 'I know scientists are advocating for the application of both organic and inorganic fertilizers but I have not had a full knowledge of it'. While 88.1 per cent of the smallholders indicated that 'I have not seen and even met with extension agents talk about this ISFM approach', about 80 per cent of them opined that '[s]mall farmers in my community have never been engaged by agriculture and other allied agencies on how to jointly manage soil fertility'. Just as about 47 per cent of the farmers either strongly agreed or agreed that '[s]mall farmers have been involved by research organizations in the decision-making process on how to manage soil on an integrated basis', about 40 per cent of them totally disagreed with the statement. Interestingly, a majority (86%) of the respondents affirmed that '[a]gric. scientists only come here to sample our opinions on soil management but it doesn't go any further than that'. Also, while 80.3 per cent of the population opined that '[t]hese western scientists have refused to listen to us in our bid to make them look into our knowledge systems in soil management', about 77 per cent of them felt that '[t]he Western scientists have always claimed that their soil management options are always the best and that we should accept them hook, line and sinker'. Just as 37.7 per cent of the population agreed that '[s]mall farmers in my area have had the opportunity of influencing researchers' decisions on soil fertility management', 50.4 per cent of them did not agree with the statement. While a significant proportion (83.4%) of the smallholders opined that '[s]cientists think about us as "soil miners" who tap resources from the soil and are not willing and ready to practice soil management', about 88 per cent of them affirmed that '[s]mall farmers in my area are perceived by scientists to lack the requisite knowledge of soil fertility management'. This stigmatisation and labelling buttress many soil mining hypotheses, which are a major bane of agricultural and rural development in the South economies [3], [24]-[26]. A significant 85.5 per cent went apiece to the farmers who either strongly agreed or agreed that '[s]cientists perceive the small farmer as being poor in terms of financial and intellectual resources', and that '[s]cientists only go to their educated clients whom they think would learn faster than the common 'uneducated' small farmer'. While 94.7 per cent of the farmers felt that '[i]t is difficult to ascertain what these scientists are up to', 91.2 per cent of them were of the opinion that '[s]cientists say they recognise our knowledge but they never used them to build on their own knowledge systems'. Just as 85.5 per cent of the smallholders either strongly agreed or agreed that '[r]elying on scientific knowledge alone [without recourse to local knowledge] has continually jeopardized our efforts and future', about 96 per cent of them were of the opinion that '[t]here cannot be any meaningful development except farmers are given the required voice in the research process'. While 47.8 per cent of the population said although they '...continued to enjoy the goodwill and efforts of Western scientists', about 87 per cent of them opined that 'Western scientists seem to be interested in the money they get from conducting research and not the small

farmer's welfare'. A whopping proportion (93.8%) of the farmers believed that '[o]ur knowledge is our own knowledge, and nothing can be compared with it'. Also, a significant proportion (89.1%) of the respondents strongly felt that '[s]cientists have learnt useful lessons from us and have surreptitiously failed to acknowledge our knowledge systems in soil management in most of their documentations, therefore, denying our intellectual property rights [IPR]'. Indeed, the scenario portrays a 'tragedy of the unlettered' (Kolawole, 2012). Certainly, this is a policy issue that needs to be addressed promptly. Over all, the relatively low average score of farmers (2.05 ± 0.47) indicates that farmers had unfavorable perceptions about their role in the implementation ISFM.

E. The Predictors of Farmers' Perceptions about the Implementation of ISFM

Data show the results of Pearson correlation and multiple regression analyses of the factors that influence farmers' perceptions on the implementation of ISFM in the study area (see Table II). The analysis reveals that at $p \leq 0.01$ level of significance, farmer's knowledge of soil fertility management ($r = -0.400$), farmer's perception about the political economy of soil fertility management ($r = -0.599$), and his or her preference for the use of local knowledge in soil fertility management ($r = -0.735$) all had significant but negative correlation with how s/he perceived the implementation of ISFM. Conversely, education level of the farmer ($r = 0.178$) had a positive and significant correlation with the farmer's perception of ISFM implementation at 99 per cent confidence level. At $p \leq 0.05$ level of significance, however, the age of the farmer ($r = -0.135$) had a negative correlation with his or her perception about ISFM implementation in the study area. Inferentially, the negative correlation between identified explanatory variables (X_s) and the dependent variable ' Y ' (farmer's perception about ISFM implementation) shows an inverse relationship between both sets of variables. For instance, the more a farmer perceives the political economy of soil fertility management as being unfavorable to him or her, the less s/he sees him/herself playing a significant role in ISFM implementation. The more the farmer prefers the sole use of local knowledge in soil fertility management, the less s/he is inclined to get involved in the implementation of ISFM, all things being equal. The older the farmer is, the less active s/he becomes in participating in ISFM implementation.

The co-efficient of determination (r^2) in Table II explains the degree of variation in a farmer's perceptions about ISFM implementation, which was attributable to each of the analyzed variables. In essence, age (1.8%), education level (3.2%), farmer's knowledge of soil fertility management (16.0%), his or her perceptions about the political economy (35.9%) and his or her preference for the use of local knowledge (54.0%) contributed appreciably to how the farmer perceived ISFM implementation.

Data were further subjected to a multiple regression analysis with a view to determining the magnitude of change in a farmer's perceptions about ISFM implementation (Y) as influenced by all significant independent (X_s) variables.

Multiple correlations co-efficient (R) explained 81.9 percent relationship between 'Y' and other variables. R-square (R^2) showed the total percentage variation in the dependent variable 'Y' as attributable to the joint contributions of all significant explanatory variables in the regression model.

Thus, 61.7 per cent of the variations in a farmer's perceptions about how ISFM is implemented were explained by age ($t = 0.728$), farmer's perceptions about the political economy ($t = 5.485$) and his or her preference for the use of local knowledge ($t = -10.254$) in soil fertility management.

TABLE II
CORRELATION AND REGRESSION ANALYSES SHOWING THE RELATIONSHIP BETWEEN FARMERS' ATTRIBUTES AND THEIR PERCEPTIONS ABOUT THE IMPLEMENTATION OF INTEGRATED SOIL FERTILITY MANAGEMENT (N = 228)

Variable	Correlation co-efficient (r)	Co-efficient of determination (r^2)	Regression co-efficient (b)	t-value for H_0
Age	-0.135**	0.018	-0.001	-0.728
Education level	0.178***	0.032	0.022	1.685*
Monthly income	0.119	0.014	-0.001	-1.931*
Household size	-0.002	0.000	0.000	-0.033
Number of contacts with Agric. Animators	0.065	0.004	-0.001	-0.037
Knowledge of soil fertility management	-0.400***	0.160	-0.017	-0.422
Political economy of soil fertility management	-0.599***	0.359	-0.202	-5.485***
Farmer's preference for the use of local knowledge in soil fertility management	-0.735***	0.540	-0.605	-10.254***

Source: Field survey, 2012

*** Test statistic significant at $P \leq 0.01$ level

** Test statistic significant at $P \leq 0.05$ level

* Test statistic significant at $P \leq 0.10$ level

$R^2 = 0.671$

$R = 0.819$

Adjusted $R^2 = 0.657$

V. CONCLUSIONS AND POLICY IMPLICATIONS

We used a mixed method of field observations, social survey and laboratory experiments to actualize our scientific enquiry in this study. In an attempt to gain a full understanding of the soil quality and conditions within the Okavango Delta, the research determined the nutrient status and CEC of selected farmers' fields in the area (Section I); described the demographic attributes of both farmers and scientists (Section II); analyzed the perceptions of both farmers and scientists about the political economy of integrated soil fertility management (Section III); and analyzed the perceptions/opinions of farmers about their involvement in ISFM (Section IV). Thus a laboratory analysis was primarily conducted to assess the soil status in the Okavango Delta. This was in an attempt to verify personal observations and farmers' perceptions/claims about the poor statuses of the soils in their farmlands. The results portrayed a gloomy situation of the soil conditions in the Okavango Delta; all the soils in the three sites are generally poor with essential nutrients lacking in most cases – available data indicated that most minerals and CEC are below the optimal levels required for meaningful agricultural production.

In order to achieve sustainable agricultural and rural development in northwestern Botswana, there is need for the implementation of pro-poor strategies geared towards enhancing the quality of the soils in the area. While it is acknowledged that small farmers devise means of alleviating the appalling conditions of their farmlands through the use of livestock manure in certain locations and through other coping strategies, there is need for policy change and direction in

terms of how, who and where to channel the delivery of agricultural inputs (particularly organic and inorganic fertilizers).

Most farmers (85.6%) were of the opinion that the agricultural extension agency did not provide any strong support in addressing soil infertility problem in the study area, which is an indication of a dysfunctional institutional roles and arrangement. Thus, institutional arrangements that allow farmers to negotiate their ways in accessing inputs for improving the fertility of their farmlands are necessary for the enhancement of sustainable livelihoods and rural development in the Delta. Indeed, the relatively high average score of farmers in political economy variable was an indication of farmers' opinion that the power relations in the allocation of scarce resources in soil fertility management did not favor them in any significant way. Nonetheless, the scientists' average score showed that most of them were somewhat neutral about their perceptions on the political economy of soil management in the study area.

A farmer's age, education level, knowledge of soil fertility management, perception about the political economy and preference for the use of local knowledge contributed appreciably to how s/he perceived ISFM implementation. The findings in the study are expected to enhance policy formulation and implementation of ISFM in the Delta. They are also expected to contribute to a growing volume of literatures and knowledge in the SSA region with particular reference to small farmers' knowledge and perspectives in soil management in the wetland regions of southern Africa.

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