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Assessing Ecosystem Responses to Land-Use Changes by Soil Quality Index

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Dedication

I dedicate this thesis to my family for their endless support

To who pushed me to science, to my first supporter in life and with him increased pride (my father).

To who weaves my happiness with strings from her merciful heart (my mother).

Declaration

I certify that this thesis submitted for the degree of Master is the result of my own research, except where otherwise acknowledged and that this thesis (or any part of the same) has not been submitted for a higher degree to any other University or institution.

Signed:…………..

Israa Sulieman Abdullah Alassa

Date: 14/07/2018

Acknowledgment:

As we take our last steps in this stage of education, I must express my thanks and gratitude to those who encouraged me and supported me in completing this thesis.

First thanks to the great God who helped me accomplish this thesis.

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To who planted hope in our path and gave us assistance and facilities, I give them all thanks, especially my Colleagues in the Soil and Hydrology Lab.

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Finally, I acknowledge all my family and friends, especially my dear parents who were the reason of what I become today, thanks for the love, advocacy and pray that made me able to get such success. To my sister and brothers for being in my life.

Abstract:

The change in land use from natural land regarding land used by humans in various areas is critical to the global ecosystem, which in turn affects soil conditions. In order to improve our understanding of land use, our study focuses on soil health assessment and it depends on long-term environmental research area near Wadi Nar in Al-Ubeidiya to assess the ecosystem response to land use, including tillage practice. The aim of this study is to evaluate of the effects of tillage on soil health for each system (natural, pastoral A, pastoral B) by using soil quality index. Three systems are studied: natural (no tillage), tillage with the removal of plants (pastoral A) and tillage without the removal of plants (pastoral B). In order to assess soil health, the chemical, biological and physical parameters of the soil must be analyzed. During our study, soil quality is assessed using the method of registration in each index using the SQI soil quality index, which determines the level of soil degradation, by collecting data on selected chemical, physical and biological indicators for each soil. Numerous statistical calculations were performed, including the PCA analysis, which shows the correlation between transactions in all systems at a given depth. Soil health assessment was used in detail for each laboratory of chemical, physical and biological indicators based on Cornell's book.

The result of soil quality index for natural land is 16, where a number of indicators have been adopted to determine the quality of the soil. The pastoral system A achieves 15.4 while pastoral B has the highest value of 16.3. The result shows that according to the soil quality index, management types including tillage and plant retention, can improve soil quality. The higher the values are, the better the soil quality is. The best soil quality index in our study is 39 and the lowest value is 10 based on the equation used to calculate the soil quality index.

تقييم استجابات النظام البيئي للتغيرات في استخدام الأراضي حسب مؤشر جودة التربة

اعداد: إسراء سليمان عبدالله العصا

اشراف: د. جواد شقير

الملخص:

إن التغيير في استخدام الأراضي من الأراضي الطبيعية إلى الأراضي التي يستخدمها البشر في مختلف المناطق يعتبر أمراً حيوياً بالنسبة للنظام الإيكولوجي العالمي ، الذي يؤثر بدوره على ظروف التربة. من أجل تحسين فهمنا لاستخدام الأراضي ، تركز دراستنا على تقييم صحة التربة لحالة الدراسة في منطقة البحوث البيئية طويلة الأجل بالقرب من وادي النار في العبيدية لتقييم استجابة النظام البيئي لاستخدام الأراضي ، بما في ذلك ممارسة الحراثة . حيث ان الهدف الرئيسي من هذه الدراسة 1) تقييم آثار الحراثة على صحة التربة لكل من النظام (الطبيعي، الرعوي أ ، الرعوي ب) باستخدام مؤشر جودة التربة. تمت دراسة ثلاثة أنظمة: طبيعية (بدون حرث) ، حرث مع إزالة النباتات (الرعي) والحرث دون إزالة النباتات (الرعوية ب). ولتقييم صحة التربة ، يجب تحليل المؤشرات الكيميائية والبيولوجية والفيزيائية للتربة.

خلال دراستنا ، تم تقييم جودة التربة باستخدام طريقة التسجيل في كل مؤشر باستخدام مؤشر جودة التربة SQI، والذي يحدد مستوى تدهور التربة، عن طريق جمع البيانات عن بعض المعاملات الكيميائية والفيزيائية والبيولوجية المختارة حيث تم اعتماد عدد من المعاملات لتحديد جودة التربة. تم إجراء العديد من الحسابات الإحصائية، بما في ذلك تحليل المكون الاساسي PCA ، والذي يبين العلاقة بين المعاملات في جميع الأنظمة عند عمق معين. تم استخدام تقييم صحة التربة بالتفصيل لكل معامل من المؤشرات الكيميائية والفيزيائية والبيولوجية بناءا على كتاب كورنيل.

إن نتيجة مؤشر جودة التربة للأراضي الطبيعية كانت 16، وحقق النظام الرعوي (أ) 15.4 في حين أن النظام الرعوي (ب) اخذ اعلى قيمة 16.3 و بناءا على النتيجة التي ظهرت وفقا لمؤشر جودة التربة ، يمكن لأنواع الإدارة ، بما في ذلك الحراثة مع الاحتفاظ بالنباتات أن تحسن نوعية التربة.

حيث انه كلما زادت قيمة مؤشر جودة التربة، كلما كانت جودة التربة أفضل. وفي دراستنا أفضل مؤشر لنوعية التربة هو 39 ، وأقل قيمة هي 10 استناداً إلى المعادلة المستخدمة لحساب مؤشر جودة التربة.

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Abbreviations

AC	Active Carbon
Al^{+3}	Aluminium
AWC	Available water content
Ba^{+2}	Barium
Ca^{+2}	Calcium
CEC	Cation Exchange Capacity
Cl^{-}	Chloride
Cu^{+2}	Copper
EC	Electrical Conductivity
EDTA	Ethylenediaminetetraacetic Acid
HCO_3	Bicarbonate
HMP	Hexametaphosphate
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
iLTER	International Long Term Ecological Research
K^{+}	Potassium
LTER	Long Term Ecological Research
LUC	Land Use Change
MDS	Minimum Data Set
Mg^{+2}	Magnesium
Na^{+}	Sodium
NO_3^{-}	Nitrate
OM	Organic Matter
PCA	Principle Component Analysis

PCs	Principle Components
POM	Particulate Organic Matter
POXC	Permanganate-Oxidizable Carbon
SAR	Sodium Adsorption Ratio
SOM	Soil Organic Matter
SOP	Standard operating procedure
SQI	Soil Quality Index
TNb	Total Nitrogen bound
TOC	Total Organic Carbon
Zn^{+2}	Zinc

Units

%	Percentage
μg/g	Microgram/gram
cm	Centimetre
Meq/l	Milliequivalents of solute per litre
Mg/l	Milligram/liter
Milligram/Kilogram	mgkg
μS/cm	Microsiemens/Centimetre

Chapter One

Introduction

1.1. Background

Since people first began to manage their environment, land use has been changing due to the growth and intensiveness of human needs, mainly for food production, as well as wellbeing and livelihood. These changes have increased dramatically over the past 50 years (Chazal and Rounsevell 2009 and Metzger et al. 2006). Nearly one-third to one-half of global ecosystem production is constituted by human activities (Foley et al. 2005 and Hoary et al. 2014), and with continued development and population pressures, the pressures on the biosphere continued. Land-use changes around the world are due to the need to provide food, water and shelter to more than 7 billion people (Foley et al., 2005 and Palomo et al., 2014). A large proportion of Earth's surface has been converted from natural ecosystems to human-controlled systems through land use (Palomo et al. 2014). The world's landscapes are changing and its ecosystem structures, functions and diversity are altering due to several reasons including; clearing tropical forests, subsistence agriculture, the introduction of over grazing, the intensification of farmland production, and the expansion of urban centers (DeFries et al. 2004a; Foley et al. 2005 and Potschin2009). Land-use changes (LUC) are so extensively significantly affecting key aspects of the earth's system, altering ecosystem services and affecting the ability of biological systems to support human needs when aggregated globally (Andrew et al. 2014). Therefore, the use of land causes us a dilemma. On one hand, many land-use practices are fundamental for human needs, since they provide critical natural resources and ecosystem services. On the other hand, some land use practices break down the ecosystems and services that we rely on. (Foley et al. 2005).

Studies have shown that land use of terrestrial systems have an impact on ecosystem responses (Foley et al. 2005; Sala et al. 2000b; Verburg et al. 2009; Yamaura et al. 2009 and Zhou et al. 2006).The term “land use” includes a wide range of human activities on land surfaces that affect the biosphere at regional scales as well as global scales. The ecosystem responses are, to a large degree, determined by the kind of land use changes and these effects depend on the intensity and the length of the human activities (Verburg et al. 2009).

Ecosystem responses depend on the initial state of the system before land-use transition. The transition from a functional state to a degraded state means that the land-use management reduces the functional capacity of the ecosystem. On the other hand, the transition from a degraded state to a functional state means that the land-use activities improve the ecosystem function.

The selection of environmental indicators to monitor ecosystem responses related to land-use changes includes complex processes, interactions and feedback (Foley et al. 2005). The selection of environmental indicators can help reduce this complexity. According to (Potschin 2009) functionality land use-based indicators have been widely used as a mean of characterizing the status and function of a managed ecosystem (functional, declining or regenerated). Recently, environmental indicators have been significant elements of environmental impact evaluation ‘‘state of the environment (ecosystem)’’ responses to LUCs. Indicators should be signs or signals conveying a complex message, in a simplified and useful way (Jackson et al. 2000; Niemeijer and De Groot 2008).

Humans play a significant role in the formation of the biosphere. Therefore, there is a need to develop new monitoring techniques and methods that deal with changes in different spatial and temporal scales. There is a need to develop and build an ecosystem framework responses to natural resource transfers that include structural and functional changes in the ecosystem which can be detected by selecting environmental indicators both soil condition (soil quality) in order to assess the response of the biological, chemical and physical processes.

The term land use includes a wide range of human activities on the surface of the earth, such as grazing, agriculture and urban use (Defries et al 2004a). A large proportion of the land surface have been transformed by land-use activities, whether it is the transformation of landscapes into human use or management practices in human-controlled territories (Foley et al., 2005).

Soil quality monitors soil functions organizing the two basic ecosystem processes of energy flow and nutrient cycling (Acton and Padbury 1993; Bastida et al. 2008 and Brejda et al. 2000). By definition, soil quality shows the ability to sustain the productivity of plants, animals and microbes, thereby promoting the abiotic and biotic interactions that are at the core of the ecosystem processes (Herrick 2000; Riley 2000).

There is an increasing need to expand and deepen our multi-faceted understanding of ecosystems, and long-term environmental research networks can play important roles in promoting and applying ecosystem studies on the regional and global scales. Our study site is part of the International long-term ecological research network (iLTER). The network includes hundreds of research sites in a wide range of ecosystems that help to understand environmental change around the world and focus on the long term, in situ monitoring. This science helps prevent and solve environmental, social and economic problems by looking for questions and problems. Long-term ecological research provides valuable data to test hypotheses about the drivers of ecosystem transformation. In 1980, the U.S. National Science Foundation (NSF) responded to the need for more long-term studies by creating the U.S. Long Term Ecological Research (U.S. LTER) Network (Callahan 1984). The semi-arid area of Wadi Nar in Al-Ubeidiya West Bank was selected as the study system since this area is undergoing degradation processes and its proximity to a source of pollution. We assume that the time scale of the land use before transition and the timescale of the transition are important in controlling the dimensions of the trajectories in the phase plane. Two testable hypotheses were generated regarding Wadi Nar ecosystem response to Land Use Change (LUC).

1.2 Research Goals

• The goal of this study is to identify the influence of land use practices on the ecosystem services based on three research protocols assigned by the ILTER protocols by using the soil quality index SQI. In order to achieve the main objective a set of Specific objectives has been assigned as follow:

1. Study the ecosystem responses to land use changes by Soil Quality Index through evaluating the effect of different management practices

2. Evaluate the effect of different natural / pastoral systems using soil health assessment. In addition to identifying appropriate indicators for assessing the impact of long-term pastoral (tillage) systems on soil quality.

1.3 Literature Review

According to (Toth 2007) Soil quality means its ability in providing ecological and social services, as well as maintaining these functions under changing conditions. The concept of soil quality explained in this definition allows practical applications with regard to targeted social services and / or ecosystems. The assessment scheme should take into account the two main components of soil quality, first the functional capacity and second the response characteristics. These elements reveal the ability of performing a function under certain conditions and the extent of the operating capacity under changing circumstances. Soil quality assessment should therefore be undertaken with particular regard to the assessment objective. Ecosystem responses to LUCs happen over a wide range of spatial and temporal scales (Foley et al. 2005 and Goldewijk 2001). It is important to make explicit time and scope assessments to highlight potential approved trade-offs in relation to land-use changes scope (Carpenter et al. 2009 and DeFries et al. 2004b). At present, the challenge is to move the focus of land change studies from land use to land function and to identify the ecological processes and responses to these human activities. This requires new methods of development in order to attain data on different spatial and temporal scales (Turner II et al. 2007). Further theoretical and empirical work is needed to manage the human-controlled biosphere when taking into consideration the significant role LUC plays in the biosphere modulation. Our understanding of the ecosystem-level impacts of LUC and their sustainable management can be developed LUC models that integrate ecosystem processes, dynamics and responses. Soil quality includes physical, biological and chemical properties that are combined to indicate soil performance determining the state of the ecosystem (Andrews et al., 2002 and Guggeno et al., 2009). The ability of soil to maintain ecosystem processes is a function of intrinsic soils and external factors (e.g. precipitation, temperature, topography and hydrology. The sustainability of ecosystem processes and responses, particularly nutrient cycling, depends directly on soil structure and function. Thus, the state of the soil is crucial for a wide range of patterns and processes in ecosystems, including bio-productivity, biodiversity, stocks and component flows, food networks and water flow, in addition to the ecosystems resilience.

Regarding to (Doran 1996) some prefer the term "soil health" because it depicts soil as a living and dynamic system whose functions mediate the diversity of organisms. Good management and conservation practices are needed because soil health, biodiversity and soil resilience are sensitive to human disorders. There is a need to balance soil function for productivity, environmental quality, plant and animal health for optimum soil health. The concept of soil health includes the environmental characteristics of the soil, which have implications, beyond their quality, for their ability to produce certain crops. These qualities are essentially those associated with soil organisms including diversity, the structure of food web and activity for a range of functions. The soil biodiversity itself may not be the property of the soil, which is important for the production of a particular crop, but it may be vital to sustain the ability of the soil to support the crop. This dynamic management component has been largely ignored by current technologies that increase agricultural production. As indicated in (Howard 1993) the aim regarding soil quality evaluation and indicators (soil characteristics) is usually associated with a specific soil function as an intermediary of plant growth and changes. This reflects several spatial and temporal scales. The chosen characteristics of the soil should be sensitive, easily measurable, verifiable, and well related to land management and environmental transformation. In contrast, the aim in (Harris et 1996) is to evaluate the quality of soil using scorecards. A mean used primarily to demonstrate the significance of soil and record what has been done to improve them is scorecards. The farmer's need for profit and soil conservation needs to be considered, when soil quality is studied for agriculture. Hammond et al. (1995) describe an indicator as ‘‘something that provides an idea of an issue of greater importance or makes it possible to perceive a trend or phenomenon that cannot be detected immediately. Therefore, the significance of the indicator goes beyond what is actually measured by greater phenomena of interest. Environmental indicators generally include indicators of environmental pressures, conditions and responses (Smeets and Weterings 1999) and usually include physical, biological and chemical indicators. Environmental indicators provide insight into the state of the ecosystem. As for the (Warkentin 1977) study, it shows the first who proposed the concept of soil quality. Even though it did not become a real focal point until the early 1990s that started the discussion. In 1990, a Soil Quality symposium to open a discussion of the quality of the soil was sponsored by the U.S Forest Service and Soil Science Society of America. In addition, the aim of the (Tarin Paz-Kagana, 2013) study is to include critical aspects at the regional level of land-use management. Moreover, it suggests that the framework could be used to assess the response of ecosystem to LUC in additional terrestrial systems in the world. The framework can be used to compare different types of transitions, to identify short-term changes and local factors in LUC dimensions as well as to compare between self-organized and imposed processes. The analysis of ecosystem response to LUC dynamics may be improved by the addition of biodiversity additional factor to the framework taking into consideration that future studies are needed. Implications for ecological science particularly for the advancement of ecosystem science in a human-controlled biosphere have been profound by ecosystem responses to LUC processes. In relation to that (Larsson 1991) finds a practical definition of soil quality and suggests that soil quality is a combination of chemical, physical and biological characteristics. These three characteristics work together to preserve plant growth, regulate water flow, and act as an environmental buffer. The first one who compared the methods of selecting indicators was (Andrews 2002). The indicators chosen by statistical methods were compared with the indicators to be selected. The indicators to be selected for the function which they wanted to measure were determined by Principle Component Analysis (PCA). Soluble phosphorus, pH, electrical conductivity, sodium absorption ratio, and soil organic matter were chosen by Expert opinion as indicators. The main element is the selection of soluble phosphorus, pH, calcium, sodium and total nitrogen. Both types of indicators were found to be equally consistent with soil quality, but the baseline component analysis would not work with the low observation study, which lacked crop rotation data. Worldwide observations have confirmed that much of the Earth's surface has changed from natural to man-dominated ecosystems, mainly to grazing and agro-ecosystems (De Chazal and Ronsifil 2006). Changes in land-use activities are largely due to demographic and economic reasons and are expected to increase over time. Different parts of the world go through different stages of transition, depending on their history, social and economic conditions, and environmental context. The type of land-use change affects significantly on the key aspects of ecosystem responses, in terms of ecosystem structures, functions and dynamics, and creates new complex interactions between soils nutrients and plants that determine ecosystem health. As (DeFries et al. 2004a and Foley et al. 2005) state the reasons why these responses vary include not only the state of LUC, but also the biophysical and ecological setting Due to changes in biodiversity, productivity and soil quality.

Chapter Two

Study Site

The study site of the system is located in Al-Ubeidiya (31°43′24″N 35°17′26″E) which is a Palestinian town in Bethlehem Governorate located 8.4km (horizontal distance) east the city of Bethlehem. Al-Ubeidiya is bordered by the Dead Sea to the east, Sawahira al Sharqiya in Jerusalem Governorate to the north, Dar Salah village to the west, Tuqu' town and Dar Salah village to the south as shown in (Figure 2.1). Al-Ubeidiya is located at an altitude of 532m above sea level with a mean annual rainfall of 246mm. The average annual temperature is 18.5C, and the average annual humidity is about 58 percent (ARIJ GIS, 2009).

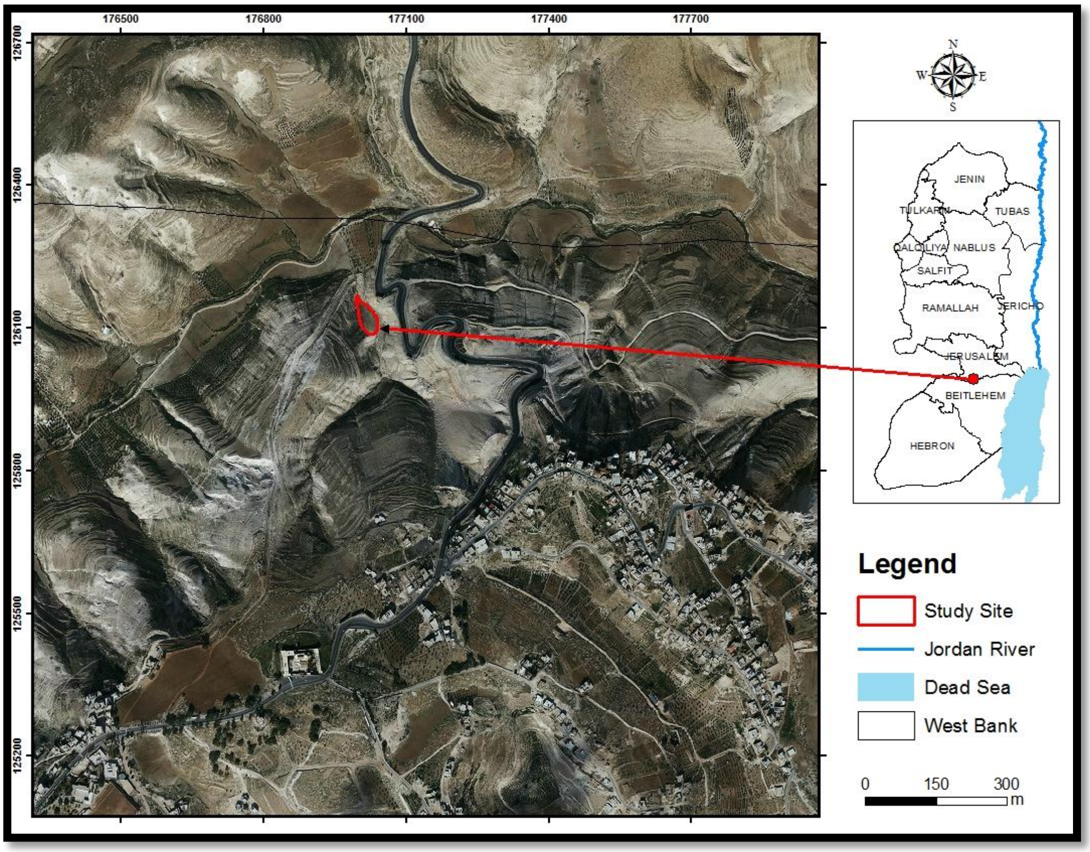


Figure 2.1: Description of the study site (left: The main road connecting the north and west of the West Bank, North: Wadi Nar stream is marked in white, south: residential communities in the town of Al-Ubeidiya, located in the Bethlehem district.

2.1 Geology of the region

The composition of Abu Dis is revealed in the study area, where chalk is the main component of the composition of Abu Dis, and maybe the only component is the expression of soft white rocks in general above the rocks of the composition of Jerusalem which are very solid calcareous. The thickness varies sharply and range from 58-175 m. The composition begins in the Jerusalem area by chalking over the formation of solid limestone Jerusalem and there are two flint layers at different heights of the base depending on the thickness of the composition, they are at a great height from the base in the thick sections and above the flint layers there is a level of phosphates and then increase the proportion of flint towards the top of the section until the start of the flints in the bottom of Al-Qalt formation (Geology of Palestine book,).

2.2 Climate

Based on the meteoblue climate diagrams available to each location on the Earth, indications were given of the usual climate patterns including temperature, rain, sun and wind and the expected conditions of Al-Ubeidiya area.

The bold red line shows the "average daily maximum" of the maximum temperature for each day of the month. The bold blue line shows the average minimum heat. While hot days and cold nights show red and blue intermittent lines for the average of the hottest and coolest days of each month in the last 30 years as shown in (Figure 2.2) (meteoblue, 2018).

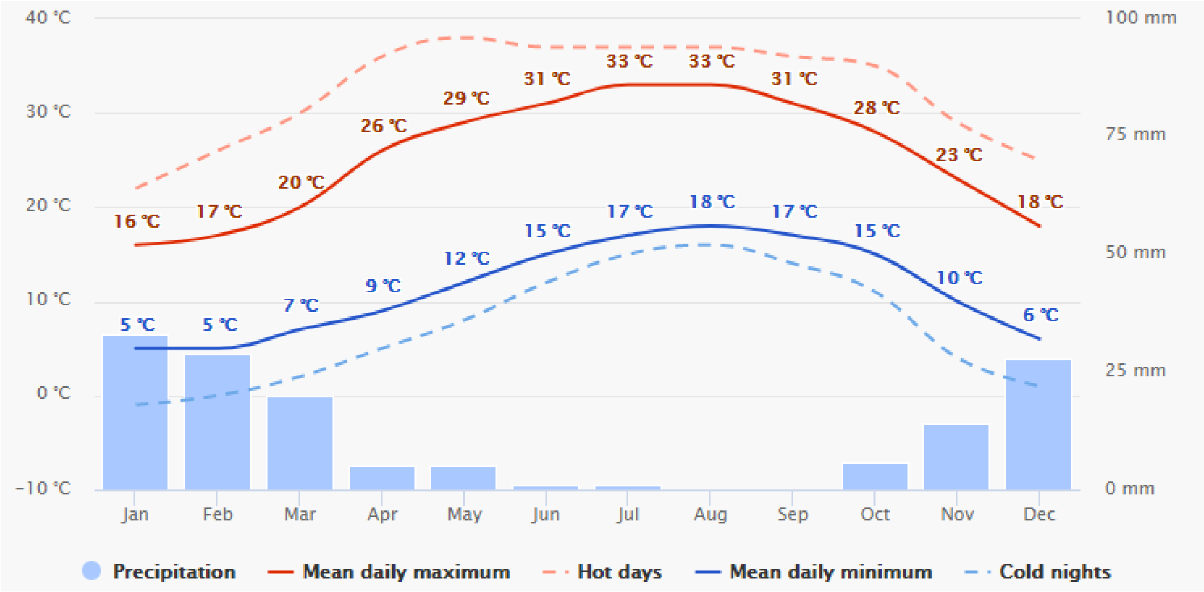


Figure 2.2: Average temperatures and precipitation in Al-Ubeidiya (meteoblue, 2018).

Chapter Three

Methodology

3.1 Site description

The study areas are located in long-term ecological research (LTER) semi-aired sites in Al-Ubeidiya. In this study, we evaluate three different systems (Natural, Pastoral A, Pastoral B systems). The site of the study is subject to graze and farm in previous years. After that, fencing Wires were put in 2015 to prevent the exposure of the site to any external impact, such as grazing, agriculture and others. Soil samples were taken in all systems at a depth of 0-5, 5-15 and 15-30 cm. The Herbaceous vegetation appears in the mid-winter after the rainfall begins and persists for 2–5 month.

3.1.1 Natural system

This system deals mainly with the absence of changes in natural processes such as fire, hydrology, sedimentation and tillage. Therefore, it does not include threats related to agriculture or infrastructure (residential and commercial development or transport corridors and services). Soil samples were taken randomly as shown in (Figure 3.1); in 2017, the site was divided into two systems.

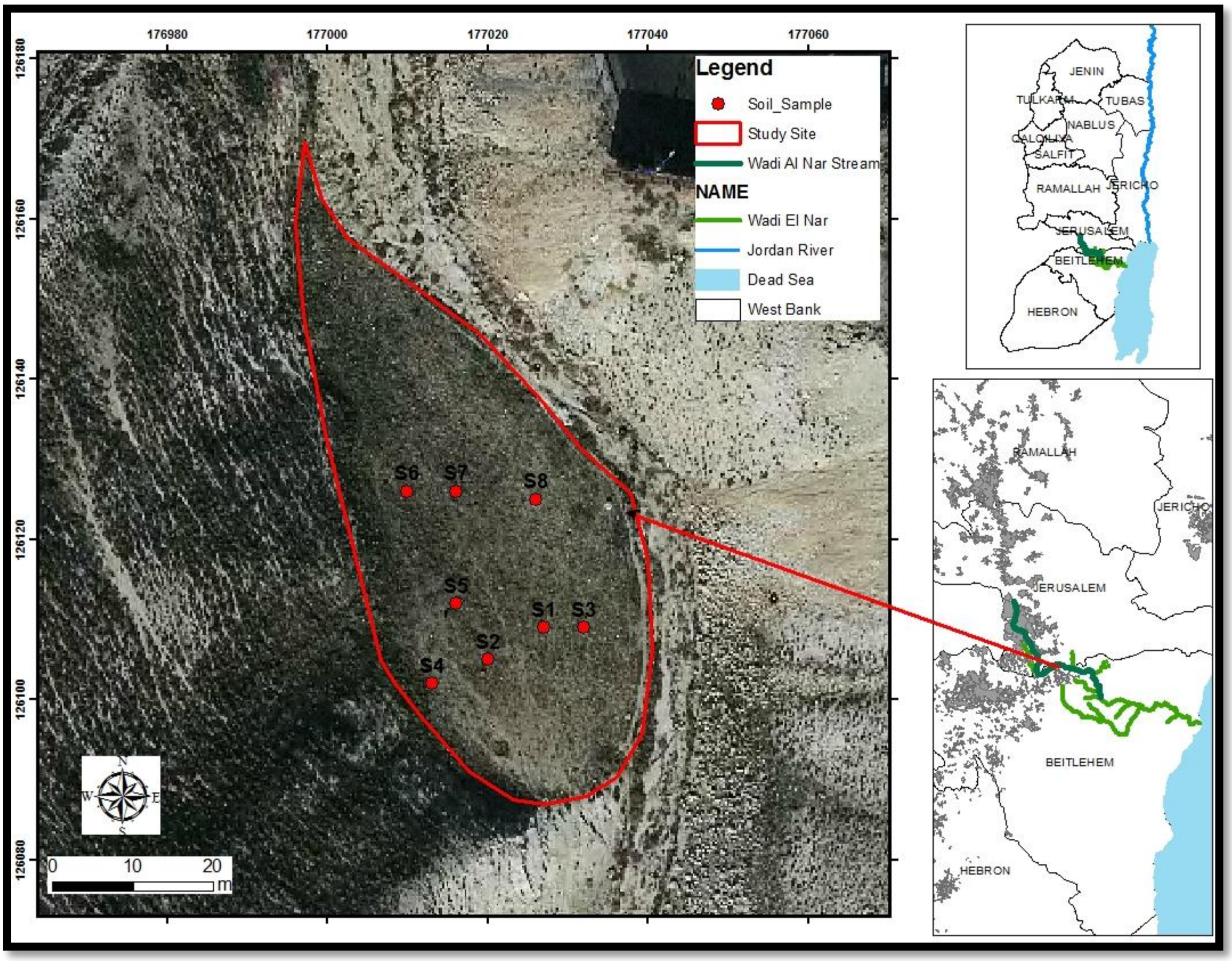


Figure 3.1: The study site of the natural system with the red points that represent the coordinates of soil sampling.

3.1.2 Pastoral System

3.1.2.1 Pastoral A

This system was exposed to the process of tillage with the removal of the plants that emerged from the tillage. The soil samples were taken from three depths on 0-5 cm, 5-15 cm and 15-30 cm as shown in (Figure 3.2).

3.1.2.2 Pastoral B

This system was exposed to the process of tillage without the removal of the plants that emerged from the tillage. In this system, soil samples were taken from three depths on 0-5 cm, 5-15 cm and 15-30 cm as shown in (Figure 3.2).

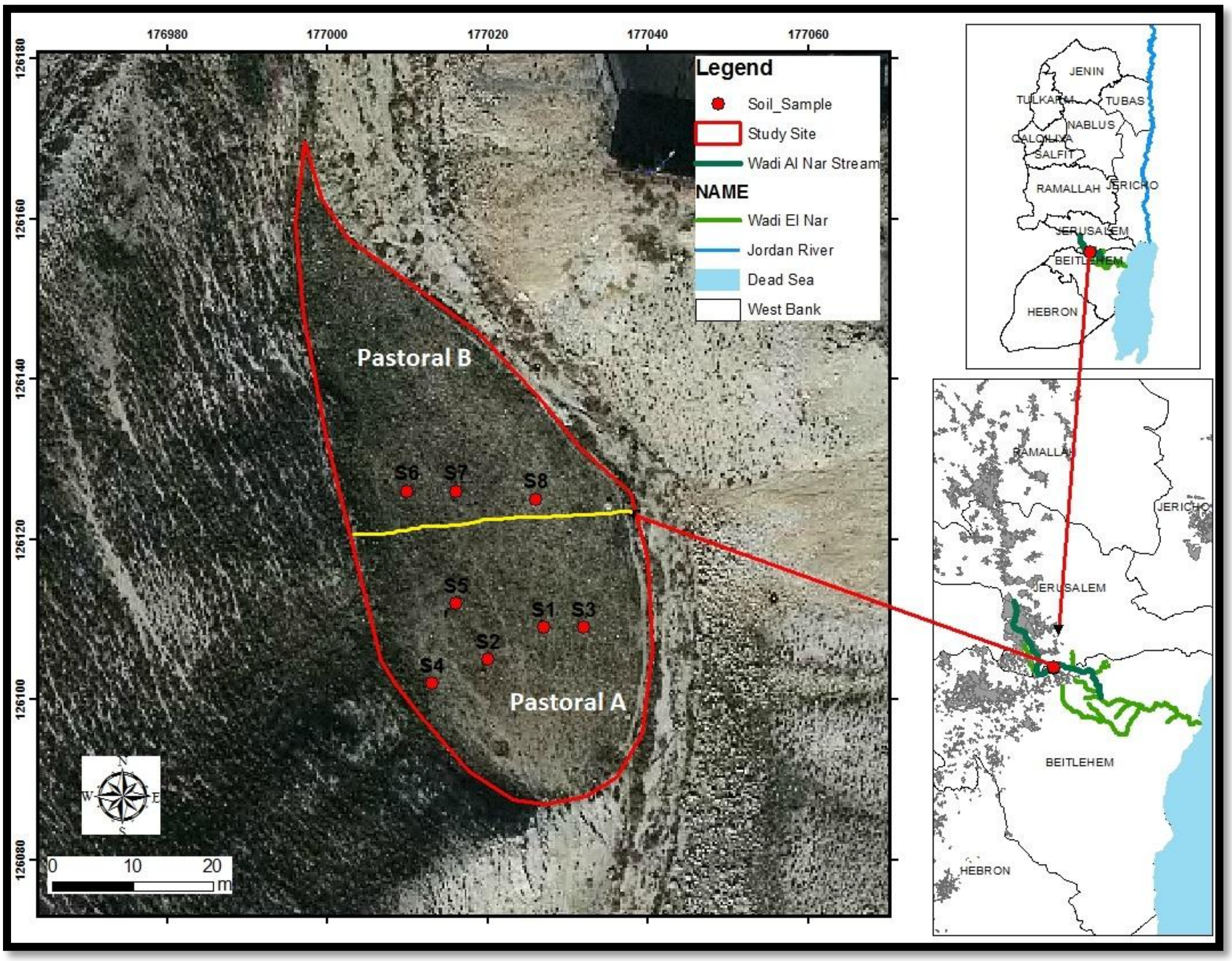


Figure 3.2: Study site division into two system (A): Pastoral A and (B) Pastoral B, in addition to the red points that represent the coordinates of soil sampling.

3.2 Experimental design and sampling

The sample coordinates are randomly selected and the soil samples are taken using the shovel and using the meter to measure the depths of 0-5, 5-15 and 15-30 cm for each sample. Soil samples are placed in paper bags and brought to the laboratory.

The experiment is performed at the two above mentioned system with different LUCs with three transitions (Natural, Pastoral A, Pastoral B) including biological experiments to study fauna and species of arthropods monthly.

3.2.1 pitfall trap: is done at the Field from 3 days to 2 week to catch large arthropods by putting quart-sized container (like cup) in the ground in the same level of soil surface, and fill it with anti-freeze, close it permeability with carton. Then identify under dissecting microscope, preserve it with alcohol 70%.

3.3 Soil sampling processing and analysis

3.3.1 Soil sampling and analysis

Soil samples were collected in October 2015 and February 2017 from two main types of land use (Natural system, Pastoral system (tillage) which are divided into a Pastoral (A) (tillage) system with the removal of plants from the system, and a Pastoral (B) (tillage) system without removing the plants from the system). Soil samples were taken from three depths: 0-5 cm, 5 -15 cm and 15-30 cm. About one kilogram of each sample was taken over the above-mentioned soil depths and placed in paper bags, dried in air at room temperature, crushed, homogenized, and passed through a 2 mm sieve prior to laboratory analysis. In (Table 3.1) shows a total of 48 soil samples (two types of land use * 8 replicates of sample plots * three of the soil depth classes: 0-5 cm, 5-15 cm and 15-30 cm) were collected for soil analysis.

Table 3.1: Sample coordinates (X, Y) in the three system (Natural, Pastoral A, Pastoral B) with the elevation.

Types of Treatment	Sample Number	X	Y	Elevation m²
Natural	S1	UTM3512519	36 R0716412	405
	S2	UTM 3512511	36 R0716406	405
	S3	UTM3512512	36 R0716412	405
	S4	UTM 3512511	36 R0716401	408
	S5	UTM 3512515	36 R0716403	406
	S6	UTM 3512525	36 R0716407	407
	S7	UTM 3512529	36 R0716407	406
	S8	UTM 3512531	36 R0716411	403
Pastoral A	S9	UTM 3512512	36 R0716415	405
	S10	UTM 3512512	36 R0716408	405
	S11	UTM 3512513	36 R0713422	405
	S12	UTM 3512509	36 R0716401	408
	S13	UTM 3512513	36 R0716400	406
Pastoral B	S14	UTM 3512522	36 R0716408	407
	S15	UTM 3512522	36 R0716413	406
	S16	UTM 3512521	36 R0716419	403

* Each soil sample was taken from three different depths 0-5 cm, 5-15 cm and 15-30 cm.

The Cornell Soil Health Test (CSHT) protocols were adopted for analyzing physical, biological, and chemical soil properties (Gugino et al. 2009). (Table 3.2) shows the physical properties including soil texture (fractions of clay, silt, and sand), soil moisture. The biological properties included soil organic matter (SOM) and active carbon (AC). The chemical properties included pH, electrical conductivity (EC), extractable potassium (K^+), extractable nitrate (NO_3^-), extractable sodium (Na^+), magnesium (Mg^{+2}), bicarbonate (HCO_3^-), total organic carbon (TOC), total nitrogen bound (TNb), calcium (Ca^{+2}) and heavy metals. However, minor modifications were introduced due to the specific management practices and available tools including: (1) available water content (AWC) which indicated soil moisture. The soil texture is a result of the three fractions composition including clay, silt, and sand, which is not a quality parameter and is not included in the SQI. However, the soil texture contributes to the inherent soil quality, the characteristic of the soil resulting from soil forming processes. These characteristics are difficult to change through management.

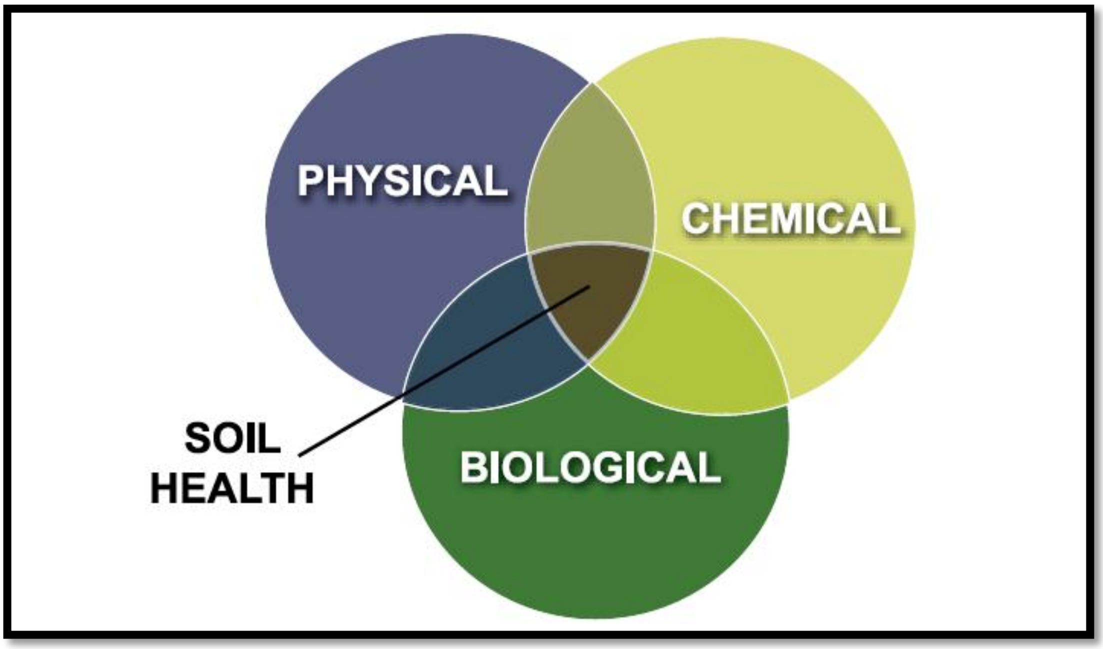
Table 3.2: Indicators of the Comprehensive Assessment of Soil Health and what it means

	Brief descriptions of the selected soil health assessment indicators
Biological	**Organic Matter:** Is a measure of all carbonaceous material that is derived from living organisms. The percent OM is determined by the mass of oven dried soil lost on combustion in a 500° C furnace *(Comprehensive Assessment of Soil Health - The Cornell Framework).*
	Active Carbon: Is a measure of the small portion of the organic matter that can serve as an easily available food source for soil microbes, thus helping fuel and maintain a healthy soil food web. It is measured by quantifying potassium permanganate oxidation with a spectrophotometer *(Comprehensive Assessment of Soil Health - The Cornell Framework).*
Physical	**Soil Moisture:** Reflects the quantity of water that a disturbed sample of soil can store for plant use. It is the difference between water stored at field capacity and at the wilting point, and is measured using pressure chambers *(Comprehensive Assessment of Soil Health - The Cornell Framework).*
	Soil Texture: Is a classification instrument used both in the field and laboratory to determine soil classes based on their physical texture. Soil texture can be determined using qualitative methods such as texture by feel, and quantitative methods such as the hydrometer method. Soil texture has agricultural applications such as determining crop suitability and to predict the response of the soil to environmental and management conditions such as drought or calcium (lime) requirements. Soil texture focuses on the particles that are less than two millimeters in diameter which include sand, silt, and clay *(Soil Science Division Staff. 2017).*
Chemical	**Soil pH** Is a measure of how acidic the soil is, which controls how available nutrients are to crops. A physico-chemical characteristic of soils, pH is an indicator of the chemical or nutrient status of the soil and Optimum pH is around 6.2-6.8 *(Comprehensive Assessment of Soil Health - The Cornell Framework).*
	Add-on Indicators: <u>Salinity and Sodicity:</u> Salinity is a measure of the soluble salt concentration in soil, and is measured via electrical conductivity. Sodicity is a calculation of the sodium absorption ratio (SAR) and is measured using ICP spectrometry to determine Na^+, Ca^{2+}, Mg^{2+} concentrations and using an equation to calculate the absorption ratio *(Comprehensive Assessment of Soil Health - The Cornell Framework).* <u>Heavy Metals:</u> Is a measure of levels of metals of possible concern to human or plant health. They are measured by digesting the soil with concentrated acid at high temperature *(Comprehensive Assessment of Soil Health - The Cornell Framework).*
	Total Organic Carbon (TOC): Is the amount of carbon found in an organic compound and is often used as a non-specific indicator of water quality or cleanliness of pharmaceutical manufacturing equipment. TOC may also refer to the amount of organic carbon in soil, or in a geological formation, particularly the source rock for a petroleum play; 2% is a rough minimum *(Technically Recoverable Shale Oil and Shale Gas Resources 2013).*
	Total Nitrogen bound (TNb): It is measured by burning the sample in the atmosphere of the oxygen, then the measured nitrogen dioxide is measured. The total nitrogen-nitrogen present in the organic and inorganic forms, including cyanide, is thus eliminated. This analysis requires specialized laboratory equipment (and expensive) *(www.hill-laboratories.com).*

3.4 Cornell's Comprehensive Assessment of Soil Health

Chemical, physical, and biological process integration and improvement of soil which are important for sustainable productivity and environmental quality are addressed through the term social health (Figure 3.3). The understanding and concepts of the soils' chemical and physical properties significance have been well accepted in the agricultural community as a whole over the years. However, until recently, the understanding and management of the soil's biological properties has not exceeded a few of the leading creative producers and scientists, becoming the focus of a wider circle. Scientific research and a larger group of producers do important progress on evaluating and managing soil biological functioning in various agricultural production systems (Moebius-Clune, et al 2017).

Figure 3.3**:** The concept of soil health deals with integrating the physical, biological



and chemical Components of the soil. Adapted from the Rodale Institute.

3.5 Laboratory work

3.5.1 Soil quality indicators

One of the first public soil testing laboratories that used Soil Quality indicator to make it available to the public is Cornell University. Among 39 potential soil health indicators Cornell's indicators were selected (Idowu et. al, 2008 and Gugino et al., 2009) and penetrometer readings with soil sample collections were submitted (Gugino et al., 2009). They provide multiple packages, the most basic including soil texture, wet aggregate stability, available water capacity, surface/sub-surface hardness, organic matter, and active carbon in addition to standard fertility tests and recommendations.

Natural and human changes should be measured when selecting indicators (Wienhold et al., 2004). The selected indicators should be easy to measure and capable of showing any problems in the soil (Schloter et al., 2003). Some of the most common indicators for soil quality assessment used in research are the pH, EC, active carbon, soil organic matter (SOM), and those related to microbial activity (Bastida et al., 2008). Other indicators include electrical conductivity, soil respiration, cation exchange capacity (CEC), and metal contamination. Many of these indicators have been found to be closely related (Arshad and Martin, 2002).

Management success regarding maintaining the quality of soil relies on our comprehension of how soil responds to agricultural use and practices over time (Gregorich et al., 1994). Therefore, soil quality estimation methods should assess changes in selected soil characteristics over time. However, quality of the soil cannot be measured directly from the soil alone, but is inferred from characteristics and behaviour of the soil under defined conditions. Furthermore, there is no single measurement that can determine soil quality (Stewart, 1992), but there are certain soil properties that could be good indicators when considered together. Understanding the soil response to agricultural practices over time helps assess whether the investigated practices maintain soil quality or improve it. Traditionally, the quality of the soil is essentially related to its productivity (Hornik, 1992), but at present, the concept of soil quality is much more comprehensive. Quality of the soil is based on a large number of chemical, physical and biological properties. Its characterization requires the selection of properties most sensitive to changes in management practices (Yakovchenko et al., 1996). Good soil quality indicators must be linked to ecosystem processes, which integrate physical, chemical and biological characteristics. They must be sufficiently sensitive to management and allow for analytical access and practical benefit to agricultural specialist and producers, environmentalists and policy makers (Doran and Parkin, 1996). Initially, it was suggested that a core set of indicators be used to assess soil quality in different agricultural management systems. While many of these key indicators are highly useful to specialists (i.e. researchers, consultants, extension staff, and conservationists), many of them exceed product experience (Hamblin, 1991). However, the use of simple soil quality indicators that are meaningful to farmers and other land managers is likely to be the most fruitful means of linking science to practice in evaluating the sustainability of management practices (Romig et al., 1995). Although soil is intrinsic in relation to its physical, chemical and biological properties within limits determined by climate and ecosystems, the ultimate determinant of soil quality and health is land management. As such, the assessment of soil quality and the direction of change over time is a key indicator of sustainable management (Doran, 2002 and Karlen et al., 1997).

Each of the following chemicals, physical and biological indicators have been analyzed:

3.5.1.1. Chemical indicators

- pH
- Electrical Conductivity (EC)
- Anions (Cl^{-}, NO_3, HCO3)
- Cations Potassium (K^{+}), Sodium (Na^{+}), Magnesium (Mg^{+2}), Calcium (Ca^{+2})
- Heavy Metals
- Total organic carbon (TOC), Total Nitrogen Bound (TNb)
- Sodium Absorption Ratio (SAR)

3.5.1.2 Physical indicators

- Soil moisture
- Soil texture

3.5.1.3 Biological indicators

- Organic matter (OM)
- Active carbon (AC)
- Pitfall trap

3.6 Soil Health Assessment Indices

Progress has been made in soil management for soil sustainability in the long term by integrating physical, chemical and biological properties and processes. In order to assess soil health and provide a systematic framework, many indicators and tools have been developed. These assessment tools include the Cornell Soil Health Assessment (Moebius-Clune et al., 2016), the Soil Testing (Haney 2014) and the Soil Management Assessment Framework (Andrews et al., 2004). Soil health assessments are carried out by comparing an unobstructed site to an adjacent non-volatile site (natural) provided that they must contain the same soil type. Soil assessment tools are usually framed in three steps: (i) indicators are identified to assess soil health based on management objectives; (ii) the function of interpreting or recording the indicator (e.g., 0 to 10 or below, 10 or higher represents the highest potential function of this system or from 0 to 100); and (3) integration of all index scores into the overall soil health outcome.

3.7 Soil Quality Index

Soil quality has been assessed using the general approach of the soil quality indices, which include recording functions for each of physical, biological and chemical parameters (Andrews et al. 2004).The provision of an overall index of social quality depends on the combination of the previous factor (Burns et al., 2006). One way of evaluating soil quality is to comparison of individual indicators with reference sites is (Bucher, 2002; Carey et al., 200 and Nelson et al., 2009). However, individual indicators are often interrelated or may show functional replication (Hunt and Wall, 2002). Therefore, their useful integration into one index may enhance evaluation (Bucher, 2002 and Andrews et al., 2002).The scoring function interpretation was combined into an index calculated by a principle component analysis (PCA) (Bhardwaj et al. 2011; Masto et al. 2008 and Masto et al. 2007). The selected indicators values are required to be converted to scores before being integrated to index. This requires a functional relationship between the relevant soil function and indicators (Erkossa et al., 2007).

3.8 Selecting Soil Quality Indicator

Table 3 shows the physical indicator such as: Soil Moisture, chemical indicators such as: soil pH, Total organic Carbon (TOC), Total Nitrogen (TNb) Electrical Conductivity (EC), Nitrate (NO_3^-), Extractable Potassium (K^+), Extractable Sodium (Na^+), Magnesium (Mg^{+2}), Calcium (Ca^+), Chloride (Cl^-), and biological indicators such as: Organic matter (OM) and Active Carbon (AC). These indicators of critical soil processes such as aeration, infiltration, water retention, nutrients retention, prevention of toxic, availability of nutrients, etc., which in relationship to soil functions such as plant production. All of the selected indicators can be measured using a composite soil sample obtained from the Natural system, the Pastoral system (tillage) .In this study, standard assessment functions are used (Andrews et al., 2004 and Qiet al., 2009) based on the scoring function new indicators were developed and modified because it is not enough for our study. An adjustment of 1 to 3 is set. Based on the sensitivity of the indicator to soil quality, (Leibig et al., 2001) where the best soil function was associated with high, low, medium or medium values.

Table 3.3. Physical, chemical and biological soil quality indicator and scoring of soil quality.

Soil indicator	Unit	Scoring indicator		
		1 (low)	2 (medium)	3 (high)
Soil moisture	%	< 7,62	7,62_30,49	> 30,49
(Kartonegoro, B.D dan Syamsul, A.S,2006 modified)				
Organic matter	%	< 0.7	0.7_4.5	> 4.5
GUIDELINES FOR INTERPRETATION OF SOIL ANALYSES BOLSA ANALYTICAL				
Active carbon	mgkg-1	< 300	300 _900	> 900
Comprehensive Assessment of Soil Health The Cornell Framework				
pH	_	< 7	7 _7.5	> 7.5
GUIDELINES FOR INTERPRETATION OF SOIL ANALYSES				
EC	mmhos/cm	< 1	1-2.5	> 2.5
Soil Test Interpretation Guide D.A. Horneck, D.M. Sullivan, J.S. Owen, and J.M. Hart				
Potassium	%	< 2	2_5	> 5
GUIDELINES FOR INTERPRETATION OF SOIL ANALYSES BOLSA ANALYTICAL				
Magnesium	%	< 12	12_18	> 18
GUIDELINES FOR INTERPRETATION OF SOIL ANALYSES BOLSA ANALYTICAL				
Cloride	ppm	< 0	0_50	> 50
Soil Test Interpretation Guide D.A. Horneck, D.M. Sullivan, J.S. Owen, and J.M. Hart				
Calcium	%	< 65	65 - 75	> 75
GUIDELINES FOR INTERPRETATION OF SOIL ANALYSES BOLSA ANALYTICAL				
Sodium	%	< 10	10_30	> 30
Soil Test Interpretations Guide A-122 Esteban Herrera, Extension Horticulturist				
Nitrate	ppm	< 10	10_30	> 30
Soil Test Interpretations Guide A-122 Esteban Herrera, Extension Horticulturist				
TOC	%	< 1,0	1,0_5,0	> 5,0
(Balittan, 2006 modified)				
TNb	mg/l	< 2	2_6	> 6
https://www.epa.gov/sites/production/files/2015-09/documents/totalnitrogen.pdf				

Information: Range of score is the result modified from a range of score at the curve of the score in Andrews et al. (2004). This range of score is used to an integration of numbers from result analysis laboratory. It is modified with an interval of score 1-3 in order to make the interpretation of some indicator easy.

The Soil Quality Index (SQI) is determined by collecting data on indicators that have been selected for each soil function. Soil quality assessment was done using scoring data method on every indicator. The calculation is done by adding the soil quality scores obtained on each ecosystem of our study. The individual index value for all the soil properties measured, are summed to give are total Soil Quality Index (SQI) (Andrews et al., 2004), which can be described as follows:

$$SQi = \left(\frac{\sum_{i=1}^{n} Si}{n} \right) x10$$

Information:

SQI = Soil Quality Index (Soil Quality Index)

Si = Scores on selected indicators of land in the Minimum Data Set (MDS)

n = number of soil quality indicators in the MDS

3.9 Statistical analysis

The GraphPad Prism7 program for 2D statistics graphics is used to analyze data and present a chart. The statistical analysis is performed with stat graphics Version 10, 2011 software. The soil quality transformation and indices (Principle Component Analysis (PCA), regression equations, scoring functions) is performed in XLSTAT by using excel package.

Chapter Four

Results and Discussion

The result and discussion sections consisted of three parts including chemical, physical and biological indicators. This section represents the analysis of soil samples and their interpretation.

4.1 Soil quality

The result of the land use change (LUC) regarding the chemical soil properties from a natural system to a pastoral system (tillage). The transition from a natural to the pastoral system shows significant differences between systems in most of the soil properties, except potassium, magnesium, chloride, Nitrate^{-}. These differences are a combination of aspect and management effects. The results of the transition from a natural system to a pastoral system show an increase in the soil moisture, pH, sodium and calcium (Table 4.1). There is also a decrease in the values of EC in pastoral A, pastoral B this is due to the time in which the samples are taken, where the samples were taken from the site in the winter.

Table 4.1: Chemical indicators used for soil analysis to assess the systems at three depths.

Chemical Indicators												
Depth (cm)	System	pH	EC µS/cm	Na+ meq/l	K+ meq/l	Ca2+ meq/l	Mg2+ meq/l	NO3- meq/l	HCO3 meq/l	Cl meq/l	TOC mg/l	TNb mg/l
(0-5)	Natural	7.48	353.1	0.39	0.27	0.21	0.46	0.03	0.58	1.82	45	3.8
	SD	±0.14	±85.8	±0.1	±0.13	±0.23	±0.12	±1.15	±0.4	±0.31	±1.53	±0.15
	Pastoral A	8.47	107.62	1.36	0.24	1.66	0.84	0.01	0.73	1.5	33.25	4.87
	SD	±0.25	±15.8	±0.05	±0.1	±0.17	±0.27	±0.1	±0.27	±0.5	±0.69	±0.64
	Pastoral B	8.51	97.9	1.36	0.23	1.73	0.93	0.01	0.61	1.84	37.4	3.72
	SD	±0.23	±7.3	±0.03	±0.04	±0.12	±0.42	±0.3	±0.2	±0.29	±1.57	±0.32
(5-15)	Natural	7.61	283.2	0.24	0.13	0.37	0.39	0.02	0.42	1.73	44.3	4.1
	SD	±0.24	±55.5	±0.04	±0.07	±0.57	±0.03	±1.37	±0.03	±0.35	±5.08	±0.06
	Pastoral A	8.66	98.4	1.39	0.18	1.9	0.72	0.01	0.65	1.9	26.91	2.69
	SD	±0.13	±4.15	±0.04	±0.07	±1.1	±0.18	±0.18	±0.27	±1.3	±1.16	±0.1
	Pastoral B	8.5	104.1	1.38	0.18	1.8	0.8	0.01	0.54	2.5	34.06	2.77
	SD	±0.1	±15.8	±0.01	±0.04	±0.1	±0.2	±0.23	±0.12	±0.6	±1.67	±0.32
(15-30)	Natural	7.64	234.2	0.37	0.14	0.38	0.34	0.02	0.42	1.87	43.7	2.5
	SD	±0.16	±55	±0.035	±0.11	±0.62	±0.03	±1.37	±0.08	±0.38	±1.57	±0.25
	Pastoral A	8.74	98	1.43	0.17	1.28	0.8	0.01	0.49	1.5	34.7	4.33
	SD	±0.07	±3.24	±0.07	±0.06	±0.9	±0.25	±0.13	±0.2	±0.46	±1.64	±0.44
	Pastoral B	8.61	100.8	1.33	0.17	1.6	1.06	0.01	0.54	1.84	37.07	2.97
	SD	±0.1	±13.6	±0.04	±0.03	±0.43	±0.5	±0.14	±0.12	±0.8	±3.1	±0.29

* (SD) Standard Deviation, (EC) Electrical Conductivity, (NO^-_3) Nitrate, (K^+) Potassium, (Mg^{+2}) Magnesium, (Cl^-) Chloride, (Na^+) Sodium, (HCO^-_3) Bicarbonate, (TOC) Total Organic Carbon and (TNb) Total Nitrogen bound.

Table 4.2: Biological indicators included active carbon and organic matter used for soil analysis to assess the systems at three depths.

Biological Indicators			
Depth (cm)	System	AC mg/kg	OM %
(0-5)	Natural	1051	7.06
	SD	±106.9	±0.6
	Pastoral A	684	9.1
	SD	±95.5	±0.7
	Pastoral B	1059	8.5
	SD	±76.3	±0.58
(5-15)	Natural	953	6.8
	SD	±236.6	±0.2
	Pastoral A	533	8.75
	SD	±152.7	±0.9
	Pastoral B	941	7.8
	SD	±55.2	±1.4
(15-30)	Natural	905	7.5
	SD	±342.8	±0.9
	Pastoral A	393	8.2
	SD	±175.1	±1.29
	Pastoral B	935	6.93
	SD	±22.7	±1.4

* (SD) Standard Deviation, (OM) Organic Matter and (AC) Active Carbon.

Table 4.3: Physical indicators used for soil analysis to assess the systems at three depths.

Physical Indicators					
Depth (cm)	**System**	**Sand %**	**Silt %**	**Clay %**	**Soil Moisture %**
(0-5)	Natural	42.4	31.2	26.4	1.04
	SD	±16.9	±14.8	±12.1	±0.18
	Pastoral A	32.4	33.46	34.14	3.41
	SD	±15.5	±15.7	14.2	±0.39
	Pastoral B	40	46.96	13.04	4.05
	SD	±13.2	±2.3	±3.03	±0.93
(5-15)	Natural	28	46.4	25.6	1.24
	SD	±8.90	±6.80	±9.20	±0.38
	Pastoral A	32.04	35.8	32.16	3.27
	SD	±1.25	±0.61	±1.50	±0.43
	Pastoral B	35.37	45.16	19.47	3.52
	SD	±0.56	±1.08	±1.71	±0.62
(15-30)	Natural	22.2	45.6	32.2	1.23
	SD	±8.2	±9.4	±12.9	±0.39
	Pastoral A	26.47	38.23	35.3	3.35
	SD	±0.87	±1.66	±1.25	±0.29
	Pastoral B	27.87	37.73	34.4	4.15
	SD	±0.91	±0.48	±1.50	±0.46

4.2 Integration into soil quality index

To understand the complex relationship between soil types and soil uses, the chemometric technique PCA was used.

PCA analysis is a non-supervised method. It allows us to infer how some variables are identified and linked. The PCA finds new virtual variables known as the main components (PC), which represent the greatest possible variation or so-called correlation in multidimensional data sets. These new variables are linear combinations of the original variables (Hammer, et al 2001). This method helps to determine the groups of variables (soil parameters) based on the physical, chemical and biological samples (soil types) based on the results.

Values below PC-1 in bold line that means the correlation ratio is strong between all systems at a certain depth of the parameter and the values below the PC-2 in a bold line mean that the bond ratio is very weak between all systems at a certain depth of coefficient of chemicals, physical and biological indicators. Where we note the relationship coefficient of the total organic carbon at a depth of 0-5 cm is 0.982 % under PC-1. This means that the relationship between total organic carbon is strong and interrelated regardless of the type of system at a depth of 0-5 cm. While the weak correlation coefficient in clay on the depth of 5-15 cm for all systems by 0.977 % under PC-2.

The indicators were developed through the calculated results of the soil characteristics of each of the physical, chemical and biological properties in land use changes LUCs, in the all system on depth 0-5 cm. The PCs had given values>1 and were included in the PCA with a total cumulative variance of 70.15 percentage in PC-1 (Table 4.4). The highly weighted variables under PC-1 were TOC, HCO_3^-, sand, magnesium, calcium, potassium, sodium, nitrate, organic matter, soil moisture, pH and EC. TNb, chloride, clay, silt and active carbon had the highest weighted variables under PC-2. These weights were determined for soil characteristics by the percentage of changes in the dataset described in two PC.

Table 4.4: Results of principal component (PC) analysis of soil properties in natural, pastoral A, pastoral B systems on depth 0-5 cm. bold values indicate eigenvalues, variability, and cumulative variance corresponding to the PC examined for the index. Bold values indicate factors corresponding to the indicators included in the indices. Bold values indicate high multivariate correlations under a single PC that were.

	Score of PC 1 70.15 %	**Score of PC 2 29.85 %**
Eigenvalue	11.926	5.074
Variability %	70.154	29.846
Cumulative %	70.154	100.000
TNb mg/l	0.398	**0.602**
TOC mg/l	**0.982**	0.018
Cl meq/l	0.408	**0.592**
HCO3 meq/l	**0.648**	0.352
Clay %	0.005	**0.995**
Silt %	0.177	**0.823**
Sand %	**0.687**	0.313
Mg meq/l	**0.846**	0.154
Ca meq/l	**0.933**	0.067
K meq/l	**0.799**	0.201
Na meq/l	**0.952**	0.048
NO3 meq/l	**0.952**	0.048
SOM %	**0.995**	0.005
(AC) POXCmgkg-1soil	0.441	**0.559**
soil moisture %	**0.830**	0.170
EC µS/cm	**0.936**	0.064
pH	**0.936**	0.064

In the all system on depth (5-15) cm the PCs had eigenvalues >1 and were included in the PCA that resulted in a cumulative variance of 78.42 percentage in PC-1 (Table 4.4). The highly weighted variables under PC-1 were TNb, TOC, HCO_3, sand, magnesium, calcium, potassium, sodium, organic matter, soil moisture, pH, EC and Nitrate. Chloride, clay, silt and active carbon had the highest weighted variables under PC-2.

Table 4.5: Results of principal component (PC) analysis of soil properties in natural, pastoral A, pastoral B systems on depth 5-15 cm. bold values indicate eigenvalues, variability, and cumulative variance corresponding to the PC examined for the index. Bold values indicate factors corresponding to the indicators included in the indices. Bold values indicate high multivariate correlations under a single PC that were.

	Score on PC 1 **78.42 %**	**Score on PC 2** **21.58 %**
Eigenvalue	13.331	3.669
Variability %	78.416	21.584
Cumulative %	78.416	100.000
TNb mg/l	**0.993**	0.007
TOC mg/l	**0.919**	0.081
Cl meq/l	0.322	**0.678**
HCO3 meq/l	**0.872**	0.128
Clay %	0.023	**0.977**
Silt %	0.478	**0.522**
Sand %	**0.681**	0.319
Mg meq/l	**0.903**	0.097
Ca meq/l	**0.995**	0.005
K meq/l	**0.983**	0.017
Na meq/l	**0.985**	0.015
NO3 meq/l	**0.983**	0.017
SOM %	**0.865**	0.135
(AC) POXCmgkg-1soil	0.396	**0.604**
Soil Moisture %	**0.947**	0.053
EC µS/cm	**0.989**	0.011
pH	**1.000**	0.000

In the all system on depth 15-30 cm the PC had eigenvalues>1 and were included in the PCA that resulted in a cumulative variance of 78.85 percentage in PC-1 (Table 4.6). The highly weighted variables under PC-1 were TNb, TOC, HCO_3, clay, silt, Sand, magnesium, calcium, potassium, soil moisture, pH, EC, sodium and Nitrate. Chloride, organic matter, and active carbon had the highest weighted variables under PC-2.

Table 4.6: Results of principal component (PC) analysis of soil properties in natural, pastoral A, pastoral B systems on depth 15-30 cm. bold values indicate eigenvalues, variability, and cumulative variance corresponding to the PC examined for the index. Bold values indicate underlined factors corresponding to the indicators included in the indices. Bold values indicate high multivariate correlations under a single PC that were.

	Score on PC 1 78.85 %	**Score on PC 2 21.15 %**
Eigenvalue	13.404	3.596
Variability %	78.848	21.152
Cumulative %	78.848	100.000
TNb mg/l	**0.555**	0.445
TOC mg/l	**0.965**	0.035
Cl meq/l	0.380	**0.620**
HCO3 meq/l	**0.774**	0.226
Clay %	**0.953**	0.047
Silt %	**0.985**	0.015
Sand %	**0.909**	0.091
Mg meq/l	**0.825**	0.175
Ca meq/l	**0.899**	0.101
K meq/l	**0.995**	0.005
Na meq/l	**1.000**	0.000
NO3 meq/l	**0.995**	0.005
SOM %	0.016	**0.984**
(AC) POXCmgkg-1soil	0.266	**0.734**
Soil Moisture %	**0.891**	0.109
EC µS/cm	**0.998**	0.002
pH	**0.998**	0.002

4.3 Chemical properties of soils of Study site:

4.3.1 pH

The chemical properties of soils from selected systems used in this study are shown in (Figure 4.1) pH results with values ranging from 7.48 to 8.74 at different depths. Factors affecting soil pH include degradation of organic matter, source of nitrogen fertilizers, weathering of metals and materials, climate, and land management practices. The availability of nutrients for plant absorption varies depending on soil pH. The availability of positive nutrients is often preceded by low solubility in very basic soils and increased filtration or loss of erosion in acid soils.

Variability of pH variations analysis under different soil management practices shows that the latter has a significant effect on pH. However, there is no significant difference between the frequencies of each systems. The results show that there is a great difference between the averages of the three systems so that the lowest pH corresponds to the natural system, while the highest is the pastoral A and pastoral B as shown in (Figure 4.1). The accumulation of lime on the surface, due to slow mixing under the no tillage system, leads to higher pH in this layer (Blevins and Fery, 1993). **(**Chatterjee and Lal 2009) reported that low soil pH related to the no tillage system in comparison with traditional tillage is due to the composition of organic acids in fertilizer application and mineralization of plant residues.

These soil grades usually have values of pH ranging from 7.5 to 8.1 as they are originally composed of limestone. When the samples were taken in the fall (natural system), the pH ranged between (7.48-7.67) mild alkali / alkaline and slightly in winter (pastoral with tillage) between (8.47 - 8.74) with alkali / alkaline strength after exposure the land of the plow whereas the soil with a pH of 8.3 or higher usually has high sodium content. Applications of sulfuric acid typically reduce pH only for a short period due to the high buffering capacity of the soil. In general, pH values in all soil profiles increase with increasing depth as they approach the original limestone rocks. There are no significant changes between pH values at all system because the original rocks of these sites are the same and the pH values of the soil are the same.

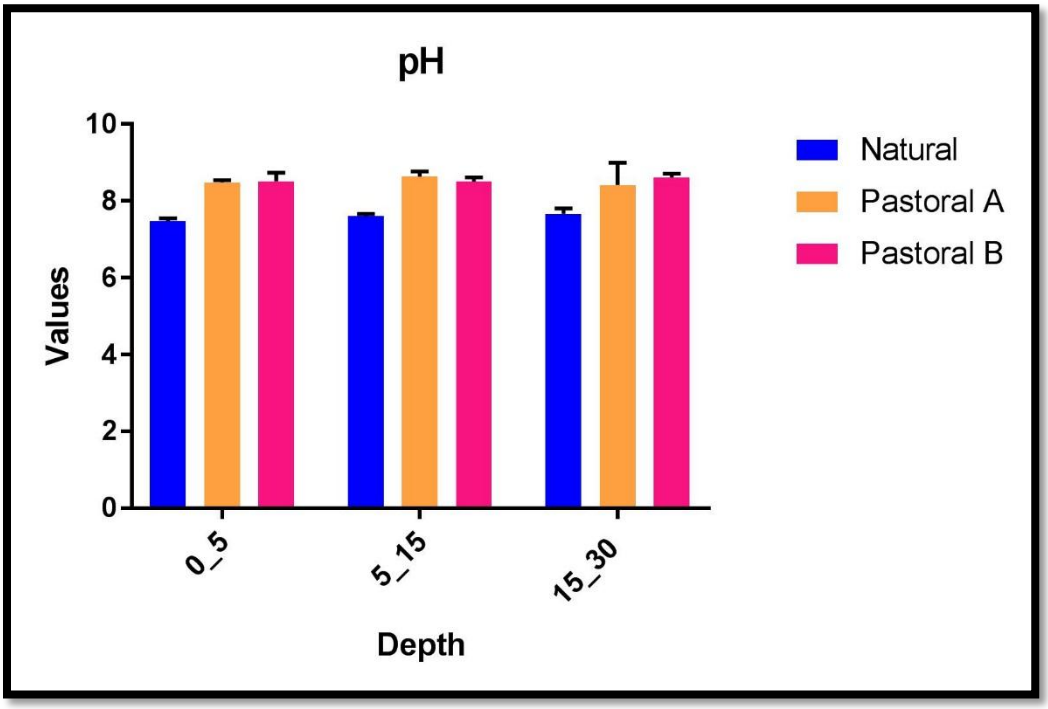


Figure 4.1: pH values on the depths of 0-5 cm, 5-15 cm and 15-30 cm for the natural, pastoral A and pastoral B.

4.3.2 Electrical conductivity (EC)

Salinity usually refers to the presence of soluble salt in the soil. The pH of the soil is likely to affect salt solubility and soil moisture content, the higher the amount of alkaline soils, the less salt soluble (Provin et al., 2001). Soil pH is negatively correlated with electrical conductivity of the soil in the form of an energy function and not in a linear relationship. This is due to many other factors such as soil minerals, porosity, soil texture, soil moisture and soil temperature (USDA, 2011).In the natural system, the electrical conductivity ranged from

(234 - 353) µS/cm, which was higher than in pastoral system, ranging between (98- 107) µS/cm.

Important difference was noticed in the electrical conductivity between three systems according to the results. The highest electrical conductivity goes to the natural system, compared to conduction data, while the lowest level is noticed in pastoral system (Table 4.2). The results of the study are in contradiction with (Chatterjee and Lal 2009). The low electrical conductivity of the soil under the pastoral systems compared to natural system was related to the movement of soil-enhanced water and improved soil accumulation development.

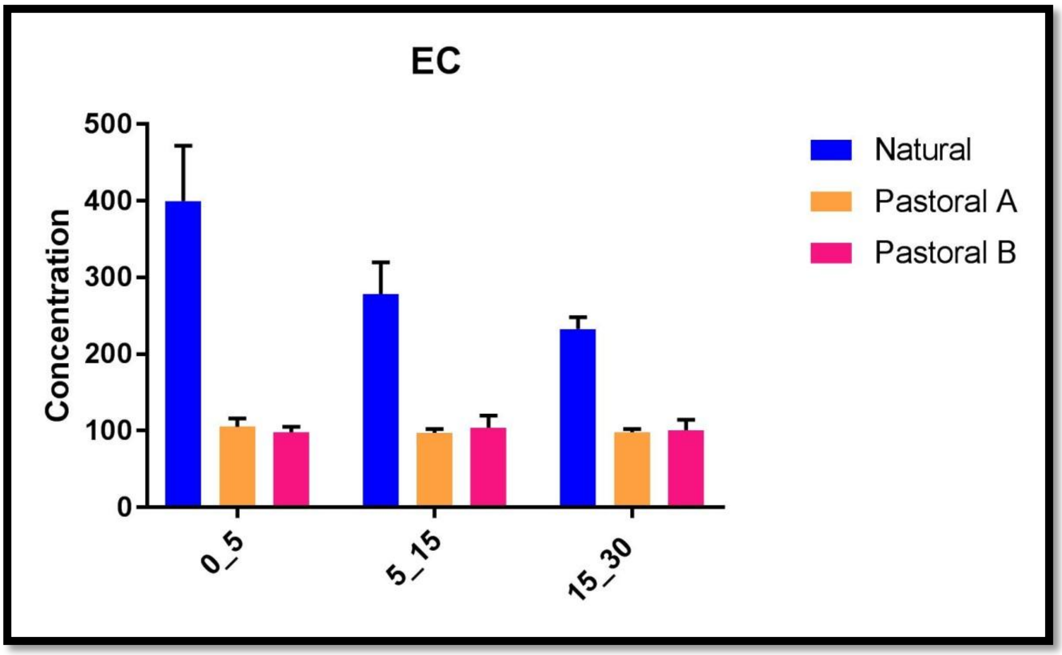
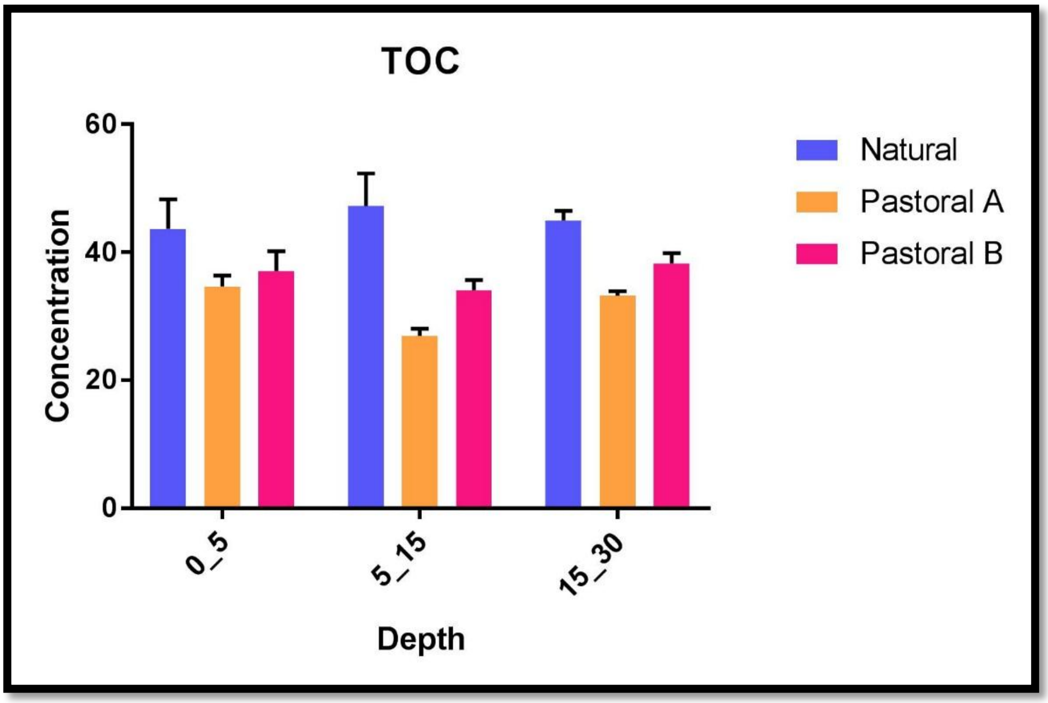


Figure 4.2: Electrical conductivity (EC) values on the depths of 0-5 cm, 5-15 cm and 15-30 cm for the natural, pastoral A and pastoral B.

4.3.3 Total Organic Carbon (TOC) and Total Nitrogen bound (TNb)

There are complex interactions of different management practices on land (such as tillage, change in the composition of plant species and organic waste inputs) that affect the dynamics of the presence of carbon quantitatively and qualitatively. However, a reduction in soil disturbance and the incorporation of organic materials or manures tend to increase soil



organic carbon stocks (Westand et al., 2008). Based on the paired comparisons between the land use and soil quality, soil TOC rates at 15-30 cm depth were estimated to be 43.7 mg/l in natural system, 34.7 mg/l in pastoral A and 37.07 mg/l in pastoral B as shown in (Figure 4.3). TNb rates at 0-30 cm depth were estimated to be 2.5 mg/l in natural system, 4.33 mg/l in pastoral A and 2.97 mg/l in pastoral B as shown in (Figure 4.4).

Figure 4.3: Concentration mg/l of total organic carbon (TOC) on all depth for natural, pastoral A and pastoral B.

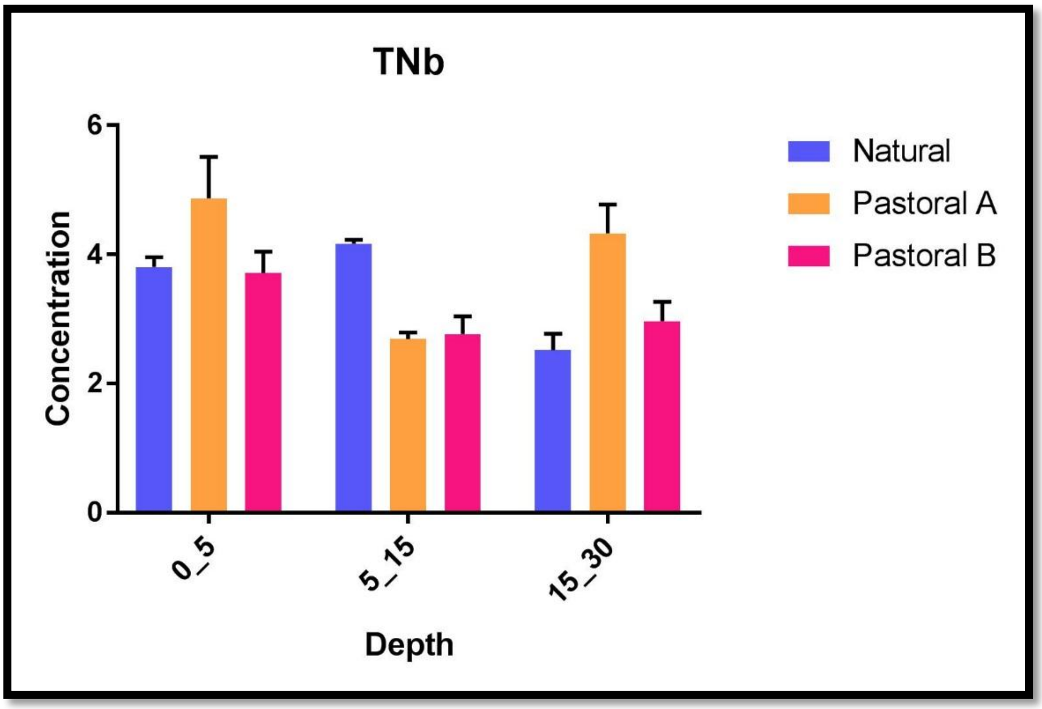


Figure 4.4: Concentration mg/l of total nitrogen bound (TNb) on all depth for natural, pastoral A and pastoral B.

The accumulation of carbon compared the nitrogen in the soil is higher because the tillage was not intensive where intensive tillage works to reduce the overall stability of carbon and this leads to the cracking of the organic matter(Six et al., 1999). TOC accumulation rates were estimated in surface soils (0-5) cm in each of natural system between 45 mg/l, 33.25 mg/l in pastoral A and 37.4 in pastoral B. It ranged of total nitrogen in the top depth (0-5) cm 3.8 mg/l in natural system, 4.87 in pastoral A and 3.72 in pastoral B.

4.3.4 Potassium (K^+)

In general, potassium levels were slightly fluctuated in soil, regardless of system or depth of the sample. However, the potassium levels were slightly present in our study compared with the natural potassium content in the soil. The values found were higher when the layer was 0-5 cm. The reason for the observed fluctuations is the deposition in the surface and the removal of potassium ratios by plants or filtration which has been restricted to recycle K in the soil. K levels in the soil were always superior at 0-5 cm in the three systems where the surface layer values ranged from 0-5 in all systems from (0.23 -0.27) meq/l while in the other layers ranged from (0.13 – 0.18) meq/l in the three system as shown in (Figure 4.5) and there was no effect of tillage in particular on the prevalence of potassium. The K-accumulation hypothesis is supported in the surface due to the recycling of plants by increasing K content even without nutrient application.

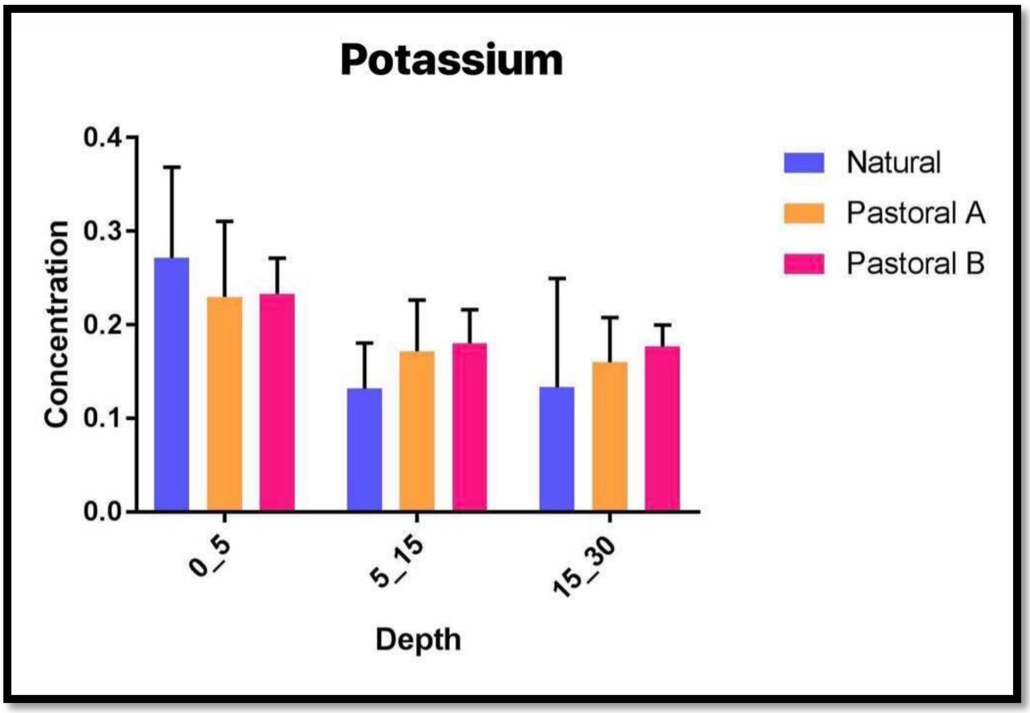


Figure 4.5: Concentration (meq/l) of potassium (K^+) on the depths of 0-5 cm, 5-15 cm and 15-30 cm for the natural, pastoral A and pastoral B

As K occurs in free cationic form in plant tissues, it can be easily lost by filtration in late growth stages, when leaves and roots are hung, as noted by Ning et al. (2013).

4.3.5 Nitrate (NO_3^-)

Nitrate is usually deficient in acid soils because low soil pH (<5.5) reduces nitrification. Nitrification ceases at pH <4.5 and the optimum pH is between 6 and 8 (Angle, 1993). Since organic matter is an important source of NO_3, accumulation may correlate with organic matter content patterns across the landscape. Nitrate concentrations ranges from 0.01 meq/l to 0.03 meq/l in all systems. Likely source of nitrate are fertilizers and animal waste.

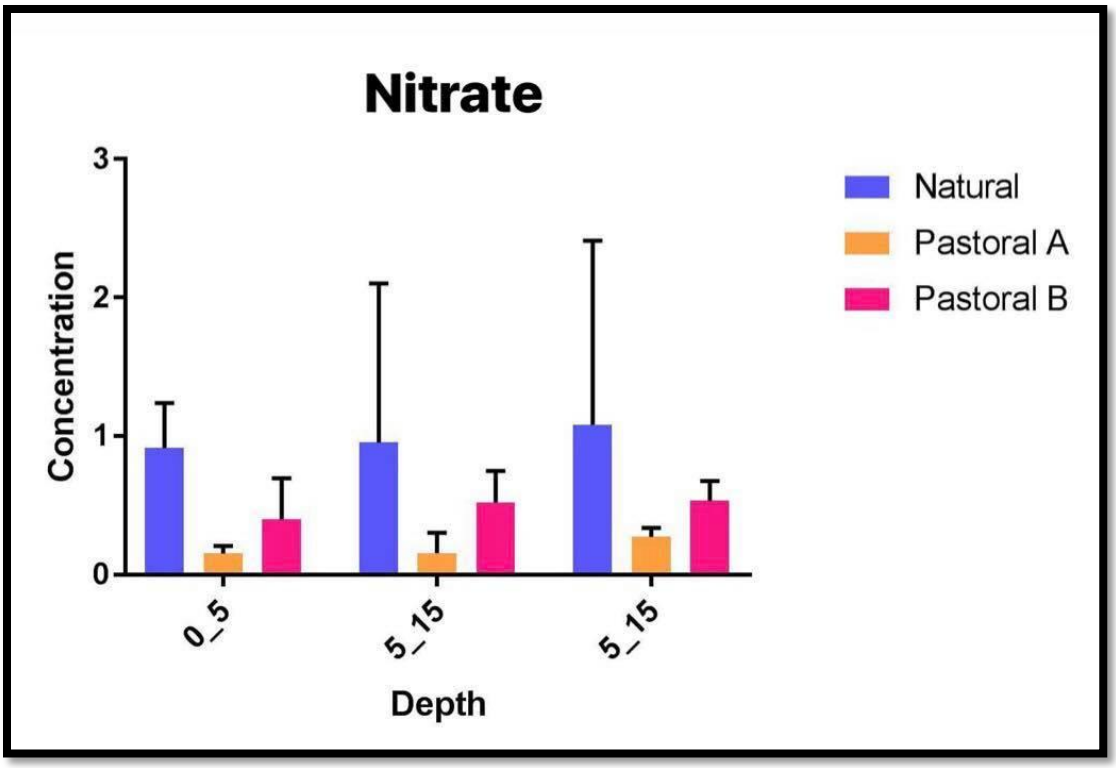


Figure 4.6: Concentration (mg/l) of Nitrate (NO_3^-) on the depths of 0-5 cm, 5-15 cm and 15-30 cm for the natural, pastoral A and pastoral B

Most nutrients are available when the pH is about 6.2 to 6.8 (Interpret a soil-test report William Scott Anderson and Charles Robinson) when the pH is higher, the availability of many nutrients, including Phosphorus, Iron, Manganese, Boron, Copper and Zinc will decrease. Similarly, with low pH in the soil under this range, some nutrients become less available, especially phosphorus, potassium, calcium and magnesium. Moreover, in some strong acid soils, some micronutrients, such as manganese, and some non-nutritious substances, such as aluminum, become poisonous to most plants, where the concentration of calcium in the natural system ranged from (0.21- 0.38) meq/l, (1.28 - 1.9) meq/l in pastoral A and (1.6-1.8) meq/l in pastoral B.

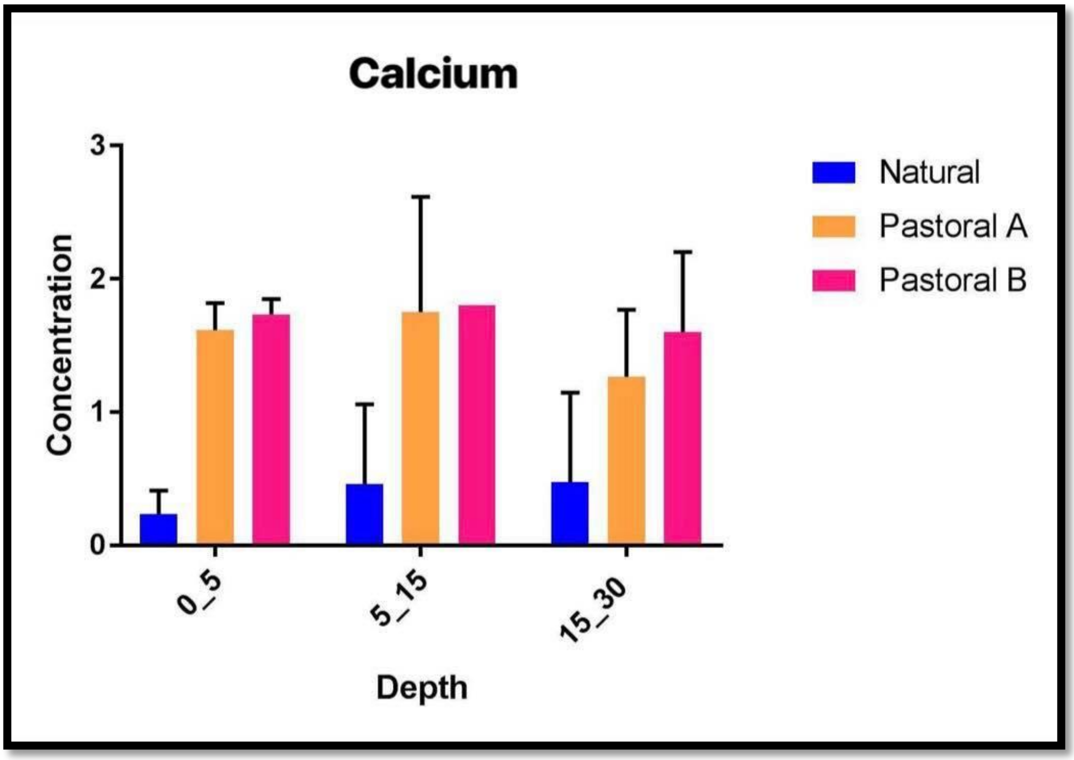


Figure 4.7: Concentration of Calcium (Ca^{+2}) on the depths of 0-5 cm, 5-15 cm and 15-30 cm for the natural, pastoral A and pastoral B.

Analysis of the variation in sodium absorption ratio (SAR) affected by tillage systems indicates an important impact on soil SAR. However, there was no significant difference between the systems as shown in (Table 4.7).

Table 4.7: Comparison of natural, pastoral A and pastoral B system effect on soil sodium adsorption ratio (meq/l) under different tillage systems

Treatment	SAR		
	0_5 cm	5_15 cm	15_30 cm
Natural	0.67	0.39	0.62
Pastoral A	1.22	1.21	1.40
Pastoral B	1.18	1.21	1.15

The results show that there is a significant difference between the averages of the three systems with the highest sodium absorption rate observed in the tillage system, while the lowest is consistent with the natural system. The results of this study are in contradiction with the results of (Hulugalle et al. 1997) and (Qingjie et al 2014), they believe that the low salinity and sodium absorption rate in the absence of the tillage systems is due to increased soil organic matter, porosity, reduced soil compaction, subsequent escalation of infiltration capacity, hydraulic conductivity of soils, and more soil filtration. In this study, less soil manipulation in the no and reduced pastoral systems, low tillage and reduced soil porosity in the implementation of short-term conservation tillage increased soil pressure and thus increased soil salinity and the rate of SAR.

4.3.6 Heavy Metals

Assess the effect of tillage on the total content available for heavy metals and among the minerals that were present in a clear percentage (Al^{+3}, Cu^{+2}, Zn^{+2}, and Ba^{+2}). The remaining elements were found in very few percentages. The results showed that the total concentrations of Al^{+3}, Cu^{+2}, Zn^{+2}, and Ba^{+2} in the soil had no statistically significant differences. However, but the total Cu and Ba were found to be significantly reduced by 0-5 cm under the pastoral system (tillage) and natural system. The availability of copper, zinc, aluminum, and barium decreased with increasing soil depth in all systems, but it was found that Al is the highest in the layers and 0-5, 5-15 in pastoral B except for the aluminum at a depth of 15-30 cm in pastoral B. The highest available in the pastoral system A at all depths, while the contents of Ba^{+2} available are the highest in conventional tillage at all depths, but tillage operations did not have a significant impact on the contents of the available Cu^{+2}.

Copper is less present when acidity is increased and the presence of copper is more correlated with the high organic matter content compared with its pH, since the soil containing large organic matter maintains the availability of copper in the soil where we noticed that the presence of copper in the natural system at all depths less than the presence in pastoral A, pastoral B system.

Aluminum is not a plant nutrient since it is very toxic to the roots of the plant when it is at high levels and thus limits the ability of the plant to absorb phosphorus from the mulch limit of the solubility of phosphorus. Extensible aluminum increases significantly when soil pH is below 5 But the results of our study show that the proportion of aluminum was limited due to high pH, where the range of Al^{+3} in the natural system between (0.035 - 0.066) µg/g, (0.6 - 1.19) µg/g in pastoral A and the aluminum presence was high on the depth of (0-5) cm in the pastoral B system compared to other systems where it reached 6.1 µg/g in pastoral B, 2.88 µg/g on depth (5-15) cm and 0.17 on (15-30) cm shows in (Table 4.8)

Table 4.8: Concentration (µg/g) of heavy metals on the depths of 0-5 cm, 5-15 cm and 15-30 cm for the natural, pastoral A and pastoral B

Depth (cm)	System	Cu^{+2} µg/g	Ba^{+2} µg/g	Al^{+3} µg/g	Zn^{+2} µg/g
(0-5)	Natural	0.017	0.08	0.035	0.01
	Pastoral A	0.04	0.04	0.86	0.31
	Pastoral B	0.05	0.09	6.11	0.3
(5-15)	Natural	0.011	0.06	0.21	0.01
	Pastoral A	0.02	0.03	0.6	0.15
	Pastoral B	0.17	0.04	2.88	0.1
(15-30)	Natural	0.009	0.08	0.066	0.01
	Pastoral A	0.04	0.03	1.19	1.97
	Pastoral B	0.03	0.03	0.12	0.17

4.4 Biological properties of soils of Study site

Land use change alters the rate at which the organic matter is oxidized, affecting its accumulation and mineralization (Solomon et al., 2002). Changes in soil moisture, temperature and C input can have a significant impact on soil microbial biomass and its activity, which in turn affects the availability of nutrients due to the rotation of soil organic matter (Ross, 1987). Microbial biomass, labile organic matter pool and respiration rate are mostly reduced with depth, as well as the organic state of the soil. Gravimetric water content showed variations with both sampling depth and season: in winter, soil- moisture mostly increased with depth and decreased in autumn due to organic matter and soil microbial.

4.4.1 Organic Matter

A critical matter to maintain the balance of soil biological communities, as it is largely responsible for maintaining soil structure, building soil capacity to store and release water and nutrients for crop use and increasing water leakage is the organic matter. It can be better preserved by reducing tillage and other soil disturbance, further improving rotation and covering crop cover (Comprehensive Assessment of Soil Health - the Cornell Framework). One of the most important indicators to determine soil quality is organic matter, which is the main element in soil quality assessment (Larson and Pearce, 1991).The result showed differences in organic matter in the pastoral A system as they increased as the depth increased while they were very close to the natural system. The proportion of organic materials in the study site ranged from (6.8-7.5) % in Natural system, (8.2-9.1) % In Pastoral A and (6.93 - 8.5) % as these percentages are considered high, and not within the natural range of the presence of organic matter in the soil. Organic matter content and overall soil health will be decreased by Intensive tillage and lack of carbon inputs with time. Similarly, increasing soil organic matter requires dedication, patience and time to rebuild. Alternatively, the addition of more stable organics such as compost, or possibly biofuels, can improve water retention and retention in the short term.

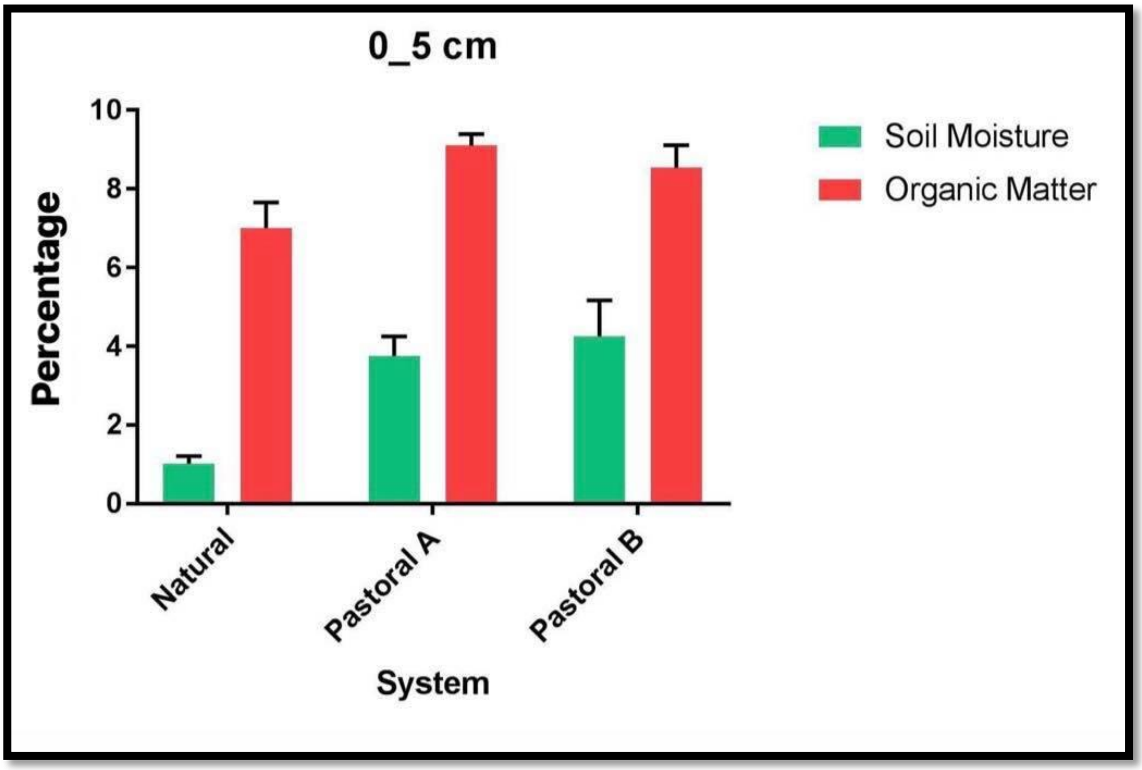


Figure 4.8: Percentage of Organic Matter (OM) and Soil Moisture at 0-5 cm in natural, pastoral A and pastoral B.

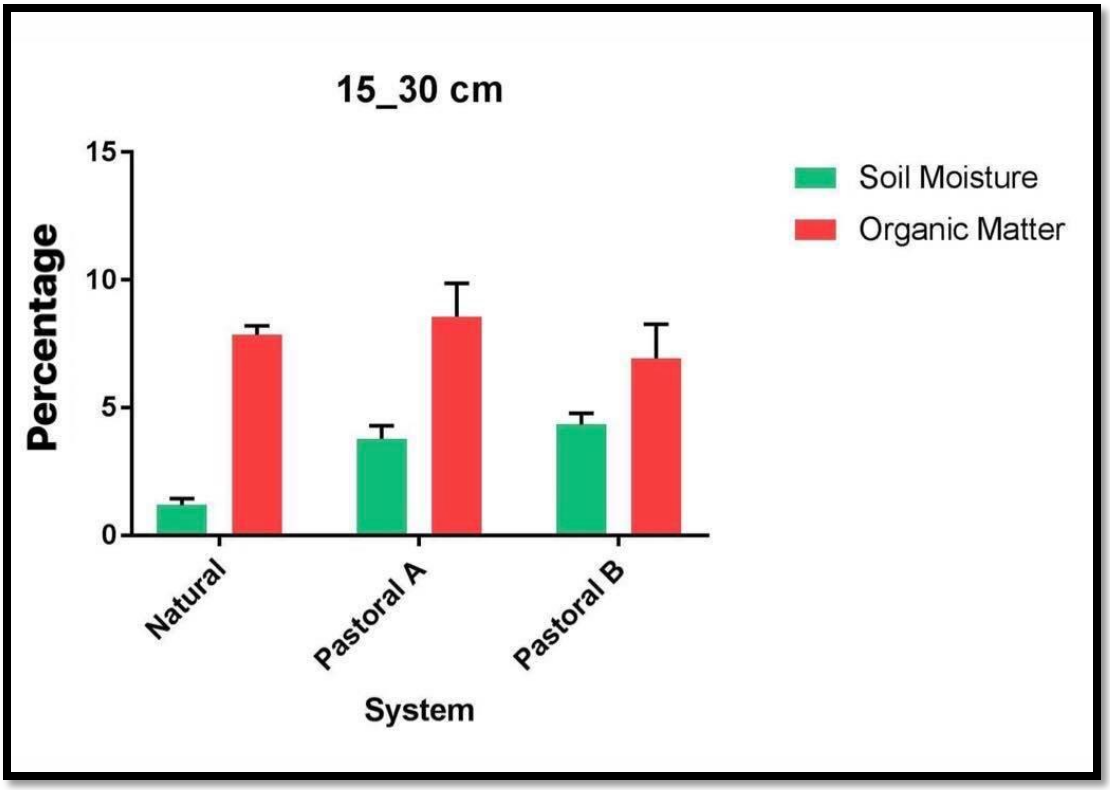


Figure 4.9: Percentage of Organic Matter (OM) and Soil Moisture at 15-30 cm in natural, pastoral A and pastoral B.

The long-term retention and accumulation of OM is enhanced by reducing the tillage and frequency of tillage (as far as possible within the constraints of the production system), and the frequent replication of various organic additives from different sources (alterations, residues, active growth of crops, Or cover crops, especially their roots) that stimulate both microbial community growth and carbon sequestration in aggregates The selection of appropriate organic matter depends on the management objective and other selected constraints on specific microbial activities and food source (Comprehensive Assessment of Soil Health- the Cornell Framework, 2015). Soil and crop management practices increase OM inputs as they play a key role in the sustainability of cropping systems. Conversely, the low OM contribution or rapid decomposition depletes SOM stocks. Traditional tillage integrates crop residues into the soil and facilitates rapid degradation of SOM by microbes due to the introduction of oxygen and increased contact with soil residues the proportion of organic matter is will be high due to a homogeneity of soil after tillage. On the other hand, no-tillage leads to the accumulation of most of the crop residues on the soil surface consequently, the proportion of organic matter in the natural system will be low compared to the pastoral system due to lack of mixing of soil.

4.4.2 Management effects on SOM indicators

Tilling generally affects soil microbial degradation rates in SOM by influencing the abundance and distribution of SOM in soil characteristics, and in regulating soil characteristics such as temperature, ventilation, water content, and pH. Intensive tillage practices work to break down soil Dissolve SOM-protected assemblies of aggregation, increase ventilation and heat, increase soil contact, and promote SOM dissolution. Thus soil erosion caused by tillage leads to movement from eroded areas to other landscape sites (Kennedy and Schillinger 2006).

4.4.3 Soil Microorganisms (Fauna)

Table 4.9: Number of microorganisms (Fauna) in natural system

Type of Species	Number
Arachnida (mites)	12
Arachnida (spider)	34
Arachnida (tick)	2
Diptera (mosquito)	9
Hymenopetra (ant)	32
Crustacea (gastropoda) snails	7
Chilipoda (centipeds)	1
Isopoda (pill bug)	24
Blattoda (cockroach)	1
Coleopetra	13
Mallophaga (lice)	4
Ticks	16
Spring tails	18
Land snail	28
Diptera (flies)	10
Thaumetopoea	6
Beetles	3
Ants	5
Collempola	5
Mallophaga (lice)	5
Orthoptera	12
Acrina	9
Araneida	3
Opiliones	7
Blattodea	3
Heteropetra	2
Odonata	1
Hymenoptera	1

Soil microorganisms are essential in the structural development of soil. Where hidden worm activity creates a network of surface-connected tunnels that increase air permeability and leakage rates. Also, drilling activity enhances soil mixing and increases soil sludge and plant residues that favour organic matter decomposition and release of nutrients.

The techniques of measuring microorganism’s soil include counting its population including management practices, such as tillage that alter micro-soil environments and disturb their habitats and food sources, affect soil animal groups. The increase in the number of earthworms is usually associated with a lack of tillage for traditional tillage due to less disturbance and fewer physical injuries. Soil microorganisms are usually concentrated in sites with higher organic content because SOM not only serves as a food source for soil microorganisms, but also maintains the soil moisture necessary for the survival and reproduction of animal life. (Umiker et al., 2009). The number of soil microorganisms in the affected areas has not yet been examined and will be examined within the next year.

4.4.4 Active carbon (AC)

Active carbon is an indicator of the organic matter part of the soil that is readily available as a source of carbon and energy for the microorganism community in the soil (i.e. food for the food network on the soil). The soil is mixed with potassium permanganate (dark purple), the color of activated carbon (which becomes less purple), which is visually observable, but is measured very accurately using the optical spectrometer changes when oxidizes (Gugino BK, Idowu OJ, 2007). Research has shown that active carbon is highly correlated with and similar to "particulate organic matter", which is determined with a more complex and labor-intensive wet-sieving and/ or chemical extraction procedure. Active carbon is positively correlated with percent organic matter, aggregate stability, and with measures of biological activity such as soil respiration rate. Research has shown that active carbon is a good leading indicator" of soil health response to change in crop and soil management, usually responding to management much sooner (often, years sooner) than the percent of the total organic matter. Thus, monitoring the changes in active carbon can be particularly useful to farmers changing practices to try to build up soil organic matter (e.g., reducing tillage, using new cover crops, adding new composts or manures). Soil OM varies in terms of its availability to microorganisms. Fresh plant residues are better sources of carbon and energy than bacterial cell walls. A measure of availability is the active carbon content. This differs faster in response to changes in crop or cultivation practice from soil OM, and is a major indicator of soil health (Gugino et al., 2007).

Where the (Figure 4.10) shows the values of active carbon in the natural system are high because the system is not exposed to tillage and therefore in the pastoral B system and there was an increase in organic matter and therefore a rise in active carbon

As for the pastoral A system, the values of active carbon were reduced due to the removal of plants from the system, which in turn led to a shortage of organic matter within the soil and thus a decrease in the values of active carbon

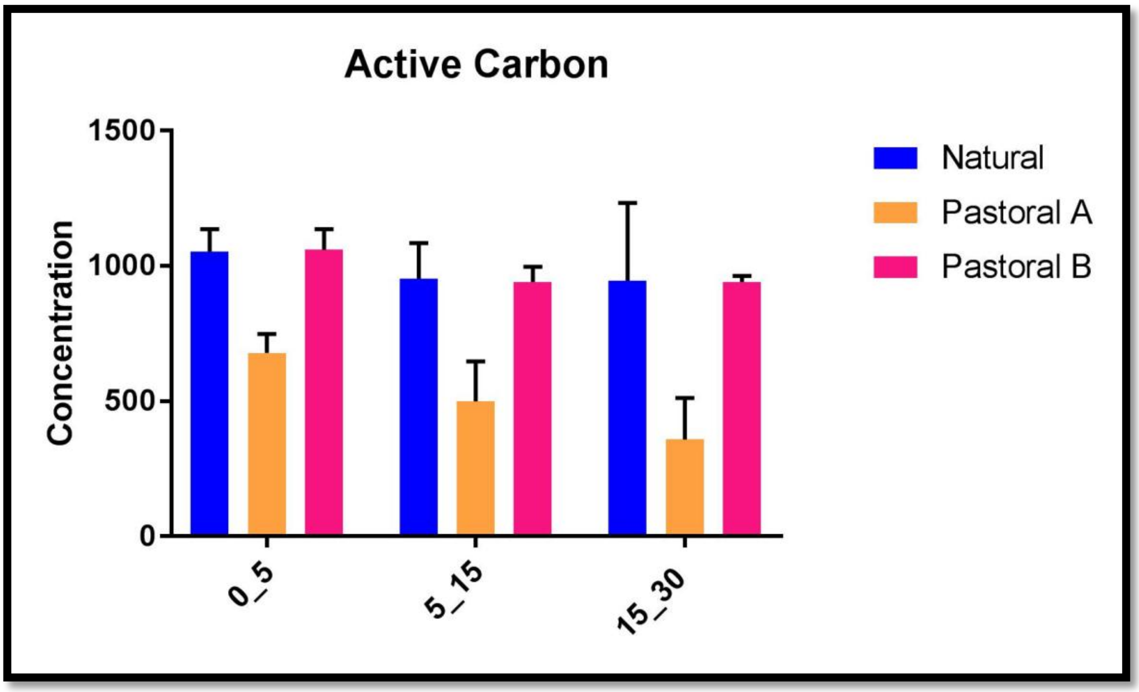


Figure 4.10: Concentration (mg/kg) of active carbon at all depth with natural, pastoral A and pastoral B system

Is closely related to particulate organic matter (POM) determined with a more intensive and complex process of sieving and / or chemical extraction. Because of its role in providing sources of food and energy for the community of soil microorganisms, active carbon is positively associated with a percentage of organic matter, total stability, measures of biological activity (e.g. respiration) and microbial biomass. Active carbon is a good "key indicator" of soil health response as research has shown for change in crop and soil management, and usually responds to management much sooner (often years ago) than the total proportion of organic matter. This is because when a large number of soil microbes are fed into the soil over a long period of time, the decaying organic matter accumulates. Therefore, monitoring changes in active carbon can be particularly useful for farmers who change practices to build soil organic matter (Comprehensive Assessment of Soil Health - the Cornell Framework, 2015). There was a negative correlation found between clay content and C content of soil.

Several previous studies have revealed strong links between C soil content and clay content as the results showed that the higher the clay content, the lower the active carbon content in soil. When the percentage of clay in pastoral A on depth 15-30 a clay 35.3 while active carbon 393 mgkg-1 the lowest percentage of carbon in the results, while the highest clay values in the results.

4.5 physical properties of soils of Study site

4.5.1 Soil texture

Texture is an inherent characteristic of the soil, and this means that it is rarely changed by management. It is therefore not an indicator of soil health, but useful for interpreting the measured values of the indicators (according to the Cornell Health Assessment Training Manual) and also for identifying appropriate strategies that will work for soil. The soil texture is clay loam in general. The percentage of clay in the surface layer 0-5 cm is more than 13%. Silt fractions represent more than 30% or less an equal percentage of soil particles, while sand fraction represents more 30%. Particle size distribution increasing in silt and clay largely according to depth 5-15 cm and 15-30 cm, while sand is decrease slope.

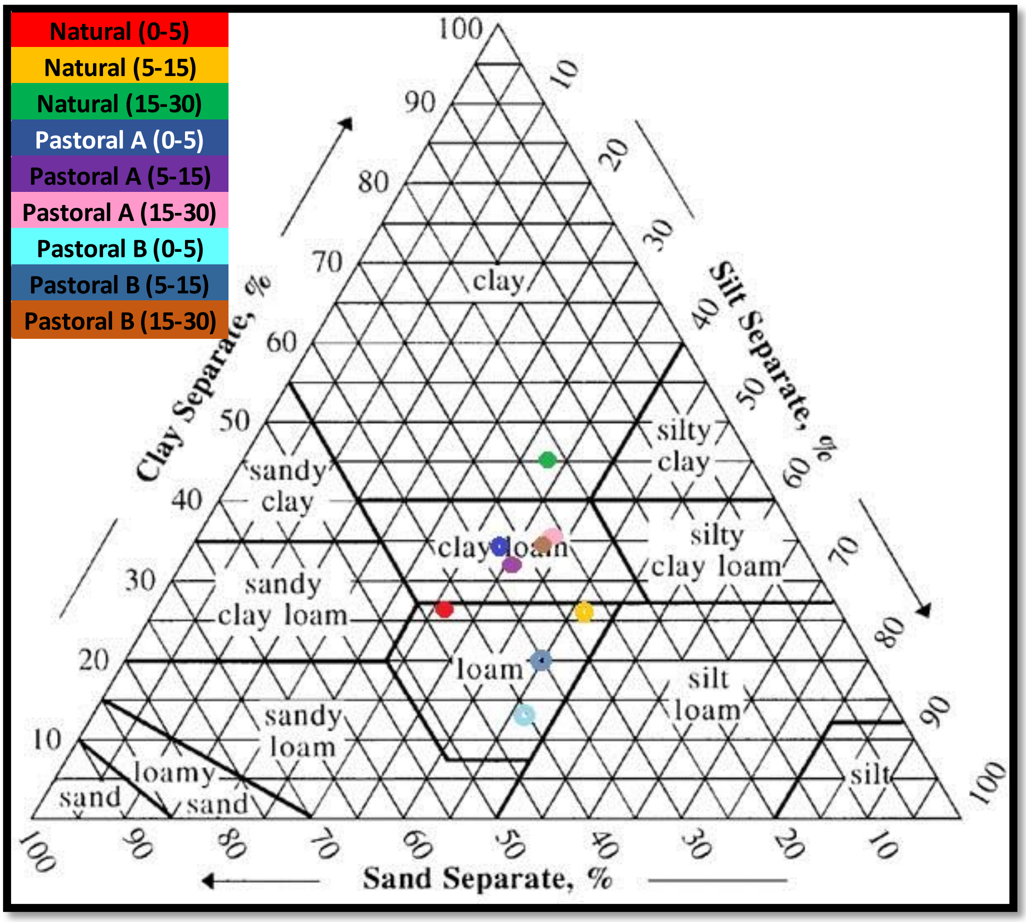


Figure 4.11: Tringle of soil texture in all systems at depth 0-5 cm, 5-15 cm and 15-30 cm.

4.5.2 Soil Moisture

Moisture determinations show significant differences, at natural system 1.04%, 1.24%, 1.23 % respectively in the three depths while moisture value increased in pastoral A the land where values ranged between 3.27% - 3.41% and 3.52 to 4.15 in pastoral B system.

(Table 4.10) shows that the greater the clay composition highest soil moisture. This could be so strengthen it by comparing all depth on depth 0-5 cm, where the composition of clay in natural is 26.4% with soil moisture of 1.04%, at the same time in pastoral A composition clay is 34.14% with soil moisture of 3.41% and 13.04% of clay in pastoral B with soil moisture 4.05% Therefore, Pastoral A has a small pore leading to increased water holding capacity and moisture required for bacterial growth Eventually increase the content of TOC and SOM. Where large pores lead to a decrease in the ability to retain the water and moisture required for bacterial growth (Hassink et al., 1993a).

Table 4.10: percentage of clay and soil moisture at all depth for natural, pastoral A and pastoral B.

Depth (cm)	System	Clay %	Soil Moisture %
(0-5)	Natural	26.4	1.04
	SD	±12.1	±0.18
	Pastoral A	34.14	3.41
	SD	14.2	±0.39
	Pastoral B	13.04	4.05
	SD	±3.03	±0.93
(5-15)	Natural	25.6	1.24
	SD	±9.20	±0.38
	Pastoral A	32.16	3.27
	SD	±1.50	±0.43
	Pastoral B	19.47	3.52
	SD	±1.71	±0.62
(15-30)	Natural	32.2	1.23
	SD	±12.9	±0.39
	Pastoral A	35.3	3.35
	SD	±1.25	±0.29
	Pastoral B	34.4	4.15
	SD	±1.50	±0.46

4.6 Measured Soil Health Indicators

The Cornell Soil Health Test measures several indicators of soil physical, biological and chemical health.

The Value column displays each result as a value, measured in the laboratory or in the field, in units of measurement as shown in the indicator summaries shown below. The Score column explains the measured value on a scale from 0 to 100, where the higher grades are better, but yellow, especially those close to the 30 grade, are also important in addressing soil health problems (Cornell Soil Health, 2015).

A rating of less than 20 indicates a constraint is a colour-coded red. This indicates a problem that is likely to limit the sustainability of the long-term ecosystem. In many cases, this also indicates the risk of environmental loss. The "constraint" column provides a short list of soil operations that do not work optimally when the indicator is red (Cornell Soil Health, 2015).

The estimate between 20 and 40 indicates low performance and coded chromatic orange. This suggests that the soil process is working fairly poorly and this should be considered in a field management plan. The management proposals table ultimately provides a soil health assessment report for field management practices that are useful in addressing all soil indicators (Cornell Soil Health, 2015).

The estimate between 40 and 60 indicates optimal sub-performance, which is colour-coded yellow. This shows that soil health can be better. Return and sustainability can decrease over time if not addressed, or not to mitigate it, through proper administration. Particular attention should therefore be paid to those indicators marked in yellow and close to 40 (Cornell Soil Health, 2015).

The estimate between 60 and 80 indicates excellent performance and is light green (Cornell Soil Health, 2015).

This indicates that the process in the soil operates at an unlimited level. Their approach to performance must be maintained or improved.

A rating of 80 or greater indicates optimal or near-optimal performance and colours are encoded dark green. The previous management was effective in maintaining soil health. It can be worth noting any particular aspects of management have probably maintained soil health, so that such management can continue (Cornell Soil Health, 2015).

The total Quality Score is calculated from individual cursor scores. This result is further vote as follows: is considered to be less than 40% very low, 40-55% low, 55-70% medium, 70% - 85%. The ratio is high and greater than 85% is very high. The highest possible quality score is 100 and the lowest score is 0, and is considered a relative indicator of soil health (Cornell Soil Health). However, the importance of greater than one general measure is to determine the restricted or sub-optimal soil processes, so that these issues can be addressed through appropriate management. Thus, the overall result of soil quality is taken as a general summary

Table 4.11, 4.12, 4.13, 4.14, 4.15, 4.16, 4.17, 4.18 and 4.19 shows soil health parameter values for factorial system of natural, pastoral A and pastoral B on three depths. The colors in the table are the same as those used to score the raw laboratory data values given in the soil health report. The lower score, the greater the constraint in the proper function of processes as represented by the indicators. Red values are 'very low' and indicate major constraints. Orange values ' low', yellow values are 'medium' light Green value are 'high' and dark green values 'very high' and suggest that the soil processes represented by these indicators are likely functioning well. As such, management goals should aim to maintain such conditions. Low and medium scores don't necessarily represent a major constraint to proper soil functions, but suggest places for improvement in management planning. The value of soil health was given out of 100 while (Table 4.11) shows the soil health at a depth of 0-5 cm in natural system while take overall quality score 42 it has been classified as a few, (Table 4.12) at depth of 5-15 cm in natural system take overall quality 44 also it has been classified as a few and 15-30 cm in natural system take 35 in overall quality score in (Table 4.13). As for the pastoral A system in (Table 4.14) at depth 0-5 cm the value of overall quality score was 34 it has been classified very low, 5-15 the value of overall quality score was 30 (very low) shows in (Table 4.15) and the value of overall quality score at 15-30 cm was 30 (very low) in (Table 4.16). The value of overall score quality in pastoral B at depth 0-5 was 38 (very low) in (Table 4.17), the value of overall score quality 37 at depth 5-15 cm (very low) in (Table 4.18) and the value of overall score quality 36 at depth 15-30 cm (very low) in (Table 4.19).

Table 4.11: Soil health assessment for natural system on depth 0-5 cm

	Natural 0-5 cm		
	Measured soil textural class: LOAM		
Sand: 42.4	Silt: 31.2	Clay: 26.4	
Group	**Indicator**	**Value**	**Rating**
Physical	Soil Moisture %	1.04	5
Biological	Organic Matter %	7.06	29
Biological	Active Carbon mgkg-1	1051	83
Chemical	Soil pH	7.48	94
Chemical	EC µS/cm	353.1	20
Chemical	Extractable Potassium meq/l	0.27	0
Chemical	Nitrate meq/l	0.03	9
Chemical	Total Nitrogen bound mg/l	3.8	95
Overall Quality Score: 42 / low			

Table 4.12: Soil health assessment for natural system on depth 5-15 cm

	Natural 5-15 cm		
	Measured soil textural class: LOAM		
Sand: 28 %	Silt: 46.4 %	Clay: 25.6 %	
Group	**Indicator**	**Value**	**Rating**
Physical	Soil Moisture %	1.24	6
Biological	Organic Matter %	6.8	38
Biological	Active Carbon mgkg-1	953	95
Chemical	Soil pH	7.61	92
Chemical	EC µS/cm	283.2	16
Chemical	Extractable Potassium meq/l	0.13	0
Chemical	Nitrate meq/l	0.02	3
Chemical	Total Nitrogen bound mg/l	4.1	98
Overall Quality Score: 44 / low			

Table 4.13: Soil health assessment for natural system on depth 15-30 cm

	Natural 15-30 cm		
	Measured soil textural class: CLAY		
Sand: 22.2 %	Silt: 45.6 %	Clay: 32.2 %	
Group	**Indicator**	**Value**	**Rating**
Physical	Soil Moisture %	1.23	6
Biological	Organic Matter %	7.5	11
Biological	Active Carbon mgkg-1	953	95
Chemical	Soil pH	7.61	91
Chemical	EC µS/cm	234.2	13
Chemical	Extractable Potassium meq/l	0.14	0
Chemical	Nitrate meq/l	0.02	3
Chemical	Total Nitrogen bound mg/l	2.5	62
Overall Quality Score: 35 / very low			

Table 4.14: Soil health assessment for pastoral A system on depth 0-5 cm

	Pastoral A (0-5) cm		
	Measured soil textural class: LOAM		
Sand: 32.4 %	Silt: 33.46 %	Clay: 34.14 %	
Group	**Indicator**	**Value**	**Rating**
Physical	Soil Moisture %	3.41	17
Biological	Organic Matter %	9.1	12
Biological	Active Carbon mgkg-1	684	76
Chemical	Soil pH	8.47	79
Chemical	EC µS/cm	107.62	6
Chemical	Extractable Potassium meq/l	0.24	0
Chemical	Nitrate meq/l	0.01	6
Chemical	Total Nitrogen bound mg/l	4.87	78
Overall Quality Score: 34 / very low			

Table 4.15: Soil health assessment for pastoral A system on depth 5-15 cm

	Pastoral A (5-15) cm		
	Measured soil textural class: CLAY LOAM		
Sand: 32.04 %	Silt: 35.8 %	Clay: 32.16 %	
Group	**Indicator**	**Value**	**Rating**
Physical	Soil Moisture %	3.27	17
Biological	Organic Matter %	8.75	15
Biological	Active Carbon mgkg-1	533	59
Chemical	Soil pH	8.66	77
Chemical	EC µS/cm	98.4	5
Chemical	Extractable Potassium meq/l	0.18	0
Chemical	Nitrate meq/l	0.01	3
Chemical	Total Nitrogen bound mg/l	2.69	67
Overall Quality Score: 30 / very low			

Table 4.16: Soil health assessment for pastoral A system on depth 15-30 cm

	Pastoral A (15-30) cm		
	Measured soil textural class: CLAY LOAM		
Sand: 26.47 %	Silt: 38.23 %	Clay: 35.3 %	
Group	**Indicator**	**Value**	**Rating**
Physical	Soil Moisture %	3.35	17
Biological	Organic Matter %	8.2	21
Biological	Active Carbon mgkg-1	393	43
Chemical	Soil pH	8.74	76
Chemical	EC µS/cm	98	5
Chemical	Extractable Potassium meq/l	0.17	0
Chemical	Nitrate meq/l	0.01	3
Chemical	Total Nitrogen bound mg/l	2.97	74
Overall Quality Score: 30 / very low			

Table 4.17: Soil health assessment for pastoral B system on depth 0-5 cm

	Pastoral B (0-5) cm		
	Measured soil textural class: LOAM		
Sand: 40 %	Silt: 46.96%	Clay: 13.04%	
Group	**Indicator**	**Value**	**Rating**
Physical	Soil Moisture %	4.05	21
Biological	Organic Matter %	8.5	18
Biological	Active Carbon mgkg-1	1059	82
Chemical	Soil pH	8.51	79
Chemical	EC µS/cm	97.9	5
Chemical	Extractable Potassium meq/l	0.23	0
Chemical	Nitrate meq/l	0.01	6
Chemical	Total Nitrogen bound mg/l	3.72	93
Overall Quality Score: 38 / very low			

Table 4.18: Soil health assessment for pastoral B system on depth 5-15 cm

	Pastoral B (5-15) cm		
Measured soil textural class: LOAM			
Sand: 35.37 %	Silt: 45.16 %	Clay: 19.47 %	
Group	**Indicator**	**Value**	**Rating**
Physical	Soil Moisture %	3.52	18
Biological	Organic Matter %	7.8	25
Biological	Active Carbon mgkg-1		96
Chemical	Soil pH	8.5	79
Chemical	EC µS/cm	104.1	5
Chemical	Extractable Potassium meq/l	0.18	0
Chemical	Nitrate meq/l	0.01	3
Chemical	Total Nitrogen bound mg/l	2.77	69
Overall Quality Score: 37 / very low			

Table 4.19: Soil health assessment for pastoral B system on depth 15-30 cm

	Pastoral B (15-30) cm		
Measured soil textural class: CLAY LOAM			
Sand: 27.87 %	Silt: 37.73 %	Clay: 34.4%	
Group	**Indicator**	**Value**	**Rating**
Physical	Soil Moisture %	4.15	21
Biological	Organic Matter %	6.93	11
Biological	Active Carbon mgkg-1	935	97
Chemical	Soil pH	8.61	77
Chemical	EC µS/cm	100.8	5
Chemical	Extractable Potassium meq/l	0.17	0
Chemical	Nitrate meq/l	0.01	3
Chemical	Total Nitrogen bound mg/l	2.97	74
Overall Quality Score: 36 / very low			

4.7 Calculation of Soil Quality Index

Table (4.20) showed the scoring of indicators soil quality measured in each sampling point in Natural system, Pastoral System. The SQI assessed in this research included a variety soil chemical, physics, and biological properties. Soil quality differences should be distinguished from soil characteristics associated with management practices associated with natural soil diversity. In this study, the soil looks similar to its mother material and topography, but differs in the management of its practice (natural and pastoral) and land use intensity.

Table 4.20: Score for soil quality indicator in natural system and pastoral system of study.

	Land Use								
Soil Properties	**Natural** (0_5) cm	**Natural** (5_15) cm	**Natural** (15_30) cm	**Pastoral A** (0_5) cm	**Pastoral A** (5_15) cm	**Pastoral A** (15_30) cm	**Pastoral B** (0_5) cm	**Pastoral B** (5_15) cm	**Pastoral B** (15_30) cm
Soil Chemical Indicators									
pH	7.48	7.61	7.64	8.47	8.66	8.74	8.51	8.5	8.61
score	2	3	3	3	3	3	3	3	3
EC µS/cm	353.1	283.2	234.2	107.62	98.4	98	97.9	104.1	100.8
Score	1	1	1	1	1	1	1	1	1
Total Organic Carbon (TOC) mg/l	45	44.3	43.7	33.25	26.91	34.7	37.4	34.06	37.07
Score	1	1	1	1	1	1	1	1	1
Total nitrogen (TNb) mg/l	3.8	4.1	2.5	4.87	2.69	4.33	3.27	2.77	2.97
Score	2	2	2	2	2	2	2	2	2
Extractable Potassium (K) meq/l	0.27	0.13	0.14	0.24	0.18	0.17	0.23	0.18	0.17
Score	1	1	1	1	1	1	1	1	1
Extractable Sodium (Na) meq/l	0.39	0.24	0.37	1.36	1.39	1.43	1.36	1.38	1.33
Score	1	1	1	1	1	1	1	1	1
Magnesium (Mg) meq/l	0.46	0.39	0.34	0.84	0.72	0.8	0.93	0.8	1.06
Score	1	1	1	1	1	1	1	1	1
Calcium (Ca) meq/l	0.21	0.37	0.38	1.66	1.9	1.28	1.37	1.8	1.6
Score	1	1	1	1	1	1	1	1	1
Biological Indicators									
Organic matter (OM) %	7.06	6.8	7.5	9.1	8.75	8.2	8.5	7.8	6.93
Score	3	3	3	3	3	3	3	3	3
Active Carbon (AC) mgkg-1	1051	953	905	684	533	393	1059	941	935
Score	3	3	3	2	2	2	3	3	3
physical Indicator									
Soil Moisture %	1.04	1.24	1.23	3.41	3.27	3.35	4.05	3.52	4.15
Score	1	1	1	1	1	1	1	1	1
∑ Scoring	17	18	18	17	17	17	18	18	18
SQI	15.4	16.3	16.3	15.4	15.4	15.4	16.3	16.3	16.3
Mean SQI		16			15.4			16.3	

The SQI for the restoration in the case study was 16 for natural system, 15.4 for pastoral A and 16.3 for pastoral B. The natural system and pastoral B value of soil quality are higher than the pastoral A. The results showed that according to SQI, land use management types can enhance soil quality. The better the soil quality, the higher the SQI is. The natural system and pastoral B had better soil quality than pastoral A, while the systems that were has no significant differences.

The soil fertility area is classified as medium to high or good. The acidity of the pH is from slightly alkaline (7.48) to moderately alkaline (8.74), with a high (6.8-9.1) organic matter, and with a low (26.9-45) total organic carbon (TOC). The soil fertility is with the total nitrogen low, though the content of another mineral, such as potassium, calcium, and magnesium, is low.

The soil physical property is not a constraint for plant growth, there is low soil moisture (Andrew, 2002). Biological properties are the basis for comparisons truly measures the soil quality indicators, which are useful in assessing soil response for soil properties with the natural system and pastoral system. The results indicate that the change in quantitative indicators of soil quality changes in most soil quality indicators is close.

The assessment of the SQI was undertaken with the totaling method. Then the Index value was multiplied by 10 to increase the value of the index in a range. The maximum value of the SQI is 16.3 if all soil properties are measured. The total SQI is then expressed as a percentage of the maximum possible value of the total SQI, for the soil properties that are measured.

The SQI is the average class of variable values, observed in all land use. Soil quality describes a range of physical, chemical and biological properties of land that have the ability to perform a variety of functions (Evanylo and McGuinn, 2000). The observation (Figure 4.14) showed that the land use for the natural system and pastoral B has the best SQI (16, 16.3) respectively and land use for the pastoral A has the smallest land quality index (15.4).

Where the best value of soil quality index in our study is 39 and the lowest value is 10 based on the equation used in calculating soil quality index.

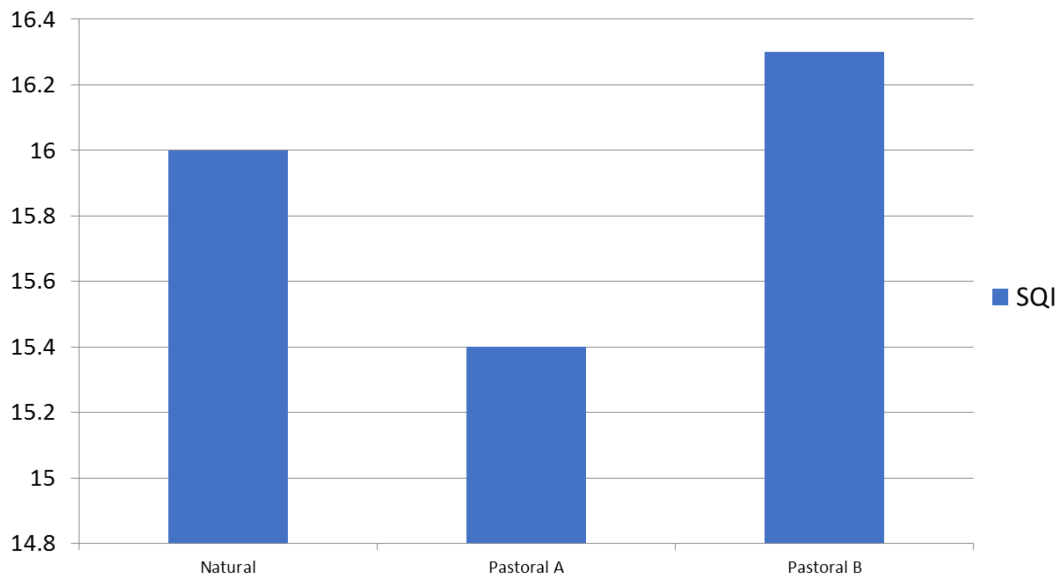


Figure 4.12: The final value of soil quality index on all systems after using the equation.

Soil depth is one of the semantics affecting most SQI in the study site. Where soil depth is a spatial function where the deeper soil has a larger area of the soil and thus contribute to the properties of good soil physically, biochemically and biologically and soil properties may be more functional or likely to be better before deepening.

4.8 Ecosystem responses to land-use change (LUC) in Wadi Nar

Ecosystem responses to LUC around the world are widespread across spatial and occur worldwide over a wide range of spatial and temporal scales (Cardille et al. 2004a). Many studies indicated that in the large scale, the LUC of natural systems to human-controlled ecosystems generated a new era, the Anthropocene, in which humans change the earth system (Steffen et al. 2007). Studies in ecosystem science have traditionally emphasized alternation and change of state in natural ecosystems (Pickett and Cadenasso 1995).

4.9 Developing a framework of ecosystem response to LUC

Implications for ecological studies are done through LUC processes, which enhance the science of ecosystems in the human-controlled biosphere (Foley et al., 2005). Ecosystems are now more widely studied as ecological social systems by ecologists (Rodriguez et al., 2006). A framework that addresses the general features of ecosystem response to LUC processes can be used to integrate ecosystem concepts. Thus, it is required that ecosystem science should provide tools to develop a theoretical and practical framework for LUC to identify changes in ecosystem functions at any stage of transition. Still there is lack in the link between ecosystem science and LUC in a theoretical framework that can enhance fieldwork for understanding LUC and the response of the ecosystem more. This is done to combine ecosystem science elements, through the use of universal terrestrial ecosystem properties; SQI into LUC processes (Foley et al. 2005). Paths of variables that refer to soil and vegetation conditions changes are used in our framework to refer to changes in the components of the terrestrial ecosystem (soil and vegetation) in response to LUC.

SQI uses as indicators for ecosystems response assessment to LUC can be evaluated in additional methods (Ben-Dor et al. 2009a). Testing the framework in the Wadi Nar case study revealed four properties of the framework that can be used for developing a science of LUC:

1. Comparison of different types of transformations: The LUC science needs to combine general and operational ecosystem responses to allow comparisons of changes in the environmental characteristics of any LUC using experimental studies. It is proposed that SQI is a good environmental indicator that can be used to compare changes in the three cores LUC by our framework. Therefore, we suggest that as a theoretical framework, the SQI path can be used as a basis to enhance LUC ecosystem response science. However, the

framework's validity and generality should be tested across a wide range of LUCs in terrestrial systems around the world.

2. Land-use change between self-regulating and management systems: The transition between self-regulating processes and heavily imposed processes affects LUC attributes (Rietkerk et al. 2004). The description of LUC from a natural ecosystem to a Pastoral ecosystem is as the imposed engineering of a new ecosystem that re-designs systems. LUC from natural to pastoral ecosystems can be viewed as a release of the engineering constraints, which enables the system to re-organize itself through self-organized processes.

3. Short- and long-term impacts identification: The LUC science needs to rely on indicators measuring "slow" and "rapid" variables that indicate the short- and long-term effects on the structure and function of the ecosystem. The SQI path framework suggests that the fundamental change of any particular ecosystem can be captured by adding the main soil and vegetation cases with long or short time scales. Soil quality shows the net impact of slow physical, chemical and biological processes in the framework that determines soil control on the LUC ecosystem response. Soil and vegetation responses on a short to intermediate time scale are the main focus of our study (10 years).

4. Biodiversity and ecosystem function combination: changes in biodiversity influence ecosystem function, where LUC constitutes an important engine (Gaston 2000). The consistent changes in the functional composition and diversity of the plant as a result of the LUC can lead to direct, indirect and interactive sequencing of various ecosystem functions (Hillebrand and Matthiessen 2009). This suggests that changes in biodiversity may be one way in which changes in land use change ecosystem functions and responses is via biodiversity changes. Within our framework, SQI is expected to reflect the extent to which

changes in plant diversity translate into changes in ecosystem functions. (Costanza et al., 2007).

Chapter Five

Conclusions

- In this study, we propose a framework to evaluate the LUC response using a global SQI indicator in LUC processes. Our work has been used to identify changes in soil and plant conditions in the components of the terrestrial ecosystem (soil and vegetation) in response to LUC.
- In the study, we evaluated the frame in two transitions from Wadi Nar as a case study. This enabled us to assess the changes that have been made through SQI and soil health assessment. We found that the relationships in SQI are closely related to each processing system and can be measured by chemical, physical and biological properties. Future studies will be needed.
- We propose that changes in biodiversity may be one way in which changes in land use change ecosystem functions. As part of our work, changes in plant diversity are expected to be reflected in changes in ecosystem performance through SQI and soil health assessment. The results of this study include several important aspects that show differences in land use.
- We propose adding an assessment of the ecosystem response that shows soil health. Land use is an important aspect to compare the shifts between different land uses to identify short-term changes and advance the ecological science of the biosphere controlled by humans where ecosystem responses to land-use change processes have profound implications for ecological science.
- Our study can be integrated into the general characteristics of land use processes in this science to modify the ecosystem.

- The selection and spread of tillage in an area is affected by the social and economic conditions of farmers and beneficiaries, in addition to climate factors and soil characteristics. As shown by the results of this study, tillage systems with the lowest level of soil disturbance and resettlement (no-tillage and reduction) will achieve the highest amounts of soil nutrients (N, P, K) and soil stability. Low salinity levels electrical conductivity (EC), increase sodium absorption ratio (SAR) and pH were noted in soil tillage systems.
- These positive benefits are particularly important in the production of agricultural crops in arid and semi-arid regions. There seems to be a change in the current system of agriculture to a new system that will improve biophysical conditions and crop production.
- It appears that improving the physical-chemical properties of soil in a long-term approach is different from the short-term approach although soil salinity under pastoral system as compared to non-tillage methods represent fewer values. We, therefore, recommend these studies for longer periods and for different climatic conditions.

Recommendations:

After making several field observations for two years of work, several recommendations will be made to collect more accurate data for analysis.

- Application of the soil quality index method to assess proposed land for agriculture to assist farmers in identifying suitable arable land by measuring indicators to assess soil health.

- In future studies, the site of the study should be tillage intensively to obtain the differences between tillage and its effect on soil health.

- Integrate our study and the methods used in soil health assessment of land use change in both the Ministry of Agriculture and the Environmental Quality Authority to assess the effect of land use on ecosystem.

- Future studies should test the of this larger and more diverse data sets, including different types of soil, climatic zones and different areas such as mountainous terrain.

- In order to examine the causes of soil quality change, more detailed research on soil measurements, in terms of laboratory analysis, should be done as input to models such as SQI.

- Samples should be studied for a longer period (for all months of the year), in order to understand seasonal changes and their effect on soil characteristics.

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- In order to examine the causes of soil quality change, more detailed research on soil measurements, in terms of laboratory analysis, should be done as input to models such as SQI.

- Thus, soil quality assessment methodologies should be able to measure identified soil functions and soil ecosystem services associated with these management objectives.

- Future studies should test the success of this framework for larger and more diverse data sets, including different types of soil and climatic zones.

- Tools should be available to develop a theoretical and practical framework for LUC to identify changes in ecosystem functions in the transition phases to which the study site is subject.

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APPENDIX 1

Site Pictures

APPENDIX 1

Procedure

1. pH: Among chemical indicators for soil quality, soil reaction (pH). This basic factor is known to influence nutrient availability and microbiological activity. These measurements were taken in the laboratory using a pH meter by method of extract for soil samples by mix 5 g of soil with 45 ml of distilled water in shaker for 1 hr (Ryan J et al., 1996).
2. Electrical Conductivity (EC): of the soil was measured by the extract method by mixing 5 g of soil with 45 distilled water and measuring by EC meter to measure the concentration of ions in the sample. It is generally used as an indicator of salinity (Ryan J et al., 1996).
3. Anions (Cl^-, NO3, HCO3)

3.1. Chloride (Cl^-): Measured chloride by titration sample preparation by extract method with 5 g and 45 distilled water, take 10 ml of the sample and add a few drops of K_2CrO_4 also titrate with standard $AgNO_3$ titrate to the end point (color is pinkish yellow with stirring) (Ryan J et al., 1996).

$$\text{Calculate it by } Cl = (VT - VB) * NT * 1000 * 35.45 / Vs$$

3.2. Nitrate (NO_3^-): Prepared 5 g of dry soil on the sieve 2mm to 50mL filtered in necessary, add 1mL HCL solution and mix thoroughly. preparation of standard curve: Prepare NO3 calibration standards in the range 0 to 7 mg NO_3 – N/L by diluting to 50 ml of the following volumes of intermediate nitrate solution: 0,1.00, 2.00, 4.00, 7.00 ect Read absorbance or 100% transmittance against redistilled water set at zero absorbance or 100%transmittance. Use wavelength of 220nm to obtain NO3 reading and wavelength of 275nm by using the spectrophotometer to determine interference due to dissolved organic matter (Eaton A. D., et al 1998).

$$Abs (net) = Abs (220nm) - 2(Abs 275nm).$$

3.3. Bicarbonate (HCO_3^-): The procedure is applied to water samples to measure the sum of titratable bases measured HCO_3 by titration through add 5 drops of mixed indicator and titrate with the same Cl standard until the indictor changes color from greenish blue to 0.1 N light brown (Eaton, A. D.; et al 1995).

$$HCO_3 (mg/l) = (Vt * N *1000 * 61.02) / Vs$$

While Vs = volume of the sample used

N = Normality of the HCL nitrate used

4. Cations (Potassium (K^+), Sodium (Na^+))

4.1. (Potassium (K^+), Sodium (Na^+)): Transfer 5g soil (2mm soil) into a 250ml flask, add 50 ml distilled water using a graduated cylinder then shake about 1hr. Centrifuge for 10 min at 1000 rpm. Read K and Na concentration by a flame photometer (Eaton, A.D.; et al 1995).

4.2 Magnesium (Mg^+): Transfer 5g soil (2mm soil) into a 250ml flask, add 45 ml distilled water using a graduated cylinder then shake about 1hr, take 25 ml of the extract soil with 25 distilled water to and add a 1-2 drops of Erichrome Blake T to titrate it with 0.01 EDTA and shake continuously and keep titration slowly when reaching the end point at the color will change slowly from purple to blue.

Calculate it by: $Mg\ mg/l = (A * N * 1000 * C) / B$

Where:

A: volume of EDTA required for Mg titration

B: volume of sample

C: equivalent weight of Mg

N: normality of EDTA

4.3. Calcium (Ca^{+}): Transfer 5g soil (2mm soil) into a 250ml flask, add 45 ml distilled water using a graduated cylinder then shake about 1hr, take 25 ml of the extract soil with 25 distilled water and add a 2-3 drops of murexide as an indicator and titrate with 0.01 N of EDTA to change the color to purple.

Calculate it by:

Ca mg/l = (A * N of EDTA * 1000 *C) / B

Where:

A: volume of EDTA required for titration

B: volume of sample

C: equivalent weight of Ca

N: normality of the EDTA

5. Heavy Metals: Heavy metals in the soil were measured using an inductively coupled plasma mass spectrometry (ICP-MS).
6. Total organic carbon (TOC), Total Nitrogen Bound (TNb): Levels of total organic carbon and nitrogen reflect levels of total organic carbon. Total organic carbon and nitrogen measured by ratio TOC select device through dilution of the filter sample by 1:10 (manual of TOC device).

7. Sodium Absorption Ratio (SAR): The following equation is used to calculate SAR: SAR = Na+ /√ Ca^{+2} + Mg^{+2} Photometry is used to measure Na. titration method is used to calculate Calcium and Magnesium in soil saturation extract. Kjeldahl method is used to measure total nitrogen.
8. Soil Organic matter: According to the ball (1964), the loss of ignition determines SOM. Depending on an assessment of the cost and relative accuracy of several methods for determining SOM in soil from the south-eastern United States (Ou, 2014) this method was chosen. All soil samples must have the same humidity level and temperature as required by this method. Overnight all samples were dried at 105 ° C in a weight crucifix (weight 1) in order to ensure the previous condition. Before weighing it again, the crucible was removed and cooled in a dryer for 10 minutes and it weight 2. In order to the ignition, the samples were placed for 16 hours in a muffle furnace at 375 °C. the samples were cooled in a desiccator for 45 min after ignition and the weighed 3.

   The SOM percent was calculated by Equation:

   SOM %= (weight 2 – weight 3) / (weight 2 – weight 1)

9. Soil moisture: This procedure describes the method for the determination of soil moisture content that influences not only the crop growth, but also the nutrient transformation and biological behavior by weight 10 g air-dry soil (W1) and dry overnight at 105c in an oven, remove from oven and waiting cool a desiccators for at least 30 min and re weigh (W2) by using SOP soil, or by soil moisture device (Ryan, J; et al 1996).
10. Soil texture: The concentration of aqueous HMP is increased to 3%, and shaking time reduced to 2 h. There is no collection of sand and POM of the 2.0- to 0.5-mm range, so only a 0.053-mm sieve is necessary to collect the sand fraction. A smaller original soil mass (15 g) can be used for the analysis, reducing the volume of liquid required to rinse the silt and clay particles through the sieve. This smaller volume of solution can be

collected in a 600- or 800-mL beaker, and the sedimentation step carried out without sub sampling. The silt and clay solution is stirred thoroughly to suspend all particles, and then allowed to settle undisturbed at room temperature (18–24 °C) for a sedimentation period of at least 90 min but, 6 h. After the sedimentation period, the suspended clay fraction is decanted from the settled silt particles and discarded. The settled silt fraction is then dried in the beaker at 1058°C to constant weight the soil Sand% and Silt% are calculated based on their fraction of the original sample mass (T. A. Kettler, 2001).Calculate percent sand, silt clay from:

Sand (%) = (dry wt sand (g)/dry wt (g)) * 100%

Silt (%) = (dry wt silt (g)/dry wt (g)) *100%

The clay% is determined by calculating the difference of 100% minus the sum of the Sand% and Silt%

Clay (%) = 100% - (Sand (%) + Silt (%))

11. Active carbon: From the larger thoroughly mixed composite bulk soil, a subsample is collected and allowed to air dry. The soil is ground and sieved to 2 mm and then take 2.5 g sample of air-dried soil is placed in a 50 ml centrifuge tube filled with 20 ml of a 0.02 M potassium permanganate (KMnO4) solution, which is deep purple in color. The soil and KMnO4 are shaken for exactly 2 minutes to oxidize the "active" carbon in the sample. The purple color becomes lighter as a result of this oxidation. The sample is centrifuged for 5 minutes, and the supernatant is diluted with distilled water and measured by spectrophotometer for absorbance at 550 nm. The absorbance of a standard dilution series of the KMnO4 is also measured to create a calibration curve for interpreting the sample absorbance data. A simple formula POXC (mg kg^{-}1soil) = [0.02 mol/L – (a+b*Abs)] *(9000mg C/ mol)* (0.02 L solution/Wt)]

Where: 0.02 mol/L = initial solution concentration a= slope of the standard curve

Abs= absorbance of unknown

9000= milligrams of carbon oxidized by 1 mole of MnO4 changing from Mn^{+7} - Mn^{+4}

0.02=volume of stock solution reacted

Wt= weight of air-dried soil sample in kg is used to convert sample absorbance value to active C in units of mg carbon per kg of soil (Steve Culman).

12. Pitfall trap: Invertebrates that travel about on the soil surface are captured by Pitfall traps (epigaeic). The simplest pitfall trap can be made from a glass jar or a plastic food container. To install a pitfall trap, dig a hole in the ground, and place the container into the hole so that the edge of the container is level with the ground surface. Carefully fill the gap around the container with soil, creating a level surface. A small amount of fluid is added to maintain the container to kill and maintain any animal that is located in - for this purpose, ethylene glycol (car antifreeze) can be used. Keep in mind, however, that ethylene glycol is toxic to people and is often fatal to cats and dogs, so propylene glycol or alcohol are safer options. A cover-type needs to be backed up by a trap to keep it from the rain if the trap is left unattended for a long time, as the rainwater will dilute the fluid retention and may even fill the trap completely (Les Firbank; et al 2010).