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Review Article

# To Review Studies Conducted on Soil Fertility Management Measures and Their Role in Improving Soil Fertility

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## Abstract

In most of Sub-Saharan African (SSA) countries, agriculture is the main economic sector). In Ethiopia agricultural sector contributes about 46.3% of the country's GDP, employs 83% of total labor force and contributes 90% of exports. The main objective of this paper is to review soil fertility management measures and their role in improving soil fertility declining soil fertility is one of the most significant constraints to increased food production in Ethiopia. Anthropogenic factors such as inappropriate land use systems, mono cropping, nutrients mining and inadequate supply of nutrients are aggravated the situation. In order to increase soil fertility in the short run, nutrients have to be added to the soil. This is often done by applying chemical fertilizers. In Ethiopia, food insecurity has always been a burning problem. The gap between demand for and supply of food can be minimized through protecting and managing soil fertility and thereby increasing productivity of crops. Use of inorganic fertilizers (DAP and urea), organic inputs (compost) and soil erosion control measure (soil bunds) were common soil fertility management practices which were practiced by most of the farmers.

## Keywords

Crop residue, Organic and inorganic nutrients, Soil fertility, Cropping system

## Introduction

### General background

In most of Sub-Saharan African (SSA) countries, agriculture is the main economic sector [1]. In Ethiopia agricultural sector contributes about 46.3% of the country's GDP, employs 83% of total labor force and contributes 90% of exports [2].

Ethiopia with about 1.12 million square kilometer area of land is one of the most Populous countries in Africa with a total population of 87.95 million [3].

Agriculture is a key pillar of the country's economy and the most important source of growth. Agriculture, therefore food security of the country, relies on sustainable management of land resources. This sector accounts for almost 48 per cent of growth domestic product (GDP) and 90 percent of export earnings.

The declining fertility of soils because of soil nutrient mining is regarded as a major cause of decreased crop yields and per capita food production in Africa; and decreasing soil fertility accompanied with increasing population pressure is one of the major causes of the gap between demand for and supply of food . The use of mineral fertilizers has been considered as crucial to boost crop productivity specifically that of cereal crops. Soils in most of the Sub-Saharan Africa have inherently low fertility and do not receive adequate nutrient replenishment [4].

The decline in soil physical, chemical and biological properties is revealed in many parts of the densely populated highlands of Ethiopia. For example, in Tigray nitrogen and phosphorus are highly deficient [5]. Nitrogen in the cultivated surface soils was 0.07-0.13 percent of Melbe area of Tigray.

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Moreover, the soil depth in many areas of Ethiopia is less than 20-30 cm.

Soil fertility changes and the nutrient balances are taken as key indicators of soil quality [6]. It is well known that in traditional farming systems, farmers use bush fallow, plant residues, household refuse, animal manures and other organic nutrient sources to maintain soil fertility and soil organic matter. Soil fertility varies spatially from field to larger region scale, and is influenced by both land use and soil management practices [7].

A number of studies were conducted on farmers 'perception of soil fertility status [8]. There have also been studies of indigenous knowledge in the evaluation of soil fertility [9]. These studies indicate that farmers 'understanding of soil is more general than that of scientists. Farmers use various indicators to evaluate soil fertility status. For instance, farmers in Dejen district of Ethiopia use soil color, soil depth, water holding capacity and crop yield performance to evaluate soil fertility [8]. In Western Kenya, crop growth vigor, soil colour and types of weeds grown in farmlands are major indicators of soil fertility status [10].

The presence of organic matter in the soil is fundamental in maintaining the soil fertility and decreasing nutrient losses. In addition, organic matter makes its greatest contribution to soil productivity. It provides nutrients to the soil, improves its water holding capacity, and helps the soil to maintain good tilt and thereby better aeration for germinating seeds and plant root development [11]. Because mineralization occurs over extended periods it can make important contribution to plant growth and to minimizing the impact of leaching associated with rainfall and excess irrigation. Furthermore, adding artificial fertilizer alone is not sufficient to retain a sufficient level of soil fertility. Organic matter is needed to retain the water and nutrient. In degraded soil, where there is little organic matter, yield response is limited, even if artificial fertilizer are being used. In general, the agriculture sector in Ethiopia is the most important sector in terms of sustaining growth and reducing poverty. However, lack of adequate nutrient supply, the depletion of organic matter in soils, and soil erosion are among the major obstacles to sustainable improvements in agricultural production [12].

## Objective

The objective of this paper is to review studies conducted on soil fertility management measures and their role in improving soil fertility.

# Literature Review

## Soil fertility management

Many researchers belief in the hopelessness of the recovery of soil such as Mulugeta [13] reviewed that the soil is heavily degraded and it would thus take centuries to recover. But evidences show smallholder farmers are maximizing returns from their limited land and capital, minimize production risks, diversify sources of income, provide food and increase productivity [14].

According to Endrias, et al. (2016) [15] on title of Determinants of Farmers' Decision on Soil Management Options for Maize Production in Southern Ethiopia, In order to select sample households, multistage sampling technique was followed. In the first stage, study districts were purposively selected based on the extent of maize production. Two districts were selected from both Wolaita and Gofa areas**.** Multiple response choice models, such as MNL and multinomial probit (MNP), are more desirable compared to binomial log it and probit models in that they allow exploring factors conditioning specific management practices as well as combination of management practices. According to the MNL model results, the most important soil fertility management decision outcomes were mineral fertilizer, farm yard manure and integrated soil fertility management.

According to Tesfaye Gemechu and Kasahun Kitila [16] on title of Assessment of farmers' practices on soil erosion control and soil fertility improvement in rift valley areas of east Shoa and west Arsi zones of Oromia, Ethiopia. Four (4) Peasant Associations were selected from each district depending on severity of soil erosion problem of in the area. For the detailed personal interviews, a random sampling technique was used to select 10 farmers from each PA. Therefore, 40 farmers were interviewed in each district making it a total of 160 respondents in all districts. All the necessary data required for the study were gathered through a farm felid survey. It was identified that biological SWC measures are the most commonly used by farmers to improve soil fertility. About 98.8% of the respondents used crop rotation, 65% animal manure, and 41.2% others as the major strategy to improve soil fertility in all districts. Even though the price of chemical fertilizer is perceived to be expensive, more than 90% of the respondents depend on it to increase production. This is because farmers' perception on use, importance of Organic fertilizer is very low in all study districts.

According to Gizachew Ayalew [17] on title of Assessment of Traditional Soil Fertility Classification and its Management Practices in the Five Districts, North western Highlands of Ethiopia. It was conducted filed survey method (The study was conducted to classify soil fertility status locally in three slope classes of 0-2, 2-5 and 5-8% of Dera, Achefer, Mecha, Buriewemberma and Jabi Tehnan districts, Northwestern Ethiopia. From each slope class about 65 farmers who had good knowledge of soils were selected and primary data were collected through interviews and group discussions) and clear that farmer fertility assessment is mainly concerned with food security which is highly dependent on land productivity. Results showed that farmers' fertility perceptions are more holistic than those of researchers. It was confirmed that farmers use a variety of inter-related criteria to characterize their soils with soil colour being dominant.

In the study area farmers preferably apply Farm yard manure or home left wastes to enset, coffee and root and tubers crops, while mineral fertilizers are used for teff, maize, wheat, haricot bean and potato. Fertilizer-allocation practices by farmers in Wolaita area specifically to the study area are also briefly indicated in [4].

According to Behailu, et al. (2016) Field surveys and SPSS software version 16 for analysis were used. The study was conducted the Essera district of Dawurozone, Southern Nations, Nationalities and Peoples Regional State (SNNPRS) of Ethiopia, in this study the highest proportion of the respondent farmers perceive that enset farm land and grazing land is classified as highly fertile soil while cultivated land is classified as low soil fertility class.

On title of Assessment of Soil Fertility Management Practices Jimma southwest Ethiopia. Field survey (In order to explore how soil fertility management practices varied across different socio economic groups of farmers, a stratified random proportional sampling method was followed) and analyzed SPSS version 20. Soil fertility is the most important asset worldwide and especially in developing countries like Ethiopia where most of the nation economy is dependent on agriculture. Many farm crops and their residues are removed from the land and the supply of essential elements becomes depleted. Under continuous cultivation soils are losing organic matter and mineral nutrients faster than they can be replaced. Regular loss of nutrients from the soil results in the loss of soil fertility. So, for the maintenance of soil fertility, replacement of the organic matter and mineral nutrients removed from the soils is necessary. The farmers of the study area have been maintaining fertility of their soils by applying organic manures, mineral fertilizers and other agronomic practices [18].

**Role of organic fertilizer for soil fertility improvement:** The title on the approaches to improve soil fertility in sub-Saharan Africa. A survey and summit of multi-disciplinary actors working in the SSA soil fertility was conducted to identify soil fertility problems. Increasing access and use of quality organic materials was consistently identified and prioritized by all regions for the goal of improving soil fertility. However, identified barriers to increase access and use of quality organic materials were numerous and spanned both biophysical and socioeconomic barriers. Critical barriers included lack of access to sufficient quantities of animal manure [19].

Organic fertilizers contribute directly to the accumulation of soil organic matter (SOM) and providing vital plant nutrients for plant, have the ability to hold water and serve as storage for dry season and especially supportive for sandy soils which contain nutrients in a small amount and they are also important for soil organisms. Compared with inorganic fertilizers nutrients are released slowly from organic resources and provide a continuous supply of nutrients over the cropping season [20]. Organic inputs used for soil fertility management commonly contains livestock manures, crop residues, woodland litter, organic refuse from household, compost, green manures, cover crops and any plant biomass harvested from the farm environment [21]. The mixed farming practices of Ethiopian farmers is a system of removing biomass from one place and feeding human and animal in another place. This requires returning the biomass to their origin.

**Role of Crop residues for soil fertility improvement:** According to Wassie Haile [12] on titles of soil fertility practice or interventions reports incorporating the leftovers of crops after harvesting time has been considered as one of the soil fertility amending practice that reduces the amounts of nutrients mined from farm fields. Although there are a number of competing uses of crop residues such livestock feed, fuel wood and construction material were found to be existing in the study areas, the farmers with large farms left maize stalk after harvest and incorporate it into soil while preparing the land for the next cropping.

Crop residues play a role in soil fertility maintenance by increasing soil organic matter. Up to 76% of the farmers indicated that they incorporated crop residues back into the soil, which is the best practice for managing crop residues. However, in the dry season, animals are allowed grazing access to the cropping lands resulting in limited crop residue recycling for soil fertility improvement purposes.

**Role of Compost for soil fertility improvement:** According to Nelson Juma on title of role of indigenous knowledge in the management of soil fertility among small holder farmers of Emuhaya division, Vihiga district, field survey were used to practices to improve the fertility of depilated soils include the application of inorganic fertilizer, manures, and compost, crop residues, crop rotation and agroforestry practice enhance nutrient cycling. And compost manure is highly amending fertility status of the soil (Figure 1).

Compost enhances soil fertility by changing waste materials into nutrients and restores soil nutrients [22]. Due to its balanced chemical composition and high water holding capacity Compost is better than chemical fertilizer [23]. The generalized definition of compost is as follows "compost is a recycled or decomposed organic waste from different crop residues, animal and human manure and wastes and sludge being stabilized by the work of macro- and micro-organisms through aerobic, semi-aerobic and anaerobic biological processes inside a pit and/or on a surface" [24-27].

**Role of Manure and farm yard manure for soil fertility improvement:** According to Abebe, et al., [18] on title of Assessment of Soil Fertility Management Practices, Jimma Zone, South Western Ethiopia. Field surveys (In order to explore how soil fertility management practices varied across different socioeconomic groups of farmers, a stratified random proportional sampling method was followed) and analyzed SPSS version 20) were used. Farm yard manure (FYM) - application of manure is another important means of soil fertility management. Some of the farmers constructed house for their animals and the animals stay in the house during night time. The manure of the cattle cleaned from the house and spread over the land. While others construct fence near their home for keeping their cattle during night and morning time, so that manures accumulated will be spread over the land to maintain fertility of the soil (Table 1).

According to Prakrti, et al. [28] on title of Assessment of soil fertility management practices and their constraints in different geographic locations of Fulbari village development committee (VDC) of Chit wan and Okharpauwa VDC of Nuwakot district, Nepal, the Information regarding soil

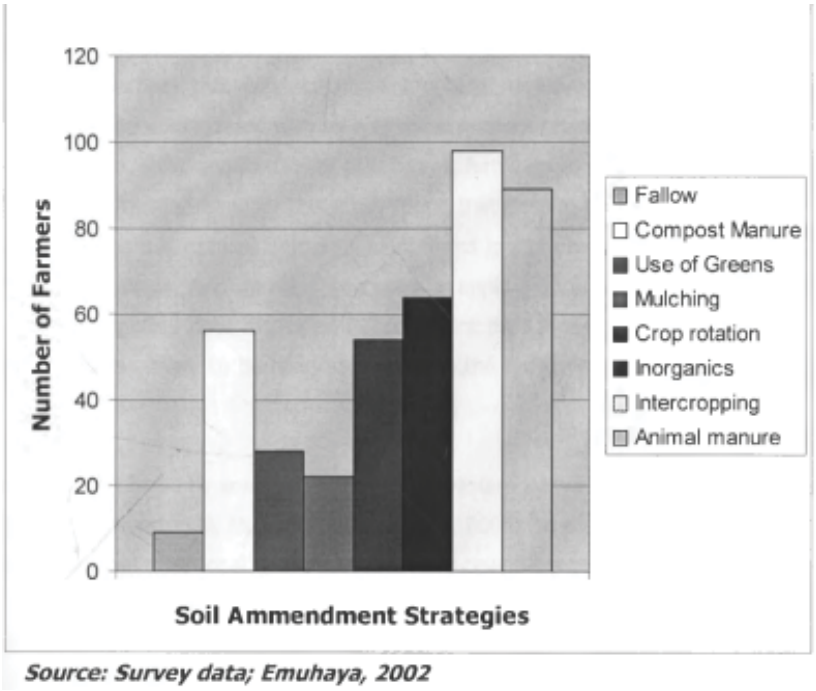


**Figure 1:** Soil amendment strategies.

**Table 1:** Numbers of farms using different source of organic manure.

| Source of Organic manures | Frequency used by farmers (percent) | |
|---|---|---|
| | Nuwakot (n = 30) | Chitwan (n = 30) |
| Farm yard manure | 100 | 100 |
| Poultry manure | 73 | 83 |
| Biogas slurry | 0 | 75 |
| Green manure | 20 | 58 |
| Compost | 6 | 25 |
| Fish pond manure | 6 | - |
| Goat manure | 80 | 33 |
| Commercial organic fertilizer | 0 | 8 |

**Table 2:** Indicates soil management activity in Bokole watershed.

| Crop and vegetation and soil management activities | Respondents practicing the activity (%) | |
|---|---|---|
| | Upper watershed | Lower watershed |
| Crop rotation | 100 | 82.3 |
| Intercropping | 86.2 | 88.7 |
| Fallowing | 79.3 | 38.7 |
| Tree planting | 93.1 | 96.8 |
| Commercial fertilizer | 79.3 | 72.6 |
| Compost | 13.7 | 14.5 |
| Organic matter (animal manure, household refuse) | 93.1 | 90.3 |
| Not using cowdug for fuel | 69.0 | 90.4 |
| Not using crop residue for fuel | 3.5 | 9.7 |
| Adopted level soil bund | 93.1 | 21.0 |
| Adopted stone bund | - | 67.7 |
| Adopted both level soil bund and stone bund | 6.9 | 11.3 |

fertility and crop management practices was recorded from the questionnaire survey of 30 households in both districts (sixty households in total). The collected data pertaining to soil, crop and fertilizer management was coded and tabulated for computer entry and analyzed by descriptive as well as inferential statistical tools, using stat graphics plus 5.1 (Stat point Technologies Inc.) and SPSS-16 (http://spss.en.softonic.com/) statistical packages. Farm yard manure (FYM) is the primary source of nutrients and serves as the major means for soil fertility management and highly fertile the status of the soil.

Manure is a mixture of dung, urine, straw or leaves. The oldest and most commonly practiced means of nutrient replenishment in Ethiopia is manure [29]. The quality of animal dung and urine is largely determined by the type of food that the animal is consuming [23]. The content of nutrient in manure is highly influenced by the duration of storage and its contact with the rain. If the manure contacts with rain, it can be eroded. So manure has to be stored in a safe area. Application of manure has to be with cautious because excess use of manure may result in accumulation of salt and leaching [30]. In the study area the common practices used in order to improve soil fertility as Manuring is the use of animal dung, ash and household trash to crop land [15].

An organic matter in which cover crops are ploughed while they are fresh and green is known as Green manure. When green manures mix with the soil, the soil gets nutrient and moisture that allows microorganisms to feed on it and the organisms improve the quality of the soil [30].

**Use of Chemical fertilizer for soil fertility improvement:** According to Yifru Abera1 and Taye Belachew [31] on title of **Assessment** of Soil Fertility Status measures in the Highlands of Southeast Ethiopia. **Field survey (**the survey work was conducted in Goro, Sinana and Gassera districts of Bale Zone, southeastern Ethiopia, representing different agro ecological zones. From each district about 20 farmers who had good knowledge of soils (elder farmers) were randomly selected) was used**.** Farmers in all districts used low rate of mineral fertilizers due to the escalating prices of chemical fertilizers. 87% of farmers applied only 50 kg DAP/ha for cereals. This rate was by far lower than the blanket recommendation (100 kg DAP and 50 kg Urea) for the area. Some farmers practiced dressing the seeds with fertilizer solutions, since uniform distribution of this low rate of fertilizer was difficult with broadcasting.

Chemical fertilizers are those fertilizers whose chemical compositions are known. It can be applied in different ways and time. Fertilizers may spread over the whole field after ploughing of the land; it can be applied in rows next to the seed and can be used once the crop has grownup known as top dressing [23]. In order to increase the productivity of crop fertilizers have a dominant role. But its availability to the majority of farmers is questionable. There is a well-known supply limitation which is related to foreign currency shortage at national level, lack of loan facilities and inefficient system of distribution [32].

In order to increase agricultural yields, the government of Ethiopia has launched an extension package which gives more attention to high external inputs and high yielding varieties. The introduction of mineral fertilizers to Ethiopia started in the1970s by the Ministry of Agriculture through Wolaita Agricultural Development Unit [24]. The national recommended application rate for Ethiopia is 100 kg of diammonium phosphate (DAP) and 50 kg Urea per hectare [24].

**Role of Integrated Nutrient Management for soil fertility improvement:** The field survey (A two-stage random sampling technique was used to select 136 sample households. A balanced sampling technique was used to collect soil samples from farmlands owned by poor, medium and rich households. One way ANOVA and a multiple regression model were used to analyze the data) was used to collected categories of data and Data analysis was carried out using Microsoft excel and statistical package for social sciences (SPSS) software version 20. Arsamma Watershed, South western Ethiopian Highlands. Prioritizing ISFM for the annual cropland and tree based soil fertility management for perennial cropland is expected to give feasible outcomes. While chemical fertilizer application was the second choice for annual cropland, organic fertilizer was the second choice of the farmers for perennial cropland management. The third preferences were organic fertilizer and ISFM, for annual and perennial cropland, respectively [33].

Using the QUEFTS model (Quantitative Evaluation of the Fertility of Tropical Soils), demonstrated a linear accumulation of nutrients with increasing yield. Nutrient accumulation decreased slightly after yields reached ~60% to 70% of the potential yield. Reliable tools able to quantify nutrient demand will significantly enhance nutrient use efficiency by minimizing over application errors [34].

Integrated nutrient management practices are survival and risk avoidance strategies of farmers. The existing cultural and social institution of communities makes Labour demanding systems appropriate. Farmers are highly linked to their innovative practices in bringing new and productive farming systems such as creating proper synergy by mixing compost and mineral fertilizer [35]. Such as the study by Channappagoudar, et al. [36] and Manyong, et al. (2001) compost and animal manure amended with mineral fertilizer gave higher yield than mineral fertilizer or compost alone.

**Role of Crop Rotation for soil fertility improvement:** According to Amelework Kindihun Assessment of Farmers 'Perception on the Status, Classification and Management Practices of Soil Fertility in Comparison to Scientific Practices: in the case of Ada'a district, central highlands of Ethiopia the overall activities of this study were classified in to three phases. The first phase was pre field activities. The second phase was field work and the last phase was post field activities. In the study area highly used in field survey and the data obtained from laboratory analysis were analyzed and summarized in to tables and graphs by using Microsoft office excel spreadsheet and Statistical Package for Social Studies (SPSS) version 20. According to the result from discussion farmers in the study village use chemical fertilizers as a main soil fertility management practices followed by crop rotation

and use of organic fertilizer. Crop rotation is commonly practiced with a sequence of cereals with pulses.

According to Kebede, et al. (2013), Data were generated by means of a field survey and analysis SPSS version 20, in Bokole watershed southern Ethiopia. Basically in the table below indicates both the Upper Watershed and the Lower watershed, the majority of respondents practice most crop and soil management activities either to improve or to maintain crop yield. The upper watershed presents activities such as crop rotation, intercropping and fallowing, that were practiced in the study area to maintain or enhance agricultural crop yield (Table 2).

According to (Snappet al, 1998:) an interview schedule was the main tool of data collection while descriptive statistics were the main analytical technique. One way the farmers can avoid a decline in soil fertility is by practicing crop rotation. A good crop rotation is that involving a legume and a cereal crop since the legumes add nitrogen to the soil through biological nitrogen fixation (Up to 79% of the farmers interviewed practiced crop rotation. However, individual farmers used various sequences depending on their objectives regardless of the scientifically correct and beneficial sequences. Of those who did not practice crop rotation, reasons given included inadequate knowledge regarding the practice and shortage of land.

By using field survey methods it was collected the relevant data and analysis SPSS-16 software computer. It is a long year's farmer's experiences in which legume crops were rotating with other non-leguminous crops for the main purposes of soil fertility improvement in Diga Woreda, Oromiya. The use of crop rotation helps to increase soil organic matter, reduce erosion and bring biological diversity back to the soil [37].

On title of Soil Fertility Management and Cropping System Function in Ameliorating Maize Productivity in Ethiopia, a study conducted field experiment at Bako using nug as proceeding crop indicted that maize grain yields were significantly increased in rotation with this crop compared to the continuous cropped maize. This result clearly demonstrated the residual benefits of crop rotation with reduced NP fertilizer amendments and enhanced maize grain yield. Also, the integrated use of precursor crops with low rate of NP and farmyard manure gave comparable maize yield to a plot received recommended fertilizer rate (110/20 kg NP ha-1) [38].

## Conclusion and Recommendation

### Conclusion

Use of organic inputs (compost) Ruther than inorganic fertilizers (DAP and urea) are measure for soil erosion control and common soil fertility management practices which were practiced by most of the farmers. Major gaps identified related to the production and uses of Organic Soil Amendment Even if there are a good start in the production and uses of Organic Soil Amendments in Ethiopia as organic fertilizer, as a source of income and an eco-friendly methods of replenishing soil fertility, a lot remains to be done to exploit the full potential of organic nutrient sources that are generated as a waste by diverse sources everyday which are considered as troubling and polluting materials to the environments. In this respect, somekey challenges/gaps on production and uses of Organic Soil Amendments were identified and listed below:

- Insufficient work on research and dissemination of information in different agro-ecologies of the country.
- Lack of awareness among potential users of soil fertility management.
- Insufficient training activities on the management and uses of soil fertility management.

### Recommendation

Thus, in order to effectively bridge these gaps and fully exploit the potential of diverse soil fertility management constraints use of fast and efficient nutrient cycling technologies the following key points are recommended:

- More research related to soil fertility managements is needed.
- Intensive training on nutrient cycling methods to famers is crucial.
- Awareness creation through various pathways including training, media, and field demonstration etc on the importance of Organic Soil Amendments as alternative or supplementary means of increasing soil fertility and maintaining soil sustainability is recommended.
- Comprehensive national road map for nutrient cycling and organic fertilizer production, marketing and use that will serve as a major guide for those stakeholders who are involving and will involve in the future is recommended.
- Organic fertilizer quality control and certifying authority is recommended to be established.
- Encouragement and incentive are needed to attract more and more private/public sector to involve in commercial production of Organic Soil Amendments.
- This in turn requires creation of markets for organic fertilizers which still needs to be done through awareness creation and promotion of organic fertilizers to relevant customers.
- All of the above targets can only be achieved however when all stakeholders (private, GO, public, NGO, Academia etc.) come together and collaborate among each other contribute to ways and methods of conversion of diverse types of organic waste into useful and marketable products. For this to be realized there is a need to establish national coordinating body.
- There is a need to organize a national workshop where by papers on research findings, technological, innovations and experiences on soil fertility managements will be presented and shared among stakeholders; and publish proceeding of papers.

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