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Unsustainable Agricultural Practices as a Driver of Soil Degradation in Santa Sub-Division, North West Region of Cameroon

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This research sets out to investigate unsustainable agricultural practices as a driver of soil degradation in Santa sub-division, North West Region of Cameroon. The major types of agricultural practices studied were bush fallowing, slash-and-burn, shifting cultivation and bush fire. The study assessed the various agricultural activities that have occurred on the environment over time and space. The causes of unsustainable agriculture were identified to be overgrazing, deforestation, climate change and population growth. The study made use of primary and secondary data sources. Major primary data sources included field observation, interviews and administering of questionnaires. Data collected were presented in the form of tables, charts and pictures and subjected to interpretation. A soil test was equally carried out based on some chemical properties on selected sites in Santa sub- division. The findings revealed that unsustainable agricultural practices in this zone contributes to soil degradation. Climate change was seen to have a silver

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lining in the crop sector. Declining soil fertility and climate change were some of the major problems faced by farmers in Santa. Mixed crop farming, crop rotation, soil management practices and mulching were recommended to limit or stop soil degradation in Santa. Finally, it was recommended that farmers should incorporate more environmentally friendly trees into their farm lands since scattered trees on farmlands improve soil fertility more.

Keywords: Unsustainable; agricultural practices; soil degradation.

1. INTRODUCTION

A panoramic survey of the planet earth shows wide reaching and overwhelming evidence of a plundered planet characterized by the growing influx of the human population with equally astronomical demands on the natural resource base. The consequences of this demographic pressure on resources have been expressed by the over-exploitation and over-utilization of planetary resources [1].

The growth of human population on the earth surface without a corresponding increase in the natural landscape that sustains life has called for the need to understand the trend of environmental problems caused by agricultural practices. Scientific and technological revolutions today have offered mankind a greater domination over nature, which have left indelible environmental imprints on some parts of the planet (soil degradation), which had since yesteryears, become a source of human concern. A remarkable shift in agricultural practices has occurred over the past century in response to technologies, and the development of world markets. This has also led to technological improvements in agricultural activities. Since the 1990s, there has been a growing interest in developing alternative sustainable farming strategies [2].

In recent years, the world's population has been increasing with an associated acceleration of environmental problems. Consequently, mother earth is charged with the huge task of feeding the increasing world population and handling their wastes. Population pressure is forcing farmers to grow crop after crop, depleting the soil nutrients and lowering yields from the land [3]. The industrial revolution with all its innovation, the benefits of science and technology are also here with us. But how well we can apply them for the enhancement of human livelihoods and for the sustainability of the environment in order to ensure that it holds promise and hope for posterity for the millennia to come remains the billion Dollar question which begs for an answer [2].

With the prospect of increasing population growth which is a reality of our time, we would require sustainable agricultural practices in order to address declining soil fertility and amelioration of human livelihoods as a global agenda. Soil infertility is one of the greatest challenges of the 21st Century. This is urgent and needs to be adequately addressed for the sustainable livelihoods of mankind. Even at that, there are about 8 billion people on the planet today. But with a world population of about 9 to 10 billion people by 2050, it would even be more difficult to resolve the problem of soil infertility alone with the allied challenges, let alone nature, the occurrence and the disastrous impacts of natural and climatic hazards which are way out of the scope of human control if we are unable to do so today.

Agriculture constitutes the backbone of the economy of most developing countries, which practice rain fed peasant agriculture. The economics of sub-Saharan Africa are glaring examples of this given that besides ensuring the sustainability of rural livelihoods, it is also a major contributor to the Gross Domestic Product (GDP). Africa's population is projected to reach 1.5 billion by 2030 and 2 billion people by 2050, the majority of which will be women and youths [3]. Soil fertility decrease on smallholder farms is a major problem in sub-Saharan Africa [4]. Deteriorating soil fertility, associated with nutrient depletion and unsustainable cropping practices, has been widely reported across Tropical Africa [5]. Most often, agricultural activities are conducted without proper conservation measures often resulting in soil fertility decline caused by acidification [6].

If Cameroon maintains its position as the "bread basket" of Central African Region, one of the areas to be credited is Santa sub- division as it remains one of the major heavens for agricultural production, particularly market gardening [6]. There is a concept that agriculture in Cameroon will enable families to survive on a "hand-to-mouth'' basis, a situation which is not worthwhile in terms of sustainability [7]. The cropping pattern in the Grass fields is hundred percent under peasant control with a variety of crops grown such as maize (*Zea mays*), beans (*Phaselus vulgaris*) yams (Dioscorea), cocoyam (*Colocasiae sculenta*), cassava (*Manihote sculenta*), Guinea corn (*Sorghum bicolor*), groundnut (*Arachishy pogaea*), potatoes (*Solanum tuberosum*) vegetables and coffee [8]. The government of Cameroon of recent, has laid emphasis on agriculture as one of the pillars for an emerging country. Achieving this goal requires not only improving the living conditions of the people in rural areas, but also insuring sustainable agriculture which is the key to sustainable economic and industrial development [1]. Known as the paradise for food in Cameroon, the North West Region is now suffering from a drop in yield due to some physical factors like climate and soil fertility [9]. Agriculture is one of the pillars of the economy of Cameroon though mostly practiced at a small scale and depends largely on household labour, with about 70% of the active population of this country engaged in it[10].

In the North West Region of Cameroon, increased intensive cropping without sufficient organic and mineral inputs is a commonplace. This deteriorates the functional or productive capacity of the soil as a result of negative changes in its physical, chemical, biological, and hydrological properties [11].

Unsustainable agricultural practice is any practice that does not maintain or restore the soil to a condition that can support plant life. Thus, anything that depletes the soil nutrients continuously will eventually result in soil that is incapable of growing crops at all. The volcanic landscape on the western slopes of the Bamboutous Mountain Range that slopes to the Santa highlands is an area where agriculture in the form of crop production and animal rearing thrives with remarkable success [12]. Santa sub-division is one of the fastest growing sub-divisions of the North West Region and about 80% of her population is engaged in agriculture. However, agricultural practices on the landscape have left a significant impact on the environment in terms of production and productivity. The value and importance of the relation between humans and nature has been neglected during recent years especially in Santa sub-division.

Studies addressing soil infertility issues and most especially the role played by agroforestry in soil fertility enhancement in farmlands are few in Cameroon [12]. This study was geared towards understanding the farming practices of small holder farmers and how these practices contribute to soil degradation in Santa sub-division. More specifically, the study sought to: (i) to identify the farming practices that smallholder farmers employ, (ii) to examine the causes of unsustainable agricultural practices and (iii) to carry out a soil chemical test to determine the fertility status of some selected sites.

1.1 Problem Statement

Environmental degradation has left ugly imprints which are today a clear-cut environmental footprint which show man's abuse of the land. Today, the problem of soil infertility is legendary in Santa sub-division. In this respect, the problem is how we can cope with the increasing and wide spread soil infertility arising from unsustainable agricultural practices in Santa sub-division. How intense soil infertility is likely to be and the degree of destruction which it would bring cannot be mathematized. So, increasing population therefore poses a significant threat to soil biota in Santa sub-division. One major limiting factor to optimum crop production is the lack of in-depth information on soil and land characteristics in mountainous ecosystems [6], especially in Santa sub-division which is characterized by hilly and mountainous terrain.

Improvement in science and technology has not been able to stop or reduce the impacts of agricultural activities on the environment in Santa. Consequently, there has been a significant change in the climate, soil, water and vegetation, which essentially constitutes the biophysical characteristics responsible for agricultural production. This manifestation can be seen in Santa through increased temperature, change in rainfall pattern and massive soil degradation.

Efforts to improve agricultural productivity in the short-term are often designed to succeed at the expense of long-term sustainability, whether this takes the form of ecological stress, loss of genetic diversity in standing crops, the consequences of these changes do not only have environmental impacts (soil degradation), economic impacts, and cultural impacts, but also affects the general nutrition, relationships, health and quality of life.

Increasing soil depletion on the hilly landscape of Santa has reduced crop output and has forced farmers into unproductive marginal lands. This expansion which is aimed at having more farmlands to meet up with the food demand of the family and the local markets have failed because the soil has been exhausted and the indigenes and the people have resorted to the use of chemical fertilizers whose application have affected surface and ground water supply. The sole use of inorganic (mineral) fertilizer not successful in the tropics as well as the sole use of organic fertilizers is limited by their bulkiness, unviability, low quality and slow release of nutrients [13]. The exploding demographic pressure on the earth's surface and its consequences on the planetary resources especially soils demand urgent attention as there is a need to address the issue of the carrying capacity of the earth.

1.2 Study Area

Santa is found in the North West Region of Cameroon and lies between longitudes 9° 58‟ - 10°18‟E of the Greenwich Meridian and between latitudes 5° 42‟- 5° 53‟N of the Equator. Santa is located in the south of Mezam Division in the North West Region. Santa-sub division is the gateway to the North West Region of Cameroon through the Bafoussam-Bamenda high way from the two big cities of Yaoundé and Douala. The grassland area is located within the western high land agro-ecological zone of Cameroon and has witnessed a great alteration in its environmental components as a result of unsustainable agricultural practices.

The climate of Santa is marked by two distinct seasons, the dry and wet seasons. The wet season usually begins around March to mid-October. The rainfall ranges between 2000 to 3000mm per annum. The dry season is usually from October to February characterized with very cold nights and very hot days. The annual average temperature in Santa hardly exceeds 19°C that is favourable to crop and vegetable cultivation qualifying this region as the agriculture cornucopia of the region. Even great stretches of the Bafut-Ngemba Forest Reserve to which Santa belongs has been cleared to make way for the cultivation of food crops like, Irish potatoes, and vegetables such as carrots, cabbages, green spices [12]. Potato production is therefore still constrained by poor farming practices, pests, inefficient use of available technologies, infertile soil, high cost of inputs like fertilizers, seed and fungicides, lack of access to credit, and a lot more despite government subsidization [14].

Santa is essentially characterized by mountains located on the North West and West Regions Mountain Chain, otherwise known as the Bamboutous ranges. The highest point in the area is Mount Lefo in Awing, which is about 2209m above sea level [12]. The relief ranges from about 400m-2600m above sea level. Another outstanding peak is the Azope hill situated in Baba II and many other ranges as seen on Fig. 1.

Santa is characterized by three soil types, which are the penevoluted ferralitic soils in low- lying parts of Baligham, Santa and Ndzong; modified orthic soils in highland areas of Akum, Baba, Mbu and Awing and then the aliatic and penevolated ferralitic red soils are in the intermediate relief areas of Mbei and Pinyin. The hydrogeological setting provides a configuration of river valleys that promotes market gardening [12]. The hilly and mountainous topography has caused much of these soils to be eroded in to valleys as fertile colluviums where cabbages, carrots, Irish potatoes and spics are cultivated. Such valleys are often the exclusive heavens of the males while the females are relegated to less fertile marginal lands where they deploy the slash-and-burn farming systems that quickly depletes the soil of its physical and chemical characteristics as seen on Fig. 2.

2. MATERIALS AND METHODS

A field survey was carried out in the villages of Akum, Mbei and Ndzong because they are major havens for agricultural production in Santa sub-division. The research adopted both the descriptive and analytical methods of investigation and was further complimented by review from published and unpublished sources. Interviews and focused group discussions were carried out with agriculturalists, small farm holders, farming cooperatives, extension workers, some key persons from the Divisional Delegations of Agricultural and Rural Development, Environment and Nature Protection as well as that of Livestock Fisheries and Animal Husbandry, and other resource persons in Santa sub- division. Questionnaires were also distributed to have more precise and reliable information.

Face-to-face interviews and focused group discussions were major sources of primary data. Interviews were carried out with at least two extension workers from each village that were involved in the study area. Vital information was also obtained from textbooks, libraries, internet, both published and unpublished journals and reports on agriculture and the environment. In addition, these sources provided ideas postulated by several authors about agriculture and the environment.

2.1 Soil Sampling

Soil analysis provided vital information about the physical conditions, fertility status and chemical properties, that affects soil suitability for agricultural activities in Santa sub- division. Soil samples were collected from ten points in each of the selected farmlands in the villages of Akum and Mbei and mixed to form one sample. From each village, one composite sample was collected representing market gardening and food crop. The soil samples were collected at a depth of 0-20 cm for both the treatment and the control plots. This soil depth was chosen because the crops are surface feeders. This depth made it possible to have a comparative analysis between the treatment plots and adjacent control plots. Overall, a total of 3 soil samples were collected for the study. These sites were chosen because they are agricultural lands with small-scale agriculture and varied land use practices, including limited control of plant diseases/pests, the use of basic tools and low fertilizer inputs, and low yields.

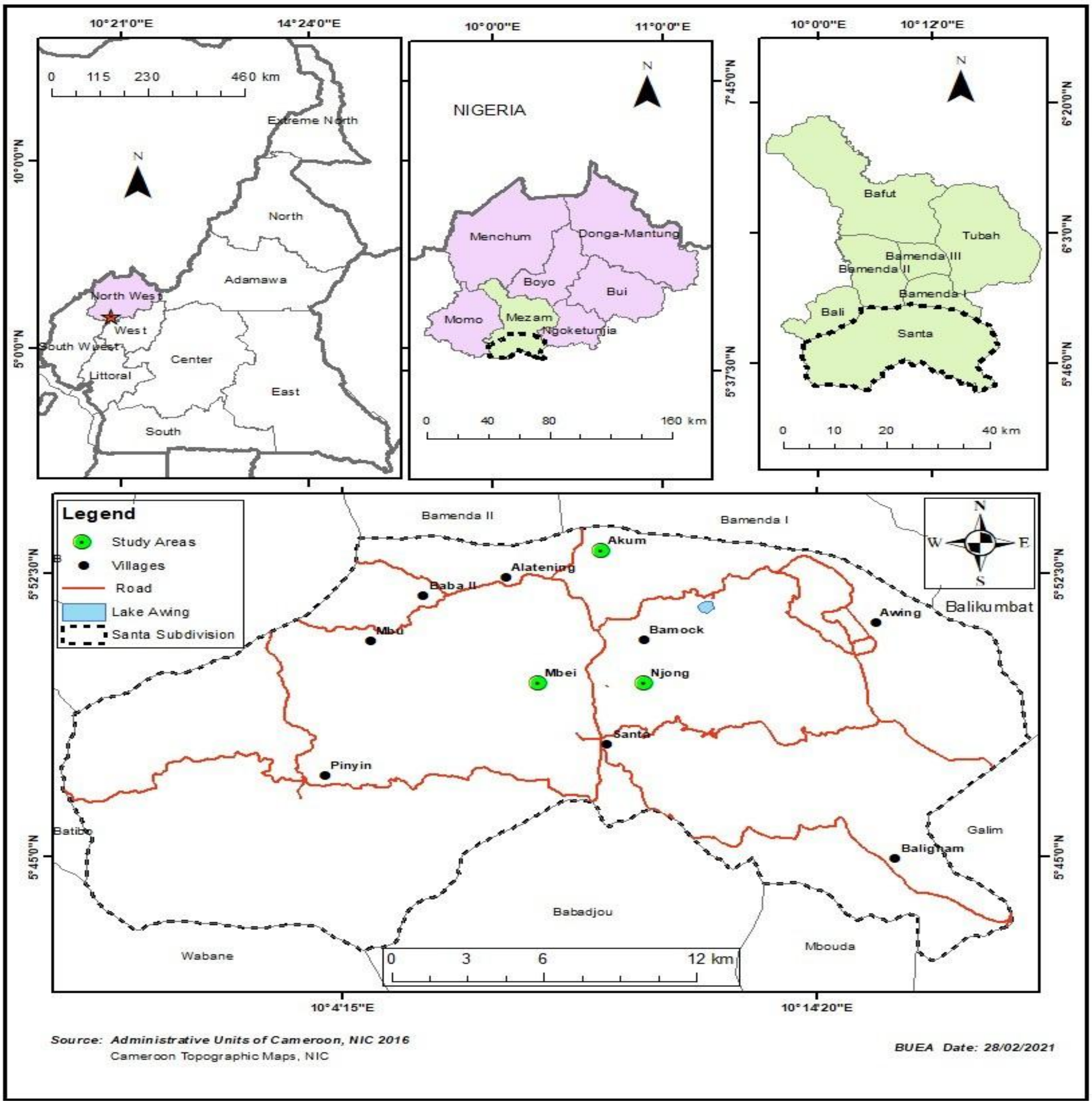

Fig. 1. Location and layout of Santa sub-division

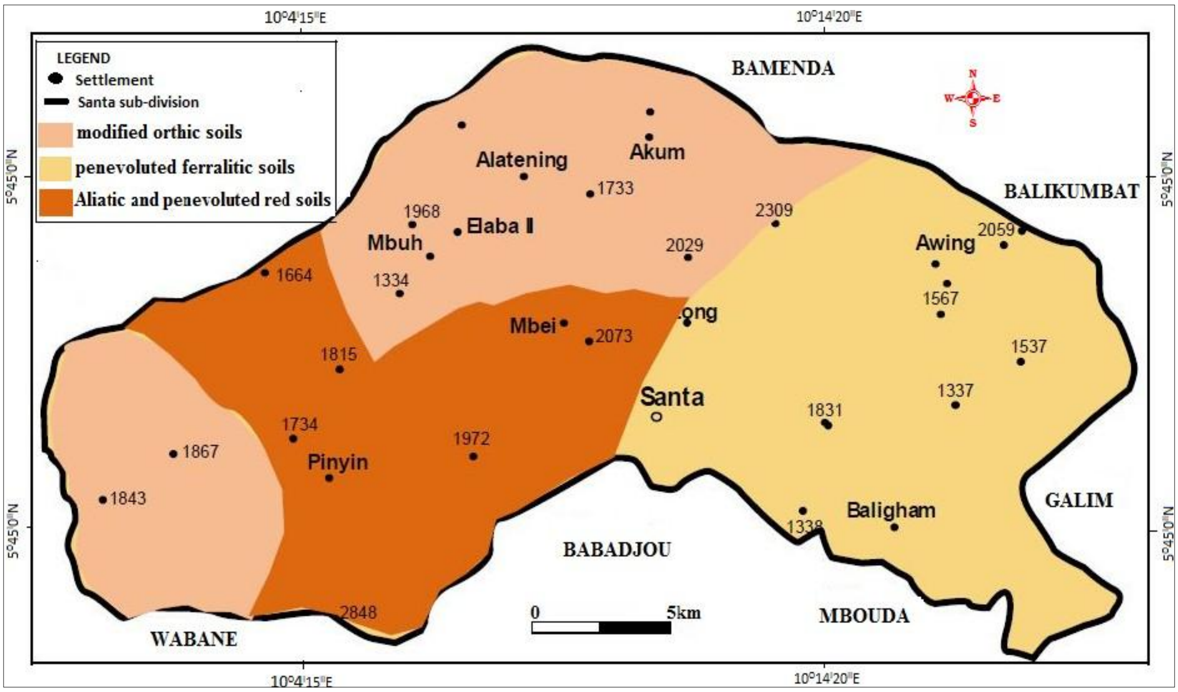

Fig. 2. Soil map of Santa sub-division

The soils were analysed for organic carbon using the method of [15]. The soil was also leached with neutral I M ammonium acetate to obtain soil extracts that were used for determining exchangeable cations. Exchangeable calcium, potassium and sodium were determined by flame photometry, while exchangeable magnesium was determined by atomic absorption spectrophotometry. Soil pH was determined potentiometrically in 0"01M calcium chloride solution, using a soil-to-solution ratio of 1:2. Soils adjacent under cultivation were collected and analysed to serve as the control sample for assessing the impact of agricultural activities on the soil. These soil samples were taken to the International Institute for Tropical Agriculture (ITIA) and Institute of Agricultural Research for Development (IRAD) Yaoundé for testing. The results were then collected and analysed by calculating the coefficient of variation for the various soil chemical properties.

2.2 Data Analysis

Data was analysed using Microsoft Excel 2010 and SPSS statistical package 20. The SPSS was used in conjunction with Microsoft Excel to perform descriptive and inferential statistical techniques. The descriptive statistics involved the production of frequency tables, charts and percentages while inferential statistics was used to compute coefficients of variation for soil test analysis.

3. RESULTS AND DISCUSSION

This part of the research is a very important section as it brings into play the components of the achievement of the various objectives. The various views and opinions of farmers on the practices and causes of unsustainable agriculture, and its contribution to soil degradation in Santa sub-division.

3.1 Major Farming Practices in Santa

Based on the responses from farmers, shifting cultivation had 54%, Ankara with 33%, while bush fallowing had a percentage of 8 and a total of 5% out of the total population did not give any responses on the various farming practices, as indicated on Fig. 3.

3.1.1 Shifting cultivation

Shifting cultivation is a traditional land management practice and a characteristic of agrarian rural communities. This was the case in Santa area before the 1970s. As a result of population increase and the introduction of the Green Revolution in the 1980s, this practice became more unpopular, though not completely wiped out as some evidence of shifting cultivation can still be traced in Santa today. This practice of shifting cultivation is very unsustainable by nature since farmers do not give proper care to the land, with the conception that in case of decline in output, he/she will move to a virgin land. Thus, the land is first degraded by humans, and then after it is left bare where natural land degradation sets in.

3.1.2 Bush fallowing

Bush fallowing just like shifting cultivation is a very old and unsustainable practice in Santa. It is a situation in which with the exhaustion of the fertility of the cultivated plots, the farmers move to new sites with the intension of coming back to the same area abandoned when their fertility would have been regained. Currently, bush fallowing is the dominant farming system in Santa. Fallow is commonly referred to as a resting period for agricultural land between two cropping cycles during which soil fertility is restored [13]. The dominant vegetation during the fallow period are grass, shrubs and Tithonia. Tithonia is a good fertilizer tree which enhances soil fertility. Tithonia has nematicidal properties, reducing disease problems in the subsequent cropping phase [16].

3.1.3 Slash-and-burn

The slash-and -burn system of agriculture popularly known in Cameroon as "Ankara'' is a widely used method of growing food in which wild land is cleared, cut and any remaining vegetation burned. At the beginning of the cropping period, soil chemical properties change significantly due to the liming effect of ashes [17]. The resulting layer of ash then provides the newly-cleared land with a nutrient-rich layer to help fertilize crops. This system is mostly used by food crop farmers especially those that are into tuber cultivation. After several years of cultivation, fertility declines and weeds increase since farmers have to depend on the natural processes for soil nourishment. Even though the slash-and-burn system of farming is unsustainable in nature, it can maintain carbon stock and biodiversity as shown on Fig. 4.

These agricultural systems have however contributed to the high depletion of land quality since most farmers have remained poor to modernize their farming systems and also because the landscape is too hilly and rocky such that most of the ecological niches are fragile and get critically degraded when disturbed by any stressor.

The environment has a direct influence on the existence and sustainability of agriculture as it depends upon the use of natural resources. Shifting cultivation, slash and burn and soil burning agriculture are all practices disastrous to the environment. The slash-and-burn method of farming destroys soil bacteria and renders the soil poor after some years of cultivation.

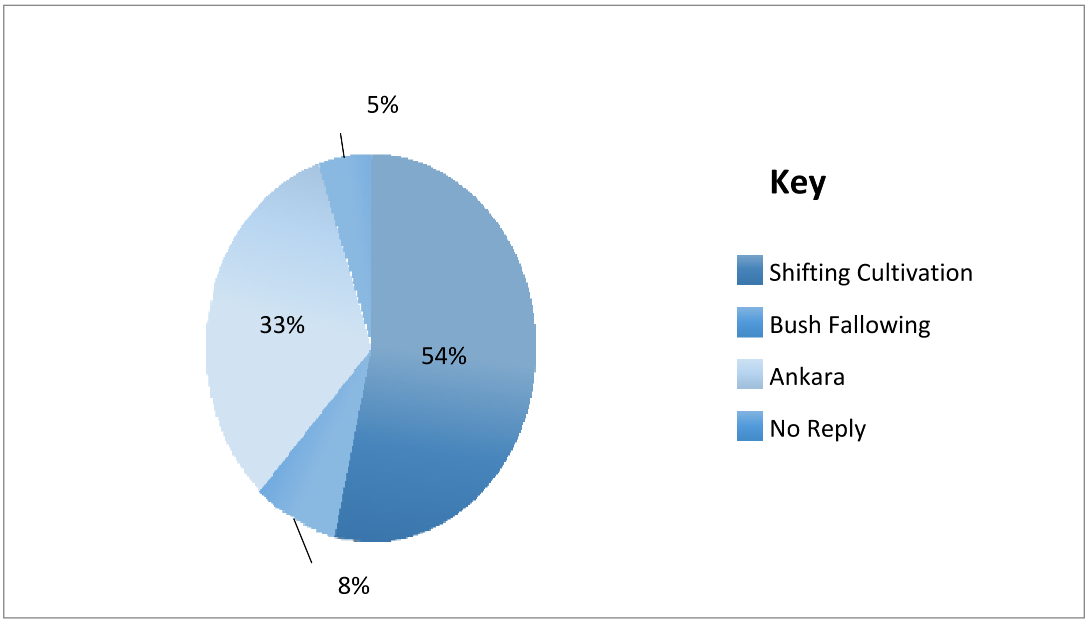

Fig. 3. Main farming practices in Santa sub-division

A: Preparation of ''Ankara'' **B: Cultivated ''Ankara''**

Fig. 4. Slash-and-burn (Ankara) before and after cultivation

3.1.4 Bush fires

Fire has been used to farmer's own advantage and has been threatened by it. Fire has been used in Santa to reduce thick bush, meanwhile others burnt bushes for hunting wildlife and to make way for their crops. In Santa, fire is being used to improve pasture land and to convert forests and fields into agricultural lands. The soil is the basic natural resource of agriculture. Fire is a readily available tool that impoverishes the rural population of Santa and the environment. Bush burning in Santa is most often a deliberate action and this is done for bush clearing, pasture regeneration for hunting and domestic animal grazing, pest and disease control [18].

Fire is being used to clear land, remove weeds and dispose of waste as seen on Fig. 5. Bush fires impoverish the soil by destroying organic matter in the soil, and it also increases leaching, wind and water erosion. Burning results in long term modification of pasture where undesirable plant species for the cattle often gain resilience.

The slash-and-burn system of agriculture also causes bush fires when it is not properly carried out. Graziers during the dry season also burn hills and bushes for regeneration of pasture lands. The hills of Akum, Ndzong and Mbei lose nearly all their unfarmed savannah to bush fires every year. Some lazy villagers have also been reported to use bush fires as a means of clearing vast land, which impoverish the soil and destroy micro- bacteria found in the soils.

3.2 Causes of Unsustainable Agricultural Practices

This sub- section examines the main causes or drivers of unsustainable agriculture. It takes into account the various opinions of farmers on some of the root causes of unsustainable agriculture. Some of the major causes of unsustainable agricultural practices as indicated by farmers include climate change, deforestation, over grazing and increasing population growth.

3.2.1 Climate change

Climate change is problematic and it is putting food safety at risk. The effect of global warming on agriculture is massive and other conditions must also be met for agriculture to be sustainable in Santa. Water required for crop production has become scarce in Santa due to increased crop water use for most crops. More extreme temperature and precipitation have prevented crops from growing.

Drought in Santa is gradually becoming intensive and this has threatened pasture and feed supplies for livestock production. Climate change also increases the prevalence of parasites and diseases that affect livestock. The earlier onset of the dry season allows parasites and pathogens to survive more easily. While increased rainfall could allow moisture-reliant pathogens to thrive as [19] opines that farmers find it difficult to adapt to such conditions and so cannot improve their output much in such situations. Alternating rainfall patterns in Santa have pushed farmers to embark on unsustainable agricultural practices which impact the environment negatively. Most farmers now in Santa use irrigation during the dry season which causes water shortages and increases soil salinity making this practice unsustainable. Farmers have resorted to use fertilizers as a soil additive to increase their yields in response to climate change. Fertilizers do not only harm the environment but italso affects human health.

A: Bush fires in Akum

B: Bush fire in

Fig. 5. Bush fires in Akum and Ndzong

3.2.2 Population growth

Increasing population exerts pressure on natural resources and these resources become exhausted especially the soil, which when overused drops in fertility. Field observation indicates that one of the main drivers of unsustainable agriculture is increasing population. Population growth in Santa has resulted in changes in agricultural practices. The changes in agricultural practices that have emerged in response to population growth, increased population density, and growth in demand for food production do not appear to be sustainable. Increasing population density and urbanization pose both an opportunity for agricultural development as well as a constraint, as they also increase pressure on agriculture and the natural resource base.

3.2.3 Deforestation

Deforestation causes unsustainable agriculture and affects temperature and rainfall. It affects agriculture and water availability. Deforestation in Santa is mainly caused by farmers and other economic operators. The transformation of the landscape is done by graziers and farmers through burning and cutting with the help of crude tools such as cutlass, axes and the engine saw. Deforestation leaves behind bear and naked vegetation which results in less water available in the air to be returned to the soil causing dryer soil and therefore limiting the ability to grow crops.

Furthermore, deforestation causes soil erosion in that trees help the land to retain water and topsoil, which provides the rich nutrients to sustain additional forest life. The barren land which is left behind in the wake of this unsustainable agricultural practice is then more susceptible to flooding. Deforestation also affects the way water vapour is produced over the canopy, which causes reduced rainfall. Without enough trees, soil is vulnerable to erosion and nutrient loss. The absence of roots can cause topsoil to be easily washed or blown awayleading to soil degradation as seen on Fig. 6.

Note that as illustrated on Fig. 6 there is high probability of excessive run-off which erodes the soils as farmers encroach on hills and slopes. Hilly environment such as the one on Fig. 6 are easily affected by soil erosion, depleting soil fertility and decreasing crop yields. Generally, Santa is characterized by hills and mountains. As a result of increasing population, agricultural lands are increasingly becoming scarce, forcing farmers to go into unproductive marginal lands and hilly environments to cultivate their crops. Soils found on hilly environments are in most cases very acidic in nature with high organic matter which makes such areas susceptible to soil erosion. The upslope extension of agricultural land in Santa has accelerated the pace of soil erosion. However, the loss of the top layer of soils is one of the pressing issues in this agricultural zone.

3.2.4 Overgrazing

Overgrazing is another grave cause of unsustainable agricultural practices in Santa. Overgrazing increases soil erosion, causes a reduction in soil depth, soil organic matter and soil fertility which impairs the land's future natural and agricultural productivity. Overgrazing causes the soil to be exposed and it reduces the vegetation's production capacity. Cattle and other livestock compact the soil, which reduces the amount of water infiltrating into the soil thereby reducing plan growth. Continuous overgrazing reduces inputs of soil organic matter, nutrients, and biotic activity. This consequently leads to deteriorated soil structure, thereby increasing the potential for erosion and reduced water- holding capacity of the soil.

3.3 Soil Degradation

Soil degradation is a concept in which the value of the biophysical environment is affected by one or more combination of human-induced processes acting upon the land [18]. In all ecosystems, the biodiversity held in soil is massive. Healthy soils are vital to creating ample food production. Poor farming practices in Santa have aggravated the rate of soil degradation. Poor farming practices have been known to cause a considerable decline in the quality of soil. The soil chemical test that was carried out in Akum and Mbei to determine whether there has been a decline in soil fertility reveals that most of the chemical soil properties that were tested have witnessed a decline most especially Phosphoric Acid, Magnesium and Calcium, with higher variations in their calculated coefficient of variation.

Declining soil fertility is a serious setback to farmers in Santa and soil is the main foundation on which agriculture is built. Soil and water have provided the population of Santa with the ability to produce food, through agriculture, for their sustenance. Rapid declines in soil fertility is accompanied by large demands for food due to increase in population and intensification of agricultural activities without proper regard for long-term maintenance of fertility by application of fertilizers in its right quantities, fallowing, rotations and prevention of large-scale erosion.

Table 1 shows test results for some soil chemical properties from Akum and Mbei that were tested at the International Institute for Tropical Agriculture (ITIA) and Institute of Agricultural Research for Development (IRAD) Yaoundé. The coefficient of variation was calculated for the various properties. Soil samples were taken from market gardening fields, food crop plots and adjacent land, which was used as a control sample.

Calculated coefficient of Variation (CV) of <25% was considered to have low variation, while a calculated CV of >50% was seen to have high variation and finally a calculated CV ranging between 25-50% was considered to be moderate. From the calculated CV, Acidity/ Alkalinity (pHH_20 and Ph kci), Organic (g/kg) and Mat Org (g/kg) had calculated CVs of 2.38%, 2.3% 1.47% and 1.47% respectively. Exchangeable acid (Al and Al +H (cmol/kg) had 0.00%, 0.00% respectively. These values lie below 25% indicating that the variation in these properties were insignificant. Total Nitrogen (N) had a calculated CV of 26.80% indicating that this property had a moderate variation.

The other remaining chemical properties Exchangeable calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Phosphoric Acid (P), Humidity and Exchangeable bases (CEC) had a high calculated CV, with Phosphoric acid having the highest (107.45%) followed by Ca with 77.65%, Mg 67.46%, K 56.54%, CEC 52.80%, Humidity 66.44% and Na 40.03%. These values with high variation indicate a great variation in soil chemical properties. Most of the properties have a high variation indicating that there is a reduction in most of these properties which greatly affect soil fertility negatively.

Fig. 6. Hilly areas in Akum which are prone to soil erosion

Table 1. Summary of soil test results and coefficient of variation

Soil chemical properties	Akum (Market Gardening)	Mbei (Food Crop)	Adjacent Plot	SD	Mean	Standard error of the mean	CV (%)
Total Nitrogen (N) %	0.661	0.384	0.508	0.1387528	0.5176667	0.080108966	26.80
Exchangeable calcium (Ca) cmol (+)kg-1	2.64	0.476	4.31	1.9222969	2.4753333	1.109838633	77.65
Magnesium (Mg) cmol (+)kg-1	0.758	0.185	1.047	8.6765028	12.86	5.009381227	67.46
Potassium (K) in cmol (+)kg-1	15.17	0.204	0.799	6.6400402	11.743333	3.833628997	56.54
Sodium (Na) cmol (+)kg-1	0.032	0.038	0.066	0.0181475	0.0453333	0.010477464	40.03
Phosphoric acid (P Ass (mg/kg) Bray 2	13.398	2.582	44.01	21.487824	19.996667	0.010477464	107.45
Exchangeable acid (Al*(cmol/kg)	0	0	0	0	0	0	0.00
Al*+H (cmol/kg)	0	0	0	0	0	0	0.00
Humidity %	16.55	4.71	7.05	6.2704492	9.4366667	3.620245534	66.44
Mat Org (g/kg)	52.892	53.927	54.443	0.7898399	53.754	0.456014279	1.47
Organic (g/kg)	30.68	31.28	31.58	0.4582576	31.18	0.264575149	1.46
Exchangeable bases (cmol/kg) T	62.428	26.428	27.503	20.481338	38.786333	11.82490601	52.80
Acidity/Alkalinity Ph. (H2O)-1:5	5.37	5.63	5.53	0.1311488	5.51	0.075718795	2.38
PH(kci)-1:5	4.22	4.23	4.4	0.1011599	4.2833333	0.058404695	2.36

Source: Laboratories of Inter Tropical Institute of Agriculture Yaoundé and Institute for Agricultural Research and Development (2020)

3.3.1 Total nitrogen

Nitrogen is an essential element in crop nutrition [18]. Mean values of nitrogen under market gardening, food crop and adjacent farmlands ranged from 0.661 to 0.384% and 0.508 % respectively. The distribution of nitrogen is moderately variable in the area and it can be concluded that as market gardening activities are intensified, the level of nitrogen increases. Hence market gardening activities have no significant impact on the level of total nitrogen in the soil. It should be noted that Nitrogen is exposed to more transformations than any other essential soil element consequently, modern agriculture relies heavily on commercial Nitrogen fertilizer to improve crop yields.

3.3.2 Exchangeable cations

The range of calcium, magnesium and potassium observed under market gardening, food crop and adjacent farmlands were 2.64kg, 0.476kg and 4.31kg for Ca, 0.758kg, 0.185kg and 1.047kg for Mg, 15.17kg, 0.204kg and 0.799 for K and 0.032kg, 0.038kg and 0.066kg) for Na. The mean values of calcium, magnesium, potassium and Sodium observed were 2.47, 12.86, 11.74 and 0.04kg respectively. The mean values of Potassium and Sodium were higher than was the case with Magnesium and Calcium (Table 1). Mg levels have slightly decreased in soils under Market gardening and food crop when compared to adjacent farmlands.

From the results, it can be seen that the level of exchangeable Ca in the soil under market gardening and food crop is lower than the adjacent land with 4.31kg. This is a clear indication of declining soil fertility as calcium and magnesium are clearly decreasing. Moreover, Exchangeable bases are most present in soils with pH levels greater than 6.0 [18]. The loss of calcium and magnesium from soils in Santa can be attributed to the clearing down of forests for market gardening and food crop production. From the soil test analysis, it can be concluded that there is a decrease in the level of exchangeable cations in the soil in Santa sub-division.

3.3.3 Available phosphorus

From Table 1, the phosphoric acid under market gardening farmlands was 13.398kg, food crop farmlands 2.582kg and adjacent farmland was 44.01kg. As unsustainable agricultural practices become more intensified, available P decreases indicating declining soil fertility.

Generally, organic matter variations were low for market gardening and higher for food crops and adjacent plots. No significant difference was observed in the level of organic matter between the farms and adjacent farmlands. Market gardening negatively affects the level of organic matter in the soil in Santa sub-division.

3.3.4 Cation exchange capacity

The results showed that cation exchange capacity was higher under market gardening farmlands (62.428 cmol/kg) than under food crop farmlands (26.428 cmol/kg) and adjacent farmland 27.503 cmol/kg. The variation in the distribution of CEC was moderate for food crops and adjacent farmlands. Thus, the high nutrient uptake of market gardening is responsible for the higher value of CEC under market gardening sites. The pH of soil under market gardening was slightly lower than that of food crops and adjacent land [20].

Belay [21] opined that Long-term fertilization results in a decrease in total organic and basic cation contents, which has an acidifying effect on the soil. An agricultural technician in Santa also added that the decrease in Total Nitrogen Content is greater with simple fertilizer treatments (N, P, or K) whereas basic cation contents and pH declines more in balanced fertilizer treatments (NPK).

According to him, crop rotation exerts effects on chemical and microbial properties of the soil and Responses of maize to simple fertilizer applications are not beneficial in terms of yield returns. He however suggested that judicious use of inorganic fertilizers may, in the long-term, maintain soil quality and productive capacity.

The soil test results show that as forest and land is being destroyed for agriculture in Santa, there is a significant decline in available phosphorus and exchangeable cations notably Ca and Mg. However, fertilizers have been used to supplement deficiencies observed, but the decline cannot be easily replenished because of the high demand of these soil nutrient by most crops especially market gardening crops. Declining soil fertility remains a serious threat to farmers in Santa [22]. compared British soil data over a fifty-year period and noted that significant reductions in the level of mineral content is responsible for reduction in modern agricultural yields. The fight to increase agricultural yields in Santa through poor farming practices have greatly contributed in declining soil fertility. In an attempt to improve crop yields, farmers have ended up degrading the already depleted soils in Santa.

The shift from hunter-gatherer societies to an agrarian way of life have drastically changed the course of human agricultural activities and have also altered the natural nutrient cycling within soils. Overgrazing and deforestation are the two most important factors affecting soil degradation in Santa. Nutrients found in soils are mostly lost by leaching and losses from various forms of erosion (wind and water). Most agricultural activities in Santa often encourage soil fertility decline and soil degradation. Soil is a non-renewable resource which needs to be conserved with care so that the next generation can also benefit. Moreover, over cultivation of soil has loosened the soil, increasing soil aeration and water infiltration. Declining soil fertility reduces crop yields and consequently affects farmers. Soil fertility decline negatively impacts the community of Santa in that their ability to meet up with food supply is limited.

According to Moulin et al., [23] the use of synthetic pesticides are widely spread among different farms. He went further to add that mulching has a major impact on soil fauna abundance and diversity. Most farmers in Santa use pesticide as a means to fight pests and diseases which can cause a drop in crop yields. Yield and quality are central to sustainable vegetable production. If not properly managed, pests and diseases can dramatically reduce crop yield and subsequent returns [24]. Moreover, mulching is a well-known practice in Santa where cover crops like beans and maize remains on the surface of the soil. Mulching is also an indigenous adaptation measure to soil degradation in most parts of Santa sub-division. In line with studies carried out by [10], the conversion of natural forest and grazing land to farmland and eucalyptus plantation greatly affected nitrogen, phosphorus, and potassium concentrations at different topographic profiles in the North West Region of Cameroon. This is clearly exhibited in Santa where natural forest has been cleared down to make way for agricultural production while part of the landscape has been replaced by eucalyptus trees for commercial purposes.

4. CONCLUSION

Agriculture is regarded as the backbone of the population of Santa sub-division. Over 80% of the population directly depends on agriculture for their lives and livelihoods. Agricultural production is largely determined by soil fertility. However, in recent years, soil degradation has been the trend around the world driven mainly by climate change and unsustainable agricultural practices. The expanding population in Santa has accelerated the need for more food to feed the many more mouths added to the division every year. Unfortunately, the desires and effort to happily feed these mouths have been cut short by the deterioration of the environment due to unsustainable agriculture. There is a rapid depletion of the soils as a result of unsustainable agricultural practices and systems such as the Ankara system, deforestation and bush burning.

However, mono-causal explanations have offered incomplete, and sometimes misleading, accounts of why agriculture in Santa sub-division has become unsustainable. Evidence from Akum, Ndzong and Mbei however, suggests that agricultural practices have ramifications on soil health. Soil infertility has proven to be a major stumbling block to the growth of the agricultural sector in Cameroon and Santa in particular. Specifically, the biophysical setting of Santa has changed over the past years in ways that have severe implications for agricultural sustainability. Soil conditions, rainfall patterns, and forest use have all changed for the worse, making farmers in Santa sub- division exposed to declining productivity and poverty. The stubborn biophysical conditions in this area have also been aggravated by ineffective economic policies that encourage farmers in Santa to use natural resources in unsustainable ways. Despite the increasing use of agricultural and arable land, the indigenous population of Santa dwellers are no better economically now than they were before. Farmers in Santa have adopted some soil fertility management practices. There is however a need to improve through training and supervision in order to get satisfactory results.

5. RECOMMENDATIONS

It is recommended that farmers should incorporate more environmentally friendly trees into their farm lands since scattered trees on farmlands improve soil fertility more.

A soil's cation exchange capacity (CEC) should be considered when determining the appropriate rates and timing of nutrient applications in a fertilizer program. In general, smaller amounts of fertilizer, applied more often, are needed in low CEC soils to prevent leaching losses, while larger amounts may be applied less frequently in high CEC soils.

Crop rotation is also an indigenous mechanism put in place by farmers in Santa to adapt to the degrading environment. It involves carefully considered cropping sequences with or without fallow. Some pathogens tend to build up in the soil when the same crops are cultivated again and again. To save the soil from these adverse effects, crop rotation is practiced. This helps to maintain and improve soil fertility, prevent pests, weeds and soil borne diseases.

It also conserves soil moisture from one season to another. Talking with a food crop farmer, he admitted that this practice has been successful as he cultivates maize, cocoyam and cassava while rotating these crops after two or four years. Crop rotation also helps in the improvement of soil structure and fertility in Santa. In some parts of Akum and Mbei, crops are alternated in two or three years. That is if maize is planted for two or three years, the field is used for the planting of cassava or cocoyam.

The population of Santa have also adopted soil management practices like using manure to improve soil quality by improving soil aeration and water movement. Proper manure management and application is crucial in managing nutrients to optimize crop production. Sound management decreases nutrient losses from surface runoff or leaching. Farmers have also reported in planting cover crops which protects the soil, air and waterways. Cover crops utilize excess nitrogen in the soil, effectively retaining nutrients for the next growing season while reducing nitrogen loss in the form of nitrous oxides. Legume cover crops fix nitrogen from the atmosphere potentially reducing the nitrogen fertilizer application rate. Reduced soil tillage is another soil management technique employed by farmers in Santa. This practice improves soil structure and fertility, and it also provides protection against soil erosion. Besides organic and inorganic inputs, farming practices such as agroforestry constitute a promising option for maintaining the stability of landscapes and soils that are subjected to human activities. Apart from pesticides, chemical fertilizers are also used to replenish soil fertility. The people using chemical fertilizers are gradually increasing as soil conditions continue to deteriorate.

Increased planting of perennial legumes in annual crop rotation act as a mitigation strategy for soil depletion. This is to promote the inclusion of short-term perennial legume stands in annual crop rotations. Perennial cover of the soil surface can benefit the environment in several ways.

Regarding the rapid soil depletion as tested in the villages of Akum and Mbei where there has been a marked reduction in the chemical properties of the soils, the continuous cultivation of Irish, beans and maize within the same piece of land rapidly degrades the soils with time because there is continuous oxidation. It is therefore recommended that for these soils to regain their fertility, fallowing should be employed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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