Chapter 9
Long-Term Chemical Fertilization in Tanzania

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Abstract Long-term application of chemical fertilizers has both positive and negative impacts on soil and the environment. Chemical fertilizers fertilize the soil and increase crop yields but they modify microbial functions involved in bioremediation and organic matter processing. As a consequence soils become unproductive. In the 1960s the Ismani area was the major growing zone of maize in Tanzania. From the 1960s to early 1990s this area attracted more people to invest in maize production. People immigrated in the area because of soil fertility where they grew maize to curb food insecurity and poverty. In 1976 Ismani contributed over 10% of the total maize in the National Milling Corporation. Subsequently, in 1983 Ismani produced 250,000 tons of maize. This production was mainly catalyzed by the application of chemical fertilizers. However, in 1990s the production trend started to diminish rapidly. The major reason for this downfall was acidification of the soils due to increasing soil pH. Long-term chemical fertilization was the major reason for this. Acidic soil limited the availability of plant nutrients and raised the concentration of toxic metals in the soil. Subsequently, this situation impaired the life of micro-organism such as earthworms, which forms humus useful for crop production.

Keywords Nutrient management • Farmers • Inorganic fertilizers • Basic soil productivity • Conservation agriculture • Microbes • Maize yields • Food security • Poverty • Ismani

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E. Lichtfouse (ed.), *Sustainable Agriculture Reviews*, Sustainable Agriculture Reviews 25, DOI 10.1007/978-3-319-58679-3_9

9.1 Introduction

Globally there is a growing demand for food and energy to feed the growing population (Plaza-Bonilla et al. 2015). This situation has forced substantive utilization of environmental resources to meet these demands (Birch-Thomsen 1996). To implement this, available agricultural systems are expected to produce food for global population that will reach nine billion people in 2050 (Branca et al. 2013). Despite of this anticipation; 41% of the Earth's surface is covered by dryland areas (Ye et al. 2013). This dryland sustain the livelihoods of over two billion inhabitants but the biome is susceptible to further stress of climate change impacts (Plaza-Bonilla et al. 2015). To sustain the required demands; sustainable agronomic practices are expected to be employed in order to produce more food for the growing global population. Rainfall variability, hydrology, pedology and vegetation are the guiding aspects considered when taking agronomic practices in diverse areas (Ye et al. 2013). Interaction between agricultural management, soil physicochemical properties, and soil microbial communities in the agricultural systems is significant when thinking of sustainable agriculture (Lienhard et al. 2013).

To meet the global demand of food; planners have opted for intensive agriculture as a driving tool. Intensive agriculture involves more irrigation and application of chemical fertilizers. However, excessive application of chemical fertilizers such as calcium, nitrate, sulphates, ammonium, potassium and phosphorus (Olsen-P) has side effects to the soil (Jacobsen et al. 2015). They sterilize microbial activity and other natural processes to perform their ecological functions (Duru 2015). Long-term fertilization of chemical fertilizers increases soil pH and soil becomes too acidic. At that peak, the soil becomes non-productive to crop production especially maize (Zea mays L). Excessive drought caused by the impacts of climate change increases stress to the already affected area (Paavola 2008). It is true that the increase in food production to feed increasing world population is inevitable. But this should not take place at the cost of excessive degradation of environmental resources (Jacobsen et al. 2015). Instead; the win-win situation between food production and environmental conservation should be considered.

Tanzanian semi-arid biome covers about 30% of the total area. Despite of that biome, the country has about 44 million hectares of arable land potential for agriculture (Kimaro et al. 2015). The National Environmental Policy 1997 and Agricultural Policy 1997 address on the sustainable utilization of available country's land resource (URT 1997; FAO 2014). These policies describe on the effective use of land resources basing on the spatial climatic differences. This means; different agronomic practices are employed to different agroecological zones. Sustainable soil management for both sustainable agriculture and environmental conservation is a central point of conservation agriculture and has a clear focus on soil and water resources.

However, shortage of innovative agronomic practices and soil degradation are the major hindrances to achieve sustainable agriculture (Branca et al. 2013). This problem is more pronounced in semi-arid areas which are limited rainfall and irrigation potentials. However, despite of drought the area may have fertile soil for agriculture. Therefore, cropping systems in semi-arid areas need to be more innovative due to water shortage (Sosoveli et al. 1999).

Maize is the staple food in most Tanzanian societies (FAO 2014). However, maize production is among the sensitive and vulnerable livelihoods affected by poor soils, rising temperatures, changing precipitation regimes and increased atmospheric CO_2 levels (Branca et al. 2013). Erratic rainfall and decreased wet spell increases the risk of crop failure. Tanzania has been listed by IPCC (2014) as among thirteen countries which are most affected and are vulnerable to impacts the climate change. Currently, conservation agriculture has been promoted in Tanzania to increase productivity and environmental sustainability of maize production. It acts as a climate-smart agriculture (Kimaro et al. 2015). Agroforestry, better crop rotation and related soil management practices are significant practices for sustainable agriculture (Duru et al. 2015).

In 1960s to 1970s Ismani was the major agricultural zone of Tanzania. Maize production especially Hybrid specie was the dominant type. Soil was fertile enough to support crop production especially maize production. In 1960s to 1970s there was an increase in maize price in the World market. The rise of food price was caused by the great demand of food product especially maize. This situation also increased food demand in the country. The domestic food demand was attributed by the famous famine occurred in 1970s. The whole situation demanded the increase in maize production to meet both internal and external demands.

To meet this demand, large scale cultivation with intensive fertilization was employed to increase crop yields. This was motivated by the government ideology of reducing poverty, ignorance and hunger (Palm et al. 2014; Nnoli 1978; Nyerere 1968). During that time; to improve the condition for crop production was a very important step to food security (Ziervogel and Ericksen 2010; Nyerere 1967). Definitely intensive agriculture increased crop yields but it has negative impacts to the soil. In this aspect, food demand was met at the cost of environmental degradation (Kimaro et al. 2015). Long-term application of chemical fertilizers killed the soil microbes and made the soil dead (Magid et al. 2002). In that stance, soils became unproductive. Up to date, the soil in Ismani is mainly unproductive. Mechanisms are needed to revive the degraded soil to make it live and productive. Therefore, it is wealthier to think of win-win situation in agricultural planning to curb food insecurity and environmental degradation.

9.2 Study Area

Ismani is situated in Iringa Rural District in Iringa Region, Tanzania; it is located in latitude 7° 30′ 0″ South and longitude 35° 48′ 0″ East. Ismani lies in the northern part of the region in the semi-arid Agro-ecological zone. Drought is the major characteristic of the area and therefore, it causes crop failure and famine in the area (Sosoveli et al. 1999). Different reports and findings show that about 30% of the

Tanzanian land is semi-arid. The technical paper of the United Nation Conference on Desertification described on the presence of semi-arid biome in Tanzania (URT 1977). Maize is the major crop produced in the study area since 1960s to date. In 1960s to around 1980s the area was a major maize producing hub in the region, southern highlands and the country at large. It was producing maize in surplus of which were sold to other regions and countries. Despite of its crop failure maize serves more than 70% of the people's livelihoods and to about 80% of the total cereal crop produced in Iringa region including Ismani (URT 2012). Soil degradation, climate change, lack of incentives and shift of labour power are the contemporary challenges facing maize production in the area. In terms of settlement; during the late 50s and early 60s, large parts of the Ismani plains (north and west of Ilambilole) were opened for commercial farming and some people settled there (Feldman 1983; Gregersen 2003) (Fig. 9.1).

9.3 Soil Characteristics

Soil types vary according to altitude and other climatic condition. It mainly ranges from loamy to sandy and in some parts clay soil and loes (Thierfelder and Wall 2009). Sand and seif dunes, barchans and loes as wind deposition features in semi rid and arid biomes eventually forms different types of soils (ibid). This wind action is more pronounced during dry seasons (July to November). Being located at the altitude above 1500 m, soil characteristic is varied over space. Its fertility ranges from poor to moderate soil (Birch-Thomsen et al. 2007). There are/were fertile soils in some areas but poor soil in other areas. Soil management and agronomic practices are among the contributors for this variation (Sieber et al. 2015; Feldman 1983). Loam, clay and sand soil are widely scattered in the area comprising different levels of fertility. Soil is in semi-arid zones is dry in most cases but it is fertile for sometimes (Magid et al. 2002; McDonagh et al. 2001). Due to increased demand of agriculture about the whole fertile land was under cultivation (Duru 2015). Currently, the area has turned to semi-dessert and therefore soil quality has gone down. The adoption of climate-smart agriculture as supported by FAO (2013); and Harvey (2014) can be the best practice to revamp the devastated soil fertility. In this area, climate-smart agriculture is highly recommended for the betterment of improved crop yields (Kimaro et al. 2015). Climate-smart agriculture refers to land management practices that increase soil nutrient and flow for crop production. It aims to increase crop yields (food security), reduce emission of greenhouse gases and increase carbon sequestration in the soil and biomass (Branca et al. 2013). Furthermore, Branca et al. (2013) urges that climate-smart agriculture should be adopted concurrently with agroecosystems such as intercropping, agroforestry and planting leguminous plants such as beans in order to improve soil fertility (Table 9.1).

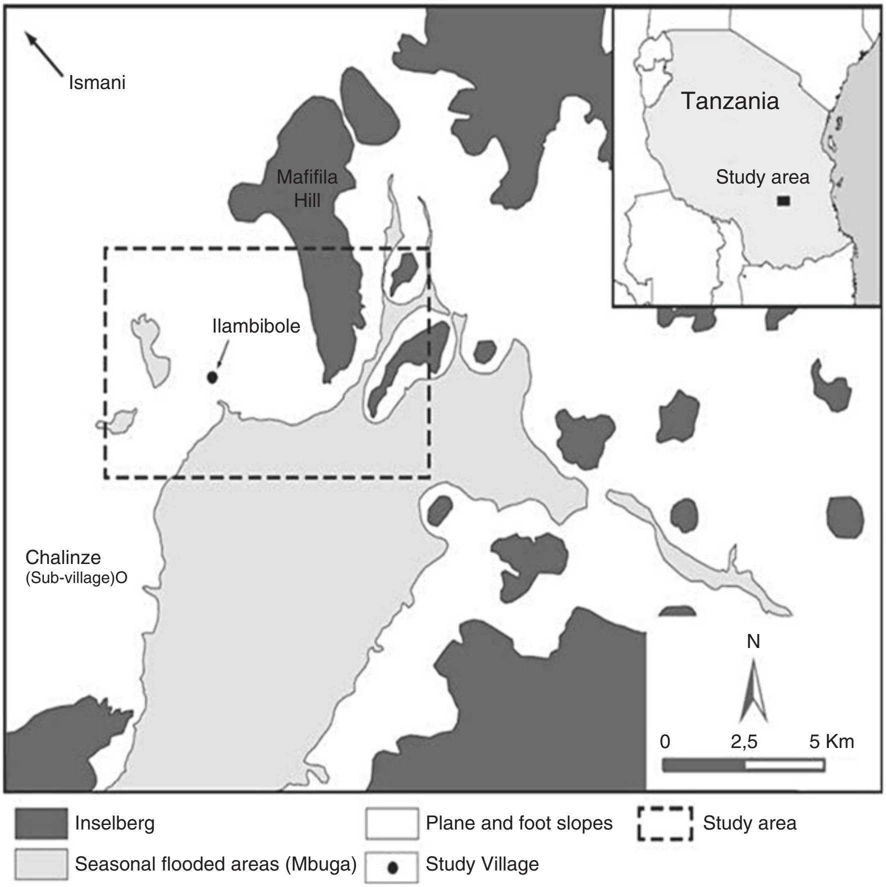

Fig. 9.1 Map showing Ismani division with an earmark of Ilambilole village. This village represents a vast area of Ismani division where it used to be the maize producing zone of Tanzania. It produced thousands of tons of maize yields to feed large part of the country and for export. However, currently the area is no longer a maize producing zone due to environmental impacts mainly caused by long-term fertilization of chemical fertilizers in 1960s to 1990s (Source: Modified from Birch-Thomsen et al. 2007)

Subsequently, soil organic management increases the resilience/adaptive capacity of farmer households to climate variability and mitigates climate change by sequestering carbon in biomass and soils and/or reducing emissions when possible (FAO 2013). In the analysis of the affected land due to agriculture intensification, there is a large portion of land called "mbuga" which covers more than covers 1201 hectares and has been excluded from the total area due to low or no agricultural potential even before agriculture intensification.

Table 9.1 Summary of the Farming Systems in Tanzania

Farming systems types (Ruthenberg 1980)	Farming systems no.	Farming systems (Food Studies Group 1992)
Fallow systems	1	Maize/legume system
	2	Livestock/Sorghum-millet system
	3	Cassava/cashew/coconut system
Pastoralist systems	4	Pastoralist system
Agropastoralist systems	5	Agropastoralist system
Perennial cropping systems	6	Coffee/banana/horticulture system
Wet-rice systems	7	Wetland paddy/sugarcane system
Irrigated agriculture systems	7	Wetland paddy/sugarcane system

Source: Modified from Sosoveli et al. (1999)
Table 9.1 above portrays the farming systems in two columns. The two studies were done in different times but both showing traditional approaches of farming. The systems were giving good results according to that time. Currently, there is a need to involve more advanced technology the farming systems. This is because of increased challenges from the changing earth. The impacts of climate change and environmental pollution are the leading factors

9.4 Vegetation

The review from satellite image in the study area from the mid-1950s to 2000 based aerial photographs (August 1955/56 and 59; June/July 1978, satellite images (November 1966—Declassified Corona Sa-tellite, August 1987—SPOT-image; August 1996; July 2000—Landsat TM-image, bands 2, 3, 4 (Birch-Thomsen et al. 2007) shows that the area was dominated by vegetation like Combretum and Acacia species while inselberg was vegetated by Combretum and Miombo species (Brachystergia) which had the socio-economic benefits to people as it supplied them with fuel wood and other non-timber products like forest fruits (Magid et al. 2002). Some areas near water bodies or in the seasonal flooded were covered by some grasslands and other annual plants (Birch-Thomsen et al. 2007). The vegetation system is natural but reforestation of other artificial forest can help to mitigate the impacts of climate changes.

9.5 Climate of the Study Area

Ismani experiences climatic characteristics of semi-arid agro-ecological zones of Tanzania. It experiences erratic and fluctuation both total and annual mean rainfall with the slight increasing temperature. At the altitude of around 1000–1500 m the area experiences unimodal and unreliable total annual rainfall ranging from 400 to 800 mm (Peters et al. 2014). Agronomic practices like monoculture, shifting cultivation and other accompanied environmental degradation have recently changed the area to semi-dessert biome. The growing season in the area is from March to May every year despite of the irregular changing of rain onset and offset. The climate patters seem to be good if not disturbed.

9.6 Farming Management

The farming system involved monoculture and bush clearing farming where soil fertility was mostly exhausted (URT 1977). The production took place in the small capitalist farms using tractors or ox-mechanization and the methods of large (Ruthenberg1980). Farming management had little to do with conservation due to agricultural intensification and monoculture system (Gregersen 2003). Farmers concentrated in areas with fertile soil as it needed little or no fertilization. However, the introduction of Ujamaa production under villagesation Programme increased the pressure to these areas to under agriculture and subsequently the area became semi-desert (Gougoulias et al. 2014b). Monoculture was the main farming systems to smallholders due to overutilization of land resources (Birch-Thomsen et al. 2001; Birch-Thomsen 1996). Apart from growing maize as a major food and commercial crop; farmers extended the production thresholds by increasing other crop and animals to improve their livelihoods (Birch-Thomsen et al. 2001). According to the review done by the government (URT 2012) other crops apart from maize produced by smallholders in semi-arid areas includes; Paddy, Sorghum, Bulrush Millet, Cowpeas, Finger Millet, Cassava, Beans, Green Gram, Chick Peas, Bambaranuts, Sunflower, Groundnut, Simsim, Tumeric, Bitteer Aubergine, Onion, Tomatoes, Spinach, Cabbage, Chillies, Cotton, Tobacco, Cashewnut, Banana, Mango, Orange, Sugar Cane Whilst livestock produced includes: Cattle, Dairy Cattle, Goats, Sheep, Pigs, Chickens, Ducks, Guine Pigs, Turkeys, Rabbits, Donkeys, Horses, Dogs. Each type of crop is produced basing on its environmental requirements. Conservation farming practices are encouraged for the betterment of both crop yields and environmental conservation. Table 9.1 below shows existing farming management while Table 9.2 shows the sustainable agricultural practices. The sustainable management includes Agroforestry, eco-farming and conservation agriculture. In this case, farming management needs to consider the sustainability of the environment and keep its natural productivity at maximum.

9.7 Historical Trend of Maize Production

Maize production is a major cereal crop produced in the area and its production began before the Independency of the country (Tanganyika, The then Tanzania). The temporal trend of maize production in the area for 20 years (1970–1990) under stressed rainfall show that it has been growing at the regression of $y = -1.2844 \times 2 + 29.418\times + 128.07$ at the rate of $r^2 = 0.2295$ (URT 2012). Before and early 1960 maize production was regarded as a major source of food and income (Nyerere 1967).

Table 9.2 Detailed list of sustainable land management practices considered in the analysis

Sustainable land management practices	Details of the practices
Agronomy	Cover crops
	Crop rotations and intercropping with nitrogen fixing crops
	Improved fallow rotations
Organic fertilization	Compost manure
	Animal and green manure
Minimum soil disturbance	Minimum tillage
	Mulching
Water management	Terraces, contour farming
	Water harvesting and conservation
Agroforestry	Trees on cropland (contours, intercropping)
	Bush and tree fallows
	Live barriers/buffer strips with woody species

Source: Modified from Branca et al. (2013)
Table 9.2 above shows the sustainable agronomic practices recommended for conservation agriculture. They cut across no or minimum tillage, cover crops and better crop rotation. Agroforestry is also inclusive as among the soil organic management and climate-smart practices. All these land management practices aims at increasing crop yield to curb food insecurity in various areas of Tanzania

Farmers were producing more to meet their daily food demand and income. The surplus was sold to National Milling Corporation as the government firm established to buy crop yields in rural areas (Feldman 1983). For example, in 1976 Iringa region particularly Ismani contributed 10% of the total maize crops bought by National Milling Corporation.

In early 1960, maize production decreased because farmers reduced their production and engaged in pyrethrum production (Birch-Thomsen et al. 2007). This came as a response the increase in price of pyrethrum in the World market thus; farmers shifted the production mind and switched to pyrethrum for economic gains. Also this was possible because the required environment for pyrethrum was highly related to that of maize. However, the production of maize resumed in 1970s when the price of pyrethrum felled.

The introduction of Green Revolution insisted the production of hybrid maize, chemical fertilizer and insects which subsequently increased the production of maize. This condition lead to surplus production to about 250,000 tonnes was marketed in 1983. However, this surplus production was met at the expense of environmental degradation through intensive agriculture (application of chemical fertilizer). In recent year 2000s the area has experienced severe drought plus poor soil fertility the condition which has greatly reduced crop yields and food security. The production is at deficit level and does not support enough crop yields (Feldman 1983). Smallholders are starving from both food insecurity and increased poverty (Ibhawoh and Dibua 2003). Adaptation to this condition has recently forced people to opt for drought resistant crops and tolerant animals as mechanism to regulate the stress.

Therefore, the production trend of maize has diminished to the maximum because of poor soil mainly caused by excessive long-term chemical fertilization.

9.8 Artificial Fertilization

In 1950s agricultural production was done through organic fertilization and in small scale farming. Tanzanian population size was under ten millions hence did not consume the 44 million hectares of arable land. In 1960s early after Independency; the country followed the Policy of "*Ujamaa and Self-Reliance*" which proclaimed independency in food security and combating poverty (Nyerere 1968; Nnoli 1978). Villagization and Ujamaa farms needed efficiency production to meet the growing demands of the people (Ibhawoh and Dibua 2003). This reflected both food security and poverty alleviation strategies. In all aspects, large area and intensive farming methods were required to carter for this demand (Albuquerque et al. 2013). The government was giving farm inputs to farmers being fertilizer and insecticides to increase maize production from household to national level. Ismani is in semi-arid agro ecological zone and its soil fertility was ranging from poor to moderate. Therefore, chemical fertilization meant to improve soil nutrients, basic soil productivity and nutrient use efficiency of maize. Application of chemical fertilizers involved the use of Triple Super Phosphate and Calcium Ammonium Nitrate. Chemical fertilizers were mostly applied in areas with poor soil while in fertile soil little fertilization was applied. During mid-1970s farmers were given inputs through National Maize Programmme (Birch-Thomsen et al. 2007). Every farmer was given 50 kg of Triple Super Phosphate and 100 kg of Calcium Ammonium Nitrate to fertilize the soil whilst pesticides and endosulphan insecticides were provided to fight with stalkbores (Pelosi et al. 2014; Albuquerque et al. 2013). Long-term chemical fertilization severely affected the biological processes of the soil (Duru 2015). Excessive drought had made the scenario more severe as it denies natural chemical decomposition to happen. Therefore, excessive application of chemical fertilizers needs to be reduced for the benefits of the environments.

9.9 Ecological Impacts of Artificial Fertilization

Degradation of soil fertility is a major ecological impact resulted from long-term application of chemical fertilizer in Ismani. Some of these impacts can be viewed hereunder as follows.

9.9.1 Soil Acidification

Excessive application of chemical fertilizers increases the level of soil pH in the soil. Most nitrogen fertilizers are the major cause of soil acidification and soil humus depletion and increased emission of greenhouse gases (Rai et al. 2014). These elements have a direct link to climate change. In a strongly acidic soil; the availability of plant nutrients especially phosphate is limited (Hooker and Stark 2011). Acidification has a huge impact on the supply of phosphorus (soil Olsen-P) to plants as well as the efficiency of phosphate fertilizers. As results; phosphate is readily fixed in acidic soil thus making it unavailable to plant. Ismani is highy affected as most of the soil is acidic. As solution, we need to apply lime in order to neutralize the acid in the soil and resume its productivity (Gougoulias et al. 2014a).

9.9.2 Death of Microbes

Increased chemical and acid content in the soil has repercussion to important micro-organisms. As results of excessive fertilization; important microbes such as earthworms become useless in the soil formation (Hooker and Stark 2011). Despite of increasing crop yields; chemical fertilizers raises soil pH and eventually slow down the enzyme reaction. Subsequently, important microbes have to rest, encysting or die from hunger. The study by Rai et al. (2014) showed that earthworms survive and flourish well under organic fertilizer as they feed from humus while dies under inorganic fertilizers because they lack food and conducive environment (Fig. 9.2).

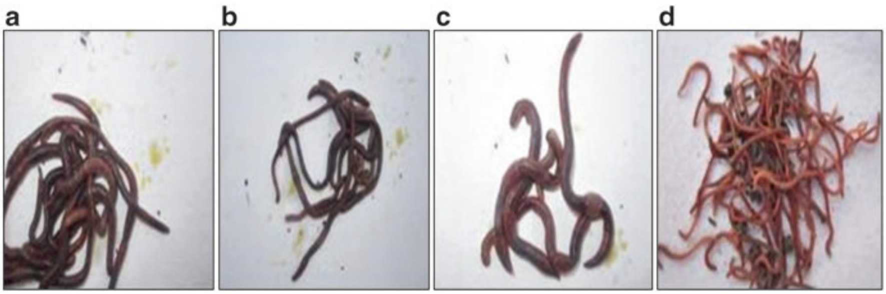

Fig. 9.2 (**a**) Earthworms in control set (**b**) Weakened earthworms in soil with urea fertilizer (**c**) Healthy earthworms with well-developed clitellum in soil with organic fertilizer. (**d**) Earthworm juveniles under organic fertilizer treatment. These figures portray the negative impacts of chemical fertilizers to the health of earthworms. Figure (**b**) shows the impacted earthworm as they are dying from added toxicant and hunger. Whilst Figures (**c**) and (**d**) show the healthier earthworms as they are subjected to organic fertilizers mainly made of humus. Therefore, the healthier microbes i.e. earthworms under organic fertilization are stable to form organic matter from biotic residues while those under inorganic are weakened, resting and dying and therefore cannot form organic matter for organic soil fertilization (Source: Modified from Rai et al. 2014)

Therefore, natural environment has to be crated to enable good functioning of micro-organisms.

9.9.3 Poor Carbon Sequestration

Due to excessive chemical fertilization soil microbes are no longer doing well their natural function (Tiessen et al. 1998). Earthworms and other micro-organisms are severely affected by the added chemical fertilizers and excessive drought. Carbon cycle is not well supported by the lithospheric carbon because there is no adequate process to make enough soil organic matter (Rai et al. 2014). Therefore, the concentration of carbon dioxide gas in the atmosphere is at maximum. Because of lack or shortage of land cover and soil fertility the soil cannot process carbon-fixing, photosynthesizing plants and photo and chemoautotrophic microbes that syntheses atmospheric carbon dioxide into organic materials (Gougoulias et al. 2014b). In turn the situation leads to increased global warming which affects the patterns of rainfall. Therefore, mitigation measures like afforestation need to take place in order to sequester atmospheric green house gases. Thus, adaptation and coping strategies like conservation agriculture need to be in place.

9.9.4 Dinitrification and Ammonification

Excess of nitrates and ammonium fertilizers expires in the atmosphere and form green house gases (Solomon et al. 2000). NH_4^+ fertilizers react in the soil in a process called nitrification to form nitrate (NO_3^-), and in the process release H^+ ions. These greenhouses are expired in the form of N_3O^- and NH_4^+ gases respectively (Pelosi et al. 2014). These gases increase global warming and subsequently lead to reduced, erratic and unreliable rainfall with increasing temperature. These processes become worse because the controlling variables such as pH mineralogy, and other related processes are not efficient as they need water for their smooth flow and the area has no water because is a semi-dessert (Hooker and Stark 2011). Therefore, the utilization of excessive chemical fertilizers needs to be reduced for the benefit of the environment.

9.9.5 Degradation of Ecosystems

The impacts from chemical fertilization have severely affected the ecosystem including soil and water (Duru et al. 2015). The application of nitrogen fertilizer always breaks down into nitrate and can simply travel the soil (Birch-Thomsen et al. 2007). Then, nitrogen can remain in the ground water for many years because it can be readily soluble in water (ibid). Therefore, further addition of nitrogen fertilizer though Calcium Ammonium Nitrate and other nitrate fertilizer as did in Ismani leads to accumulative effects (Gougoulias et al. 2014a). Currently the area (Ismani) is very dry (semi-desert agro ecological zone) hence has poor soil fertility replenishment which can flow within a defined ecosystem. Vegetation is scarce in the area hence cannot support some biological function to work properly (Branca et al. 2013). Drought resistant trees like acacia are dominant. The former miombo (*Brachysteria* woodland) are no more due to the change of life pattern of the ecology. Therefore, carbon which used to be stored in that biomass (*Brachysteria)* has been expired long time ago in the atmosphere (Munishi and Shear 2004). Ecology and its ingredients needs to be restored at place in order revive the natural processing of the environment.

9.9.6 Loss of Carbon Stock

The historical trend from both land use change and modification particularly intensification and expansion for maize production shows that soil carbon stock has reduced (Kimaro et al. 2015; Solomon et al. 2000). Ismani is in semi-arid biome and has been severely affected by long-term intensive agriculture which degraded carbon stock from the soil (Plaza-Bonilla et al. 2015). A number of wealthier literature shows that carbon loss in semi arid areas due to agriculture is more pronounce between 0 and 10 cm depth (Branca et al. 2013; Batjes 2011; Birch-Thomsen et al. 2007). In the study area; carbon loss within that depth (0–10 cm) was mainly caused by oxen ploughing and the changes of cultivation among other factors. However, this loss was not spatially uniform because of the differences in the soil condition, application of manure and burning and spreading of ashes in the fields (Birch-Thomsen et al. 2007). The overall review shows that the carbon loss in the soil due to farming practices for 20 years is approximated to be 1.7 kg C m^{2} (8000 t C). This trend show that at the period of 50 years (1960s to 1990s) is high when other factors are constant (Sieber et al. 2015; Thierfelder and Wall 2009). In this stance, soil organic management needs to be in place to increase carbon storage in the soil which has multiplier benefits to the environment.

9.10 Situation After Impacts

Most of the farms are abandoned by smallholders because they can no longer support crop production (Gregersen 2003). Farmers in different wards and villages of Ismani have abandoned most of their farms because they are too exhausted (Magid et al. 2002). Maize production has lowered down and people are starving of hunger (Ziervogel and Ericksen 2010). Large scale farming is almost no more; farmers have changed their mind from agriculture. Some are doing other businesses as adaptation strategy while some have shifted to other regions (other agro-ecological zone) to undertake agriculture (Ye et al. 2013). In terms of food availability, most households are food insecure and some are very low food secured (Sieber et al. 2015). People are trying to adapt and cope to the condition of food shortage. According to USDA *food insecure households* refers to unable, at some time during the year, to provide adequate food for one or more household members due to a lack of resources whilst *very low food secured households* refers to normal eating patterns of some household members were disrupted at times during the year and their food intake reduced below levels they considered appropriate. The majority farmers are experiencing the two scenarios above and they suffer a lot. (Sieber et al. 2015; Birch-Thomsen et al. (2007). Therefore, short and long term solutions need to be taken to revive the livelihoods of the people. This is should be more focused to the poor in marginal areas.

9.11 Conclusion

Basing on this review, this study gives the following conclusions; long-term application of chemical fertilizer has enormous negative impacts to the soil. It makes the soil more acidic and subsequently unproductive for crop production. For sustainable utilization of soil resources there should be win-win situation between the demand to increase crop yields and that of environmental conservation. This will keep on providing both environment services (food production) and conservation of the environment. Then, the degraded ecosystem is harmful to micro-organisms depending. Intensive measures are to be taken to recover the condition otherwise severe impacts are expected from this degraded ecosystem by chemical fertilizers.

A number of soil management practices need to be practiced for sustainable development of both human and his ecosystem. Sustainable land management through good agricultural practices is more recommended as does not add toxicants to the soil. Agroforestry, better crop rotation, mulching and addition of organic manures are suitable for sustainable agriculture. This will increase the capacity of the soil to form organic soil and sequester atmospheric carbon dioxide. In turn, this condition will restore the functions of microorganisms such as mycorrhiza and earthworms which facilitates and improve nutrient uptake. They increase of surface absorbing area of the plant roots and realize powerful enzymes into the soil. Eventually, this help to dissolve hard-to-capture nutrients, such as organic nitrogen, phosphorus, iron and soil nutrient including trace elements. Therefore, soil organic management practices increases soil fertility for sustainable agricultural production (Kimaro et al. 2015; Kilembe et al. 2012; Paavola 2008).

We recommend that sustainable agriculture should be worked upon to serve the livelihoods of the majority. In Tanzania, agriculture provides livelihoods to about 80% of the rural dwellers and therefore its sustainability is more substantial. Soil fertility loss and climate change impacts are among the major problems facing Tanzanian agriculture. Subsequently, it is wealthier to incorporate adaptation and mitigation measures in the agricultural practices (Kimaro et al. 2015).

Agroecosystems such as agroforestry, better crop rotation, mulching, little or no tillage among others are proper agronomic activities are possible and implementable practices in the context of Tanzania. They serve as climate-smart agricultural practices through conservation, soil carbon sequestration and increasing crop yields (Lienhard et al. 2013). Lastly, irrigation potentials should be well harnessed to curb the impacts of climate change and variability (Chai et al. 2015). Therefore, planners, policy makers, agricultural experts ranging from researcher to extension officers and other affiliated stakeholders should work diligently to improve food security and environmental conservation in the country through sustainable agriculture.

Acknowledgment Authors give thanks to the authors of the journal papers, books and reports from which they have reviewed.

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