ECONOMICS AND POLICY CONTEXT FOR THE BIOLOGICAL MANAGEMENT OF SOIL FERTILITY (BMSF) IN ETHIOPIA

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Abstract: *Many developing countries implement programs and policies to increase or maintain soil fertility, with the objectives of increased crop yields and decreased poverty. However, few countries give emphasis to the biological management of soil fertility (BMSF) compared to more traditional approaches. Ethiopia emphasizes the use synthetic fertilizers to increase food security and reduce poverty, with little attention to BMSF. This paper examines the long term fertilizer consumption and agricultural productivity response trend and discusses the potential for BMSF to promote agricultural productivity and reduce poverty in Ethiopia. The paper also discusses the Economics and Policy Context for BMSF for the well functioning of the ecosystem. To do so, we used long-term fertilizer consumption and crop productivity national data as well as data from several studies carried in Amhara Region near Bahir Dar. The methods include analysis of soil chemical properties for various land uses (crops, pastures, and forest) household surveys, focus group discussions and a review of pertinent literature. Aggregate data indicate increasing fertilizer use but stagnant crop yields. The lowest carbon and nitrogen levels in soil are for crop land, followed by grassland and forest. Continuous cultivation, removing crop residue and using cow dung for cooking rather than fertilization probably are responsible for the low values on cropland. At 1.49 percent threshold of carbon content, crop yields cannot be optimized through use of synthetic fertilizer alone. The household survey and focus group discussions suggest that farmers use of synthetic fertilizer to be minimal due to many and complicated factors. Surveys also indicated that all productive land in surveyed watershed was under cultivation, limiting the potential to increase crop production through expanding cultivated area. Thus, technologies and practices to increase yield per ha are needed. BMSF should be investigated further for its potential to increase agricultural production in Ethiopia, to reduce poverty and to achieve food security.*

1. Introduction

Biological management of soil fertility (BMSF) is a way to utilize management practices to influence soil biological populations and processes in such a way as to achieve desirable effects on soil productivity by affecting the chemical and physical properties of the soil and its overall health (http://www.fao.org/ag/AGL/agll/soil biod/default.htm). Soil biological populations are extremely diverse and contribute to a wide range of ecosystem services that are essential to the sustainable function of natural and managed ecosystems. The soil biological populations can have direct and indirect impacts on land productivity. Direct impacts are those where specific organisms affect crop yield immediately. Indirect effects include those provided by soil organisms participating in carbon and nutrient cycles, soil structure modification and food web interactions that generate ecosystem services that ultimately affect productivity (Barrios 2007). In the past century, BMSF has got little attention both from scientists and policy makers. This is partly because in the past century a dramatic increase in land productivity that has been largely achieved due to the introduction of new crop varieties into farming systems in dry land and irrigated environments with good supplies of fertilizer and pesticides (Brown et al., 1994). However, in many less endowed areas land productivity has actually been declining in the last decades (Sánchez et al., 1997). Though it is possible to increase the overall agricultural production through high input agriculture, the low resource use efficiency makes high economic and environmental cost (Swift and Anderson, 1993) and this creates a problem for the suitability of agriculture. The other problem associated with the delay of BMSF in policy analysis is due to the knowledge gap resulted from the difficulty of studding soil biodiversity and the need to identify common methodology and still continue to be one of the greatest challenges in soil science (Giller et al., 2005)

Recently, many developing countries including China, India, and South Africa have put in a place large national investment programs to promote sustainable land management and rehabilitate degraded land through biological measures (Penning de Vries et al., 2003) hopping that establishing productive farming system with high efficiency of internal resource use by lowering input requirement cost through biological means in a sustainable way (Swift et al. 2004; Giller et al., 2005). The growing agreement within many scientific communities on the desirability of biological factors and dynamics to enhance and maintain soil fertility and soil ecological functions reflects a convergence of policy concern arising both within and outside the agriculture sector. The promotion of effective BMSF on globally effective scale will require mobilizing political action (Doran et al 1996). This in turn requires explicitly linking the BMS research and development agenda to important policy objectives. For example, soil health, soil productivity, and soil erosion are not a great intrinsic concern to politicians, but these imply policy calculations if they occur in place and scale that will affect aggregate food supply, food price, or economic growth. These combined and interrelated problems call for a collaborative effort between multidisciplinary scientists and policymakers to achieve major policy objectives through incorporation of BMS.

In the highlands Ethiopian where steep topography with high rainfall intensity and low vegetation cover dominates, environmental degradation associated with erosion is a serious problem (Ministry of Agriculture, 1986; Amede, 2003; Berry, 2003; Awulachew et al. 2008). The average soil loss from farmland is estimated to be 100 tons/ha/year (Hagos, 2003; Nedessa et al., 2005) resulting in massive environmental degradation and constituting a serious threat to sustainable agriculture and forestry (Hurni, 1990). In some area of highlands the severity of land degradation is estimated to reach as high as to offset the gains from technical change (WDR, 2008, pp 180). This consequently decreases the productivity of external imputes by affecting directly or indirectly the level of soil organic matter as well as soil biological population. For overall agricultural productivity increment, several research finding stresses that promotion of BMSF (Woomer and Swift 1994; Swift et al. 2004; Giller et al., 2005) as complement to synthetic fertilizers. Understanding that the existence of chronic food insecurity, extreme rural household’s poverty, and environmental degradation in Ethiopia. This paper examines the long term fertilizer consumption and agricultural productivity response trend and discusses the potential for BMSF to promote agricultural productivity and reduce poverty in the country. The paper also discusses the Economics and Policy Context for BMSF for the well functioning of the ecosystem.

2. Material, Method and Organization

We used long-term (27 years) fertilizer consumption and crop productivity national data as well as data from several studies carried in Amhara Region near Bahir Dar. The methods include analysis of soil chemical properties for various land uses (crops, pastures, and forest), household surveys, focus group discussions and a review of pertinent literature.

The primary data used in this study include soil survey data and data generated from household interview and focus group discussion.

A. Soil Survey

The soil survey was conducted in Bezawit sub watershed near Bahir Dar city, Ethiopia. The sub watershed extends from 11033’38.11 – 11034’15.29 north to 37024’04.85 – 37024’57.54’ East. The soil sample was analyzed in Bahir Dar Soil Testing Laboratory.

The purpose of soil survey in this paper is to determine the level of SCC and nitrogen content in three different land use types and compare the management practices.

Statistical analysis of the data was carried out by one-way analysis of variance (ANOVA) using SPSS window version 16 software (www.spss.com) at 0.05 significant levels and at 0.01. A post hoc multiple comparison tests of means was done by univariate LSD.

B. Interview and Focus Group Discussion

The focus group discussion about farming activities was conducted in three Woredas of Amhara National Regional State, namely Mecha, Farta and Bahir Dar Zuria (Bezawit Watershed). Furthermore, in Mecha Woreda (Koga Watershed), we performed 210 survey of household. Descriptive analysis was done to interpret the data from interview and focus group discussion.

Secondary data for crop production and fertilizer were obtained from Ethiopian Economics Association (2007 statistical database compiled from various sources). We used 27 years time serious data for Ethiopia. 1991 and 1992 data were removed from the analysis because of political instability and lake of data. Pre 1991 data was used as a base for comparison to observe changes in the current agricultural development era (Agricultural development Led Industrialization (ADLI)). In addition to the above data sources, pertinent literatures were included to supplement discussions. For organizational purpose, the discussion is presented in to two major topics:

I. Policy interest in biological management of soil fertility
II. Mainstreaming of Biological Management of soil in Economics and Policy Analysis in Ethiopia

3. Policy Interest in Biological Management of soil Fertility

Though, there are several specific elements interest scientists towards BMSF, form the eyes of policy makers' arguments in favour of BMSF can be divided in to four broad categories. These include ecological, agronomic, socio-economic and ethical or moral reasons. This paper emphasis to those potential benefits of BMSF directly linked to national food security, poverty reduction, public health, and ecosystem function of alternative approaches to agricultural production because these issues are usually the most important in the eyes of policymakers.

A. Addressing National Food security

Human population is expected to grow from a little over 6 billion today to over 8 billion by 2030, an increase of about a third, with another two to four billion added in the subsequent 50 years (Cohen, 2003). But food demand is expected to grow even faster due to urbanization and rising incomes, and more food will be required if hunger is to be reduced among 800 million people currently under-nourished (UN Millennium Project 2005). Ethiopia has faced persistent food deficients over hundreds of years, and its population is expected to rise from 63 million in 2000 to 120 million by 2015. Although nearly 10 million farm households annually cultivate about 9 million hectares of land (Table 1), one half of the population lacked sufficient food (FAO, 2000). Consequently, greater food production capacity is a national goal (FDRE, 1996). And many agricultural development efforts aimed at the highlands, which are home to over 90% of the human population, 75% of livestock, and 95% of annually cropped land. Most (62%) of these households own less than one hectare of land; land expansion for agricultural production is almost exhausted in the highlands Ethiopia (CSA, 1999). For instance, the survey result conducted in Mecha *Woreda* in 2008 found that average per capita cultivated land was about 0.25ha, which implies that the inelastic nature of agricultural output growth through land expansion.

Table 1 shows that the relationship between cereal production, population, cultivated area, and fertilizer consumption. ADLI strategy aims to develop the agricultural sector mainly through increases in agricultural output and productivity from green revolution technologies such as fertilizers and improved seeds (FDRE, 2001). Compared to the base year (1980-1990), with 252 percent increase in fertilizers consumption, would result only an increased in total grain production by 50 percent. However, within this agricultural output, fertilizer productivity and land productivity were decline by 69 percent and 2 percent respectively, which results in low resource use efficiency (high economic and environmental cost (Swift and Anderson, 1993) and unsustainable agriculture. Furthermore, compared to the base year food production was less than population growth (Table 1) in the era of ADLI.

Table 1: Cereal production, population, cultivated area, and fertilizer consumption in Ethiopia Between 1980-2006

Year	Total Population (in millions)	Grain production ('000 qt)	Cultivated area of grain ('000 ha)	Fertilizer consumption (MT)	Land productivity (Q/ha)	Fertilizer Productivity (Q/Fert)
1980-1990 (Avarage/ Base Year)	40.63	61780	5559	75,578	11.09	1.18
1993	51.74	56497	7067.9	107,457	7.99	0.53
1994	53.15	67394	7680.7	190,000	8.77	0.35
1995	54.68	100279	8749.8	246,722	11.46	0.41
1996	56.37	100168	8011.2	253,152	12.50	0.40
1997	58.12	80367	8069.2	220,431	9.96	0.36
1998	59.88	85525	7964.1	281,371	10.74	0.30
1999	61.67	88507	8160.8	290,264	10.85	0.30
2000	63.50	100742	9601.1	297,907	10.49	0.34
2001	65.34	90504	8146.4	279,602	11.11	0.32
2002	67.22	109600	9845	232,270	11.13	0.47
2003	69.13	81570	9502	264,349	8.58	0.31
2004	73.04	106990	9036	313,387	11.84	0.34
2005	75.07	137510	9234	481,775	14.89	0.29
2006		158530	9784		16.20	
1993-2005 (Avarage)	62.22	92743	8544	266053	10.79	0.36
Percentage Change Compare to the Base Year	53.15	50.12	53.68	252.02	-2.63	-69.21

Data source: Ethiopian Economic Research Institute, statistical database 2007, Ethiopian Economic Association.

Beyond the severity of soil erosion due to topographical factor and rainfall intensity, the land management practice in most parts of the highlands of Ethiopia suggested to contribute the declining of fertilizer productivity. Visual observation, focus group discussions, household survey and soil carbon and nitrogen analysis showed that the existence of continuous cultivation as well as removal and burning of crop residue and caw dung leads to a negative nutrient balance. For example, the soil analysis result in Bezawit Watershed indicated that both soil organic carbon and total nitrogen significantly vary between the three land use types at $p < 0.5$ and both carbon and nitrogen behave similar pattern across land uses.. Cultivated land has 1.49% SOC, which is even significantly lower at 0.01 probability level from both forest land (3.32%) and grass land (2.88%) associated with continuous cultivation and removal of both crop residual and animal dung. At low level of SCC content, crop yields cannot be optimized through use of synthetic fertilizer alone due to low productivity of fertilizer and it requires integration of BMSF (Swift et al. 2004; Giller et al., 2005; Swinton et al., 2007). Therefore, the incorporation of BMSF in crop production can be advocated in achieving food security by increasing the marginal productivity of fertilizer. The focus group discussions held in Farta Woreda (one of the most degraded area in Amhara region) discover some promising experience of BMSF among those farmers who has close contact with NGOs in production of crop.

B. Addressing Rural Poverty

Ethiopia faces dire challenges in alleviating poverty and food security that are worsening over time. The most recent drought of 2002/2003 affected approximately half of the country people (EM-DAT, 2004). During the 1990s there were significant changes in the political and economic landscape of the country. The regime that had ruled for nearly two decades was ousted from power in 1991, leading to the end of the civil war. In 1992–93 the government adopted an Economic Reform Programme with the support of the international financial institutions. The development strategy, ADLI, was laid out with a major objective of promotion of economic growth and poverty reduction. The ADLI strategy relies primarily on the international market for the imports of synthetic fertilizers to improve agricultural productivity. The logic of this approach is that the increase in output will help the country to achieve food self sufficiency in the short to medium turn, and rapid productivity growth will increase the income of small farmers that makes the great majority of the farming population of the country. Sufficiently large increases in the income of farmers will reduce poverty. Equally importantly, growth of rural incomes will contribute to an increase in the demand for manufactured products leading to demand-led industrialization in the country (FDRE, 2001). Based on this logic, the government invested a financial and political capital in implementing this strategy over the past 15 years, and still apparently considers it the fastest and surest path to economic development. However based on the data (table 1), the performance of ADLI was not promising even if synthetic fertilizer utilization was increased more than 200 percent compared to the pre ADLI era. Nevertheless, as we have mentioned in the previous section, fertilizer productivity decline by 69 percent. The total agricultural production fluctuation seems as a result of the amount of cultivated land use rather than the instrument (fertilizer). The coefficient of correlation between grain production and cultivated land was found to be 0.73 and significant at 0.01 probability level.

Policymakers concerned with rural poverty reduction have become interested in BMSF in part as a means to improve food security and raise incomes of low-income farm households (UNEP, 2001). BMSF can improve crop yield and quality, especially through controlling pests and diseases and enhancing plant growth. Furthermore, below-ground biodiversity determines resource use efficiency as well as the sustainability and resilience of low-input agro-ecological systems (by increasing productivity of external inputs), which ensure the food security of much of the world's population, especially the poor. The rational of assumption of BMSF for poverty reduction in Ethiopia can be justified in relation to the above justification as well as price of synthetic fertilizers and extreme land degradation. In the first hand, extensive use of synthetic fertilizers (and other agrochemical inputs) is still not an economically viable option for low value crops or for remote communities where poverty is greatest there are two potential issues here: high fertilizer prices imply that the marginal value product of fertilizer must be high for rational, profit-maximizing farmers to use it. Second, land degradation may also itself reduce the marginal physical product of fertilizer like what we observed in our data Table 1. Thus, the local price of nitrogen fertilizer is two to four times the world price, due to high transportation costs and inefficient marketing systems (http://www.un.org/news/Press/docs/2002/GAEF3 001.doc.htm; Uphoff et al 2006).

With land degradation, the requirement of fertilizer to cultivate a hectare of land increases. In Mech Woreda (Koga Watershed), a survey result from 210 households indicates that within the last fife year land productivity seriously decline, about 65% of respondents report that to get the pre five year ear of maize production form a given land the application of fertilizer should be increased to more than double. According to farmers, previously teff production was one the dominant cereal crop in the Worda, however, due to productivity loss, currently the majority of farmers abandon production of teff. Similarly, most farmers reported that the local price of synthetic fertilizer was also more than double within the last five years and prevent them to purchase the amount needed to attain the previous production. Furthermore, the majority of the respondent report that the presence of fertilizer marketing inefficiency such as delay in supply as well as time taken nature transaction (in average to purchase a quintal of fertilizer take 3 to 5 days) have some contribution to the minimal use of synthetic fertilizers. These question ADLI to revise its instrumental approach and advocacy in achieving food security and reducing poverty in a nation with through holistic approach.

C. Addressing Threats to Human Health

Ecosystem degradation is widespread as a result of cumulative impacts of human straggle to survive, growth and development. This is particularly problematic when those ecosystems perform natural services (Daily, 1997), such as purification of environmental media (agricultural chemicals) and control of the spread of infectious disease both human and animal. The degradation of the natural ecosystems and the biosphere have posed a set of risks to human health and preclude any simple extrapolations from the past. Newly emerging diseases, increasing exposure to toxic substances, increasing prevalence of many vector borne diseases, increasing scarcity of potable water, increased exposure to harmful UV radiation and a number of other transformations in the natural environment, have definitely negative implications for the sustainability of human health (Rapport et al., 2003; Suter II et al.2005; Odada et al., 2006; Pattanayak and Wendland, 2007).

Considering, the health impact of ecological degradation, recently, medical schools are beginning to rise to the challenge of expanding the traditional curriculum to include topics on ecosystem and human health relationships. These programs encourage a new breed of professionals who, in addition to having the skills to diagnose and treat, may also have the skills to recognize that caring for local and regional environmental conditions is conducive to maintaining healthy populations (Rapport et al., 2003). Policymakers with responsibilities in public health have also begun to take notice of the potential benefits of biological management. Their primary interest is to reduce the negative impact on human health from pesticide use through promotion of alternative crop-production system that use much lower levels of these chemicals (Uphoff 2006). The benefit of BMSF is not limited as alternative solutions to reduce use of chemicals; it has also the potential to remove all inter related problems that has been mention above. For example biological treatments that use microbes (bacteria and fungi) and plants to degrade chemical materials, can both decontaminate polluted sites (bioremediation) and purify hazardous wastes in water (biotreatments). Overall biological methods are more effective than physical, chemical, and thermal methods, because the latter methods often simply transfer the pollutant to a different medium instead of converting it to a less toxic substrate, as biological methods often do. The ability of bioremediation to provide continuous cleanup of contaminated sites, such as agricultural ecosystems with toxic pesticide residues, is a significant advantage of this method.

Furthermore, a significant degree of self-regulation is present in such biological systems because the added microbes survive by consuming and degrading chemicals but die when the nutrient source, that is the pollutant, is reduced or eliminated (http://www.fao.org/ag/agl/agll/soilbiod/integr.stm).

D. Addressing Ecosystem Function

Agriculture landscapes both provide and receive many valuable ecosystem services. Agricultural practices have environmental impacts that affect a wide range of ecosystem services, including water quality, pollination, nutrient cycling, soil retention, carbon sequestration, and biodiversity conservation (Dale and Polasky, 2007; Swinton et al., 2007; Wossink and Swinton, 2007). In the context of BMSF, we divide the discussion in to three sub topics. These are watershed function, carbon sequestration and conservation of biodiversity.

I. Watershed Function

According to the report on the Millennium Ecosystem Assessment (2005), several ecosystem services that relate to agriculture land use are in decline. Most importantly, decreases in supply and quality of fresh water in many parts of the world can be traced to increasingly intensive agriculture, both in terms of withdrawal of water from rivers for irrigation, and lower water quality from the flow of nutrients, sediments, and dissolved salts from agricultural lands. These threaten the majority of the rural population that directly relay on rivers, streams, lakes and ponds for consumption, sanitation, and hygiene. For example, UNICEF (2005) estimates that 3 billion people lack access to sanitation facilities related to water scarcity and another 1.3 billion lack access to improved water sources.

BMSF is one key element of watershed management. Scientists from diverse fields have conclude that biologically healthy soil are a critical part of the natural infrastructure of well-functioning a productive hydraulic cycle (Uphoff 2006; Swinton et al., 2007). According to Doran et al. (1996) soil health can be defined as: the continued capacity of soil to function as a vital living system, within ecosystem and land use boundaries, to sustain biological productivity, marinating the quality of air and water environment, and promote plant, animal and human health. Figure 1 shows a picture of healthy soil. In a watershed, BMSF reduces input costs by enhancing resource use efficiency (especially decomposition and nutrient cycling, nitrogen fixation and water storage and movement). Fewer pesticides are needed where a diverse set of pest-control organisms is active. Furthermore, as the soil structure improves due to biological activity, the availability of water and nutrients to plants also improves (Barrios 2007; Swinton et al., 2007).

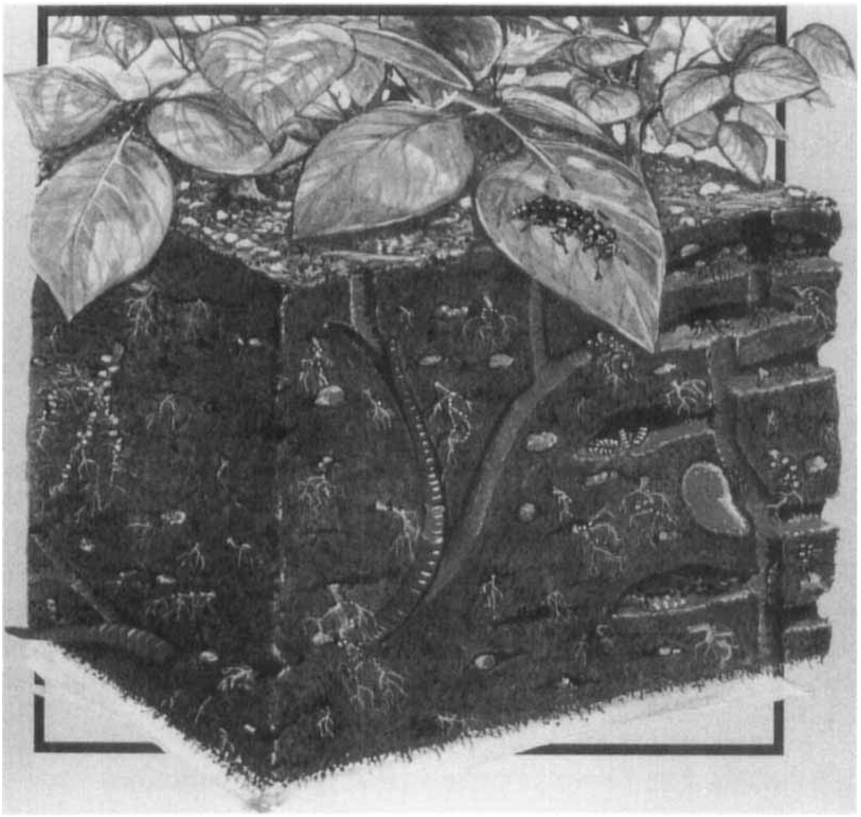

Figure 1: A healthy soil is full of macro-organism and microorganism in proper balance with the physical and chemical condition of soil (Courtesy of American Journal of Alternative Agriculture, Volume 7, 1992 in Doran et al. 1996)

The survey in Koga watershed also looked the proposed irrigation household's valuation of sustainable year round irrigation water flow, the survey result indicates that about 63 percent of the interviewed households are willing to pay the proposed price for maintaining the watershed service; about 23% households willing to pay less price than the proposed and the remaining 14% completely refused to pay for the watershed service. The aggregate expected willingness to pay for the total of 7,000 hectare of irrigable land was 1,008,000 birr per year. This indicates that the possibility of implementing BMSF to enhance agricultural productivity with the involvement of community participation at least where irrigation infrastructures are implemented. Furthermore valuation of watershed services in developing country can be used in generating new financial resources to sustain environmental conservation that required for the sustainability of upstream ecosystem functioning, which ultimately affect both upstream and downstream resource productivity (Kassahun et al. 2009).

II. Conservation of Biodiversity

The soil not only houses a large proportion of the Earth's biodiversity but also provides the physical substrate for most human activities (Barrios 2007). All external factors that alter the management of soil such as organic matter management, plant management, water, nutrient, and sediment management have direct implication for biodiversity of soil biota. Considering, the persistent nature of soil degradation in Ethiopia (Ministry of Agriculture, 1986; Amede, 2003; Berry, 2003; Awulachew et al. 2008) one can suggest the possible negative impact on the population soil biota. This consequently leads to a loss in a wide range of ecosystem service for agricultural landscape that is linked to the roles of life support (Nutrient cycling) and of regulation of ecosystem processes (Soil structure modification and Pest and disease control).Therefore, in addition to reducing possible soil erosion effect, the management of soil biodiversity requires a thorough understanding of ecosystem processes linked to ‘soil based’ ecosystem services and of the scale at which each member of the soil biota makes its exclusive contribution (Giller et al., 2005).

III. Carbon Sequestration

Global warming is considered by many scientists to be the major environmental problem confronting life on Earth.Global level of climate change due to the rise of atmospheric CO2 concentration is most likely to affect the function and stability of Earth’s ecological system currently as well as in the future (IPCC, 2001). The potential damage caused by climate change is so severe that it threatens the livelihoods of millions of people in the world and threatens the fight against poverty (www.eldis.org- Climate Change Threatens the Fight Against Poverty-2007). Several scientists pointed out that carbon dynamics in the terrestrial ecosystems has been one of the major factors affecting CO2 concentration in the atmosphere (IPCC, 1996; Houghton, 1999; IPCC, 2001; Pacala et al., 2001). This in turn creates global level of concerns and has promoted a rethinking of the management of agricultural soil.

Carbon sequestration in soil organic matter is increasingly advocated as a potential win–win strategy for reclaiming degraded lands mitigating global climate change, and improving the livelihoods of resource-poor farmers (Batjes, 2001; FAO, 2001; Lal, 2002; Ringius, 2002; Bartel, P. 2004). Because, measures taken in soil management such as reduced tillage, mulching, composting, manure application, fallowing, agroforestry, diverse rotation, introducing forage legumes and grass mixtures in the rotation cycle are not only expected to increase the rate of carbon dioxide (CO2) uptake from the atmosphere but also to contribute to erosion and desertification control and enriched biodiversity increasing crop production through improving soil properties such as nutrient uptake and nutrient cycling, moisture retention, and tilth (Woomer et al., 1994, Lal et al., 1998; Lal, 1999; Lal et al., 1999; Lal,2002; Hao et al., 2002; Swift et al., 2004; Wardle et al., 2004).

4. Mainstreaming of Biological Management of soil in Economics and Policy Analysis in Ethiopia

Policy-making can be defined as an expression of intent to achieve certain objectives through the conscious choice of means and usually within a specified period of time. Until the last decade, soil quality issues have been of relatively little interest to economists or policy analysts, largely because no connection was seen with the major policy concerns (national food security, poverty reduction, public health, and ecosystem functions) (Uphoff, N., et al., 2006). However, recently soil environment interaction is becoming increasingly obvious that numerous issues that were previously thought of as independent of the major policy concerns are intimately connected to it. Understanding, the role of BMSF on these major policy concerns, some countries of the world have also incorporated in their national economic plan.

However, in Ethiopia BMSF has still received little attention from policy makers. One reason may be that research and development in the country is in the early stages of development. Therefore, research and development on BMSF according to the agro-climatic condition of the country is the primary and the fundamental step to incorporate BMSF in to the national agricultural development plan. In addition, future analyses must exercise care not to underestimate the benefits of BMSF for crop production by accounting for positive externalities. Positive externalities are defined as benefits generated as an unintended by product of an economic activity that do not accrue to the parties involved in the activity. Positive externalities that may be important for BMSF incorporated for crop production include carbon sequestration, removal of pollution, hydrological function, erosion or sediment reduction, disease control, preservation of biodiversity, and the value of these should be included in any estimate of societal benefit.

Another important consideration with respect to BMSF (and other agricultural technologies) in Ethiopia is initial investment. Whatsoever researchers have developed excellent BMS fertility strategy that increases agricultural output significantly, if the initial investment outlay is high, from experience, the majority of farmers will not adapt the technologies. Previous work has also identified that marginal returns for a new technology must be sufficient (>0.5) and investment costs reasonably low for farmers to adopt them.

The non market environmental services of BMSF that are directly associated with crop production is calculated indirectly from the agricultural market and farmers can easily recognize the change in output as a result of their management option. A farmer as an individual producer considers the direct part of the benefit and cost relation in agricultural production. If his or her private cost is greater than his or her benefit, farmers defiantly reject the adoption of the technology. However, farmers also produce various non marketable products that benefit the society. In this case to facilitate the adoption process of BMSF, charging of environmental services beneficiaries and paying service providers (adopter of BMSF farmers) can be justified in implementing BMSF. In this case a collaboration work between farmers, scientists, Economists and government bodes are required.

Scientists and economists should work together to enhance the understanding of the linkages between the policy agendas of the government to outcomes that arise from application of BMSF. One key element of this is expanding the knowledge base about the biological, economic and social outcomes arising from use of BMSF compared to other agricultural development strategies as well as a complementary production input. Key questions to consider include:

- Where do poor soil conditions create a significant problem for agricultural, social, health, or in general ecosystem, and for which geographic region and farming group?
- What are alternative solutions to tackle the problems?
- What are the benefits of promoting BMS other than for farm land recovery? (That is, have positive and negative externalities been adequately identified and analyzed?)
- Is promotion of BMSF is the most appropriate response to this problem? On what base can BMSF be justified economically and in terms of implementability?

- If Biological soil management is a preferable solution; what are the most appropriate types of interventions to address those specific policy concerns (national food security, rural poverty reduction, environmental service, and public health)?

The above research questions are the pillars of any more thorough analysis of BSMF. To the extent that research indicates that BMSF is desirable, data can be presented to policymakers to support BMSF. Without government support, widespread adoption of BMSF will not occur.

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