

THE PRODUCTIVITY AND MANAGEMENT OF GHANAIAIAN SOILS



SAMUEL G.K. ADIKU

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Soil Productivity Management in Ghana

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Over decades we have longed for a book that related the scientific principles of soils to the Ghanaian context. Most of the textbooks were written by foreign authors with little or no data on soils from Ghana. Our reading and understanding about soils were abstract. This book fills this great vacuum with data from the soils in Ghana. The book will enhance the capacity in solving the peculiar problems of soils in our ecological zones. The book takes the reader not only through the knowledge of soils but also the related edaphic properties which directly or indirectly impact soil productivity.

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To
*My dear wife, Edem and children, Kofi, Selase and Senyo, for their support
throughout my academic career and also through the difficult and bumpy moments on
this journey.*

..." And a sower went to sow and as he sowed, some seeds fell on stony soils, where there was not good soil. They sprang up quickly but when the sun was up, **they were scotched** because they had no root and withered away. But some fell on **good ground and yielded a crop, some hundred-fold, some sixty, some thirty** (Matt 13: 3-9)".

The seed may be good, but the soil determines the growth and yield!

"The soil comes first. It is the basis, foundation of farming. Without it, nothing, poor soil poor farming, poor living: with good soil, good farming and living. An understanding of good farming begins with the understanding of the soil". Henry L. Ahlgren, Grass: Yearbook of Agriculture, 1948. US Department of Agriculture. P. 425.

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Preface and Acknowledgments

Agriculture continues to contribute significantly to the development, employment and Gross Domestic Product (GDP) of most tropical African countries such as Ghana. The connection between agricultural productivity and soil productivity is, however, not obvious to many, even if there is some recognition of soil productivity decline over the years. The common notion that fertilizer application and improved seeds alone would resolve all soil productivity deficiencies is not valid because the many years of fertilizer application and improved seed policy have not increased crop yields substantially in Africa. Thus, a re-visit of the soil productivity problem and a re-assessment of the productivity dynamics of tropical soils is necessary.

My motivation to write this book stemmed from the desire to collate, as much as possible, the available information (both published and in grey literature) on Ghana's soils into a volume and analyze the changes that have occurred over time. Great emphasis is laid on the quantitative estimation of productivity indices. It is also an aim of the book to review the management technologies that are feasible for the adoption at farmer level to sustain soil productivity. The book is targeted at tertiary-level agricultural and environmental science students, drawing on examples from Ghana that readers can immediately relate to. The content of this would also benefit readers in similar tropical regions within West African and beyond.

I would like to express my gratitude to my colleagues for their encouragement and support. I would like to thank especially Drs. Dilys S. MacCarthy, Samuel K. Kumahor, and the external reviewer, for their detailed review and critical comments. I would also like to thank the Alexander von Humboldt Foundation, Germany, which funded several short-term research visits to Germany to work and complete this book. The Building of Stronger Universities (BSU) Project of the University of Ghana, supported by DANIDA enabled the production of this book as an E-book. I acknowledge their support.

Professor Samuel G.K. Adiku

Foreword

I am delighted to write the foreword for this book “the Productivity and Management of Ghanaian soils” by Professor SGK Adiku. Over decades ago, when Prof. Adiku taught us Soil Physics in the University, we longed for a book that related the scientific principles to soils in the Ghanaian context. Most of the textbooks were written by foreign authors with little or no data on soils from Ghana. Our reading and understanding about soils were abstract. This book fills this great vacuum with data from the soils in Ghana. The book will enhance the capacity in solving the peculiar problems of soils in our ecological zones.

In order to make the soils productive and maximize their productivity, an understanding of the features of the soil properties is needed. The soil is linked and it interacts with crop/animal production, climate, and many other disciplines. Without a good management of the soils, there will always be crop and animal production failure, which is obvious in many African countries. Indeed, the knowledge of the soil comes first, as it provides the first foundation for sustainability of life on the planet earth.

The book takes the reader not only through the knowledge of soils but also the related edaphic properties which directly or indirectly impact on soil productivity. Each chapter begins with the learning objectives, the soil science principles, followed by local case problems, linking the soil properties to productivity, a summary, and finally an opportunity to challenge the reader in applying the principles to certain pertinent problems.

Prof. SGK Adiku, who is also an Alexander von Humboldt Scholar and a systems modeler has modeled several components of the soil-plant-climate system. Modeling involves putting various parts of the system together to form a whole. Therefore, it is not surprising that Prof. SGK Adiku was able to bring various pieces of hidden soil knowledge together to help us improve soil productivity. As an environmental soil scientist, I find the book useful and would adopt it for my class, to challenge my students in relating the soil science principles to local problems.

This book is not only for soil scientists or those intending to become one. It is a must read for agronomists, environmental scientists, animal scientists, atmospheric scientists and policy makers. I welcome this book and it is my expectation that it would serve as a reference material for all those who care about the deteriorating condition of the soil and have the desire to improve it. I encourage you to buy it, read and keep it, as it would always come handy.

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Chapter 1: What is Soil Productivity?

Objectives

The purpose of this chapter is to introduce readers to the concept of soil productivity and how it is affected by management within the tropical African and Ghanaian contexts. Readers will learn about the fragility of tropical soils and the need for soil productivity maintenance. Traditional and some modern methods used to manage soil productivity and their limits of success are discussed. A holistic approach to soil productivity management in the tropics is presented.

Soil Productivity within the Tropical and Ghanaian Context

Soil productivity is a composite term that describes the function of the soil to support plant growth. The term encompasses chemical/fertility, biological and physical properties of the soils. A productive soil is one that provides satisfactory anchorage to plants, has appreciable available water capacity, withstand disruptive forces (e.g. raindrop impact, soil entrainment, animal trampling and heavy machinery compaction), has abundant nutrients and can support microbial activity.

Soil productivity changes with time because soil properties change with the type of management practices. Poor management leads to rapid deterioration of soil productivity and degradation of the soil. Once degraded, the restoration of soil productivity is often a difficult task. Hence, it is advisable to minimize soil productivity decline for sustained agriculture.

To understand the concept of soil productivity, we need to note that soils are the outer unconsolidated materials found on the upper surface of the earth. The thickness of soils is often not more than 3 m. It is comparable to the skin of an orange fruit relative to the size of the whole orange. Soils are formed when rocks weather and their formation process is very slow, often taking hundreds of years to “create” 1 cm of soil. Soils are not uniform in space.

The differences in soil types from place to place can be explained in terms of 6 main factors, often termed the “factors of soil formation”. These are (i) parent material, (ii) climate, (iii) vegetation, (iv) relief, (v) time and (vi) biological activity or management. Therefore, soil productivity also varies from location to location. Depending on the intensity of the factors and the way they interact, some soils lose their productivity faster than others. Therefore, tailored management of soils becomes essential in many cases.

Exhibit 1.1: Soil Productivity Concept

1. Soil productivity is a COMPOSITE term that unifies various PROPERTIES of the soil to describe the productive function. Soil properties can be chemical, biological and physical.
2. Soil chemical and fertility properties include pH, organic matter content, cation exchange capacity, nitrogen, phosphorus, potassium, among others.
3. Soil biological properties include microbial biomass and activity, and earthworm activity.
4. Soil physical properties include structure, water retention ability, aeration.

The Productivity Problem of Tropical Soils.

The rapid decline in the productivity of tropical soils, once cleared for cultivation, is of major concern, because it adversely affects food security. African soils are particularly fragile and under the very harsh environment (e.g. high rainfall intensities, high temperatures), sustained productivity is often not achieved. The link between African soil productivity and food security has been highlighted in many reports. For example, the March 2009 edition of the *Crops, Soils and Agronomy News* carried an article titled: "*African Soils: The Root of the Problem*". Drawing on observations and remarks by eminent experts, the following were highlighted:

- (i) African soils are among the poorest in the world.
- (ii) Fifty-five percent (55%) of the land in Africa is unsuitable for any kind of cultivated agriculture except for nomadic grazing (Bationo et al., 2006).
- (iii) The African continent loses the equivalent of more than US\$4 billion worth of soil nutrients annually, severely limiting its ability to feed itself.
- (iv) Across the continent, farmers face a range of constraints including low productivity, limited access to new agricultural technologies, among others, and
- (v) Increased agricultural production in Africa can be largely attributed to increased cultivated land acreage. This approach is not effective because no region of the world has been able to expand agricultural growth rates and thus tackle hunger, without increasing soil inputs and sustaining productivity.

Other such reports include that by Sanchez and Swaminathan (2005) who discussed the problem of African soils and their inability to feed the rapidly growing population under the title "*Hunger in Africa: the link between unhealthy people and unhealthy soils*". The article established a linkage between the generally poor health of the African people and the poor and degraded state of the soils. The article suggested some interventions that could help "heal" the African soils. Another example was by Adiku and Jones (2008) under the title "*Hungry Soils, Hungry People*".

The fragility of tropical African soils and their propensity to degrade rapidly following conversion to agriculture due to poor management was the theme of the 11th Annual General Meeting of the Soil Science Society of Ghana in 1988. The keynote speaker, Professor D.K. Acquaye re-iterated that the introduction and misuse of heavy agricultural machines by tropical African country Governments as the main component of mechanization drive, which led to the "*sweeping*" away of the top soil that holds much of the soil organic matter (the life-blood of soils) and the smaller mineral particles, leaving behind

a barren and unproductive landscape. Severe soil erosion which accompanies the poor management of African soils leads to drastic productivity loss. Soil erosion studies in Ghana show loss rates ranging from 3.2 ton/ha/yr when the soils were cultivated to leguminous plants such as canavalia, cowpea and groundnut to 11.2 ton/ha/yr on bare soils (Quansah et al 1988). Data by Bonsu et al., (1997) also showed that more than 12 t/ha/yr soil erosion has been recorded on some ferric Acrisols in the semi-deciduous forest zones of Ghana

Cumulatively, such high erosion rates will adversely affect crop yields. Data by Lal (1983) indicated that the application of high fertilizer rates of 120 kg N/ha to a 20-cm de-surfaced Alfisol in Nigeria could still not produce maize yield beyond 700 kg/ha, whereas the application of the same rate to the “un-eroded” soil yielded as much as 2600 kg/ha. Diao and Sarpong (2007) estimated that land degradation via soil erosion reduced agricultural income in Ghana by a total of US\$4.2 billion over the period 2006–2015, which was approximately five percent of total agricultural Gross Domestic Product (DP) in these ten years. Stocking (2003) observed drastic reductions in crop yields in Nigeria from 4000 to 1500 kg/ha by the time the cumulative soil erosion reached about 200,000 kg/ha (an average of 20000 kg/ha/yr). Such soil losses could occur within 4 to 5 years of cultivation.

Exhibit 1.2: The Productivity Problem

1. Tropical soils are fragile and lose their productivity quickly once converted to agriculture.
2. Increasing agriculture output via increased land acreage is not a sustainable way of agriculture.
3. Heavy agricultural machinery is not necessarily suitable to tropical soil cultivation. This approach leads to severe soil erosion and drastic crop yield decline.
4. There appears to be an erroneous view that the tropical soils are naturally fertile because the environment (temperature, humidity) allows the easy growth of crops. This popular view is, however, not supported by scientific data.
5. Soil productivity loss has severe consequences for the national GDP.

Managing Soil Productivity in the Tropics

Farmers in tropical Africa are aware of the fragility of the soils and therefore, have traditionally used shifting cultivation as a land rotation system to regulate the soil productivity decline. In a typical shifting cultivation practice, the land is cleared of original vegetation, cultivated for short period of time while the inherent productivity lasts (often not exceeding 2 to 4 years) and then left fallow to regain its productivity. Tillage was by slash and burn and planting by sticks. Though bush burning is generally undesirable, there is minimal disturbance of the soil structure. Fallow periods tend to be very long, often 15 to 25 years (Sanchez, 1976). Farmers fully recognized the fact that the inherent land productivity of tropical soils is short-lived, and regeneration of productivity requires long periods (Fig. 1). The shifting cultivation practice was appropriate in low populated communities, where pressure on land was also low, so that access to new land is easy. The major goal was to primarily meet the family food needs.

The traditional shifting cultivation system, however, fails in the current situations, not only because of rapid population rise and the consequent pressure on land, but also because the high rural-to-urban migration requires that the food requirements of the large proportion of non-agricultural urban population must be met. In effect, fallow periods must reduce to increase the production cycle (Fig. 1) or agricultural lands must be continuously cultivated. With no external inputs and appropriate soil management, soil productivity declines rapidly, and crop yields are adversely affected. A holistic multifaceted approach is required for the prevention of the rapid productivity decline of tropical soils. Some suggestions are given below:

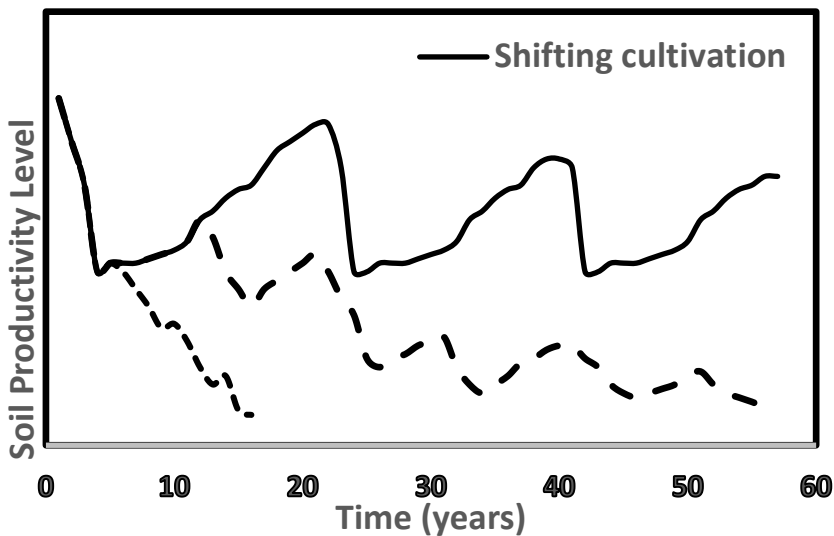
First, a soil productivity management system must be developed. In so doing, all the aspects of the soil, physical, chemical, biological and biochemical aspects must be considered in developing the management practices. For soil productivity sustenance, the soil must provide nutrient to plants, provide favourable physical medium in which plant roots can grow, water and nutrients can be stored and transported, and micro-organisms are able to decompose organic materials to release nutrients (FAO, 1994). To achieve this, the very high rates of erosion must be minimized at all times through the constant maintenance of soil cover.

Second, the use of external inputs (fertilizers and other agro-chemicals) must be optimized to reduce the mining of soil nutrients and fertility decline. Estimates by Sanchez et al. (2009) indicated that the average rate of fertilizer application in tropical Sub-Saharan and tropical areas in the last decades was about 10 kg/ha. In the case of Ghana, Benin et al. (2013) observed fertilizer application rising from 8 kg/ha to 13.4 kg/ha. More recent assessments indicate a further increase in fertilizer application to 30 kg/ha on some small-scale farms (MacCarthy et al., 2017). These application rates are

still far lower than recommended rates of 60 kg N/ha by the Ministry of Food and Agriculture (MoFA). While promoting fertilizer use, attention must also be paid to possible environmental consequences and the fact that when soils are severely eroded, high fertilizer applications do not necessarily lead to crop response (Lal, 1983).

Third, a good soil management policy that maintains soil organic matter and biological activity must be spearheaded.

Fig 1.1: Schematic representation of soil productivity cycles under different soil management systems



Summary

This opening chapter presented and discussed the concept of soil productivity, especially as it pertains to tropical African context. Soil productivity was defined as a term that relates to the soil's ability to function, e.g. to support plant growth. The soil productivity was described in terms of three components: the physical, chemical/fertility and biological, and it was noted that the productivity is not a permanent feature, but changes, depending on the way the components are managed. It has been indicated that Ghanaian and African soils are fragile, and their productivity declines quickly, once natural forest lands are cleared for agriculture. It was highlighted that though tropical farmers are aware of the fragility of their soil, their age-old farming system described as shifting cultivation has become somewhat ineffective in sustaining soil productivity, largely because increased population pressure has reduced fallow periods. Soil productivity loss has economic and food security

consequences. Addressing the soil productivity decline problem requires a holistic approach. This may include reduction of erosion, optimizing the use of external inputs and the development and implementation of soil management policy.

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Chapter Review

Review Question 1

Review the literature on the tropical soil productivity problem for the West African countries of Ghana, Nigeria, Sierra Leone and Liberia. What are the similarities and differences with respect to the solutions adopted by the Governments?

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Review Question 2

Review the article by Bationo et al. (2006) (see reference above). Can African soils be considered as scarce resources?

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Chapter 2: Physiography and Distribution of Soils in Ghana

Objectives

This chapter presents the major ecological zones of Ghana and the types of soils that occur in these zones. The learning outcome is to understand how soil forming factors determine the distribution of the soils in Ghana. Also, the important soil properties that determine the productivity of the different soils are discussed.

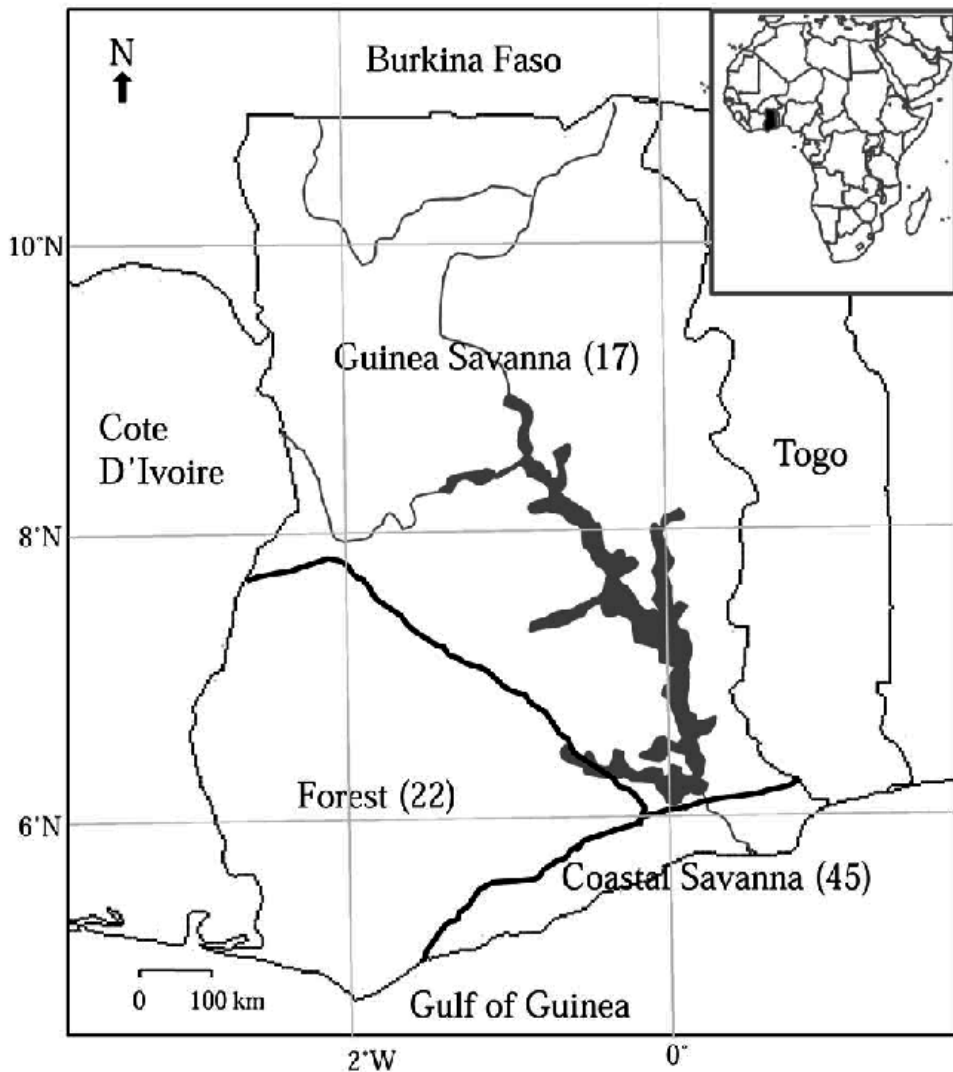
What are the Ecological zones of Ghana?

The country Ghana lies on the West African coast covering a total land area of 240 000 km². The total land is distributed among several land use types. According to Asare (1990), forest reserves constitute 11%, wildlife reserves: 5%, unreserved humid forest: 2%, savannah woodland: 30%, tree crops: 7%, annual crops: 5 %, unimproved pastures: 15%, and bush fallow and other uses: 25%. Except for the reserved portions which constitute 16%, some forms of farming are carried out on the rest of the 84%. Under the current situations, farming has encroached even into reserved lands. Forests play vital roles in maintaining the ecosystems through the provision of varied ecosystem services such as biodiversity, biomass, water supply, water quality, air quality, disease mitigation and carbon sequestration, among others. Unfortunately, these contributions have not been properly quantified within cropland-forestland systems. Thus, expansion of croplands into forest areas continue without taking account of the losses of these ecosystem services.

The various land use types are found in two broad ecological zones, namely: (i) the high or closed forests and (ii) the open savannahs. Further subdivisions can be made leading the recognition of 4 major agro-ecological zones, described briefly as follows:

- (i) The wet evergreen forest, largely found in the south-western zones, receiving rainfall between 1500 and 2000 mm. A typical location is Axim (Plate. 2.1)
- (ii) The moist semi-deciduous forest located in the south-middle zones of the country, receiving from 1500 to 1750 mm rainfall. Typical locations are Kumasi and Tafo.
- (iii) The dry semi-deciduous zone or forest-savannah transition zone which lies to the north (Sunyani) and to the east (Donkokrom, Kpeve) of the moist evergreen and moist semi-deciduous zones. Annual rainfall ranges between 1000 and 1750 mm.
- (iv) The savannahs, which are classified into (a) Guinea savannah (Tamale, Wa) with rainfall between 900 to 1200 mm, is located to the north and north-west of the transition zone, (b) Sudan savannah (Navrongo, Bawku) with rainfall of 1000 mm, located at the north-east of the Guinea savannah and (c) the coastal savannah (Accra, Akuse, Keta) with rainfall of 600 to 1000 mm, located at the southern coastline of the country.

Plate 2.1: Map showing the some of the major ecological zones of Ghana.



(Source: <https://www.google.com/search?q=agroecological+zones+of+Ghana+Images>).

Temperature variation over the entire country is less in comparison to rainfall. The average temperature of the southern locations is 28 °C while that of the northern locations is 33 °C.

Exhibit 2.1: Ecological Zones of Ghana

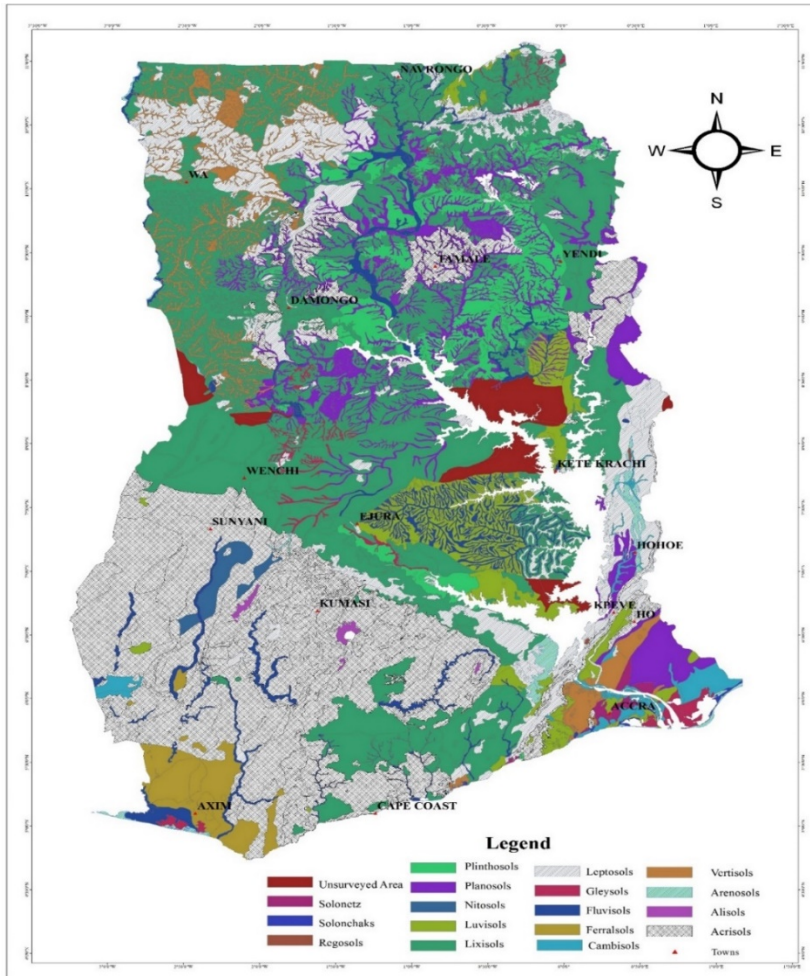
1. Four major ecological zones can be found in Ghana.
2. The savannah zones are found along the southern coastal areas and the interior northern areas. The savannah vegetation is wooded grasslands.
3. Rainfall is highest in the south-west where the vegetation is largely tropical rain forest.
4. The ecology of the middle belt is semi-deciduous forest and forest-savannah transitions.
5. Temperature variation over the country is far less than rainfall variations.

Distribution of Soils in Ghana

The different types of soils found in the country are linked to the ecological zones in which they occur. The soil types reflect the combined effect of soil forming factors such as climate, parent material, vegetation, relief, biological activity, among others. Much of the survey and descriptions of Ghanaian soils can be found in texts by Brammer (1959) and other memoirs of the Soil Research Institute, Kumasi, Ghana. A general soil map of Ghana is presented in Plate. 2.2 and a summary of soil types at different locations is given in Table 2.1.

Moving from north to south, several different types of soils can be encountered. Typically, soils of the Sudan savannah (Navrongo, Bawku) are classified as Plinthosols according to the FAO-UNESCO (1988) nomenclature and are yellowish-brown in colour. A typical example is the *Kpelesawgu* series. These soils develop from iron-rich parent materials and are typically coarse-textured with sand reaching 70 % in the top soils (35 cm thickness) but declining to 15 % at lower depths. The pristine soils are deep reaching 250 cm with medium pH decreasing from about 6.6 at the top to 4.5 at lower depths. Organic matter is high in top of the pristine soils (1.9 %) but declines sharply to 0.1 % below 50 cm. However, once cultivated, the soils undergo severe erosion, losing much of the top soil.

Plate 2.2: Soil map of Ghana (Source: Soil Research Institute, CSIR, Ghana).



Soils of the northern Guinea savannah (Tamale) are classified as Ferric Acrisols (FAO nomenclature, 1988). Typical examples are the *Nyankpala* series (found in Tamale) and *Changnalili* series (found in Yendi) and *Wa* series (found in Wa). These soils are shallower with pristine soils reaching up to 150 cm. The top soils are only 15 cm thick with sand reaching between 65 to 70 % and declining to about 30 % at lower depths. Organic matter is high in the tops of the pristine soils reaching 2.3 %, reducing sharply to 0.14 % at lower depths. When cultivated, the top soil is rapidly lost exposing the iron rich subsoil that forms nodules or concretions with subsoil hard iron pans. The organic matter

content is low in these cultivated soils (less than 0.5 %) and the soil depths hardly exceeded 50 cm.

The forest-savannah transition zone carries soils that are developed over sandstones but can be differentiated by drainage. Generally, they form shallow concretionary soils at the savannah locations but deep soils in the forest areas. Examples include *Damongo* series which carries tall grass vegetation interspersed with trees with depths reaching almost 300 cm. The sand content reaches 90 % in the top soils, decreasing slightly to 79% at lower depths. Organic matter content is generally low even at the top (1.1 %) reducing to 0.1 % at lower depths. Soil pH is neutral in the top (7.3), reducing to about 5.8 at lower depths. These soils remain deep even under cultivation. Another example is *Ejura* series, which is somewhat shallower (250 cm) but well-drained. Iron concretions are found only in the deep subsoils.

The soils of the semi-deciduous forest zone are classified as Ferric Acrisols and develop from granite, phyllites and sandstones. They are often deep reaching 300 cm. A typical example is *Kumasi* series that has dark reddish brown colour at the top. The top soil is about 20 cm in the pristine state and has iron concretions increasing with depth, especially in the subsoil. Sand content in the top soil is about 60% decreasing gradually to 56 % at lower depths. The soil pH of the top soils is generally low (4.4), increasing gradually to 5 at lower depths. The organic matter in the top of pristine soils is very high reaching 8 %, but declines sharply to about 0.3 % at lower depths.

The soils of the evergreen tropical rain forest are classified as Oxisols. They are very deep reaching more than 300 cm in the pristine state. They are often well-drained and well aggregated but have low pH ranging from 4.5 to 5.5. Typical examples include the *Ankasa* series. Due to the high rainfall regimes, the soils are exposed to erosion, once cleared. However, good plant cover is maintained even under agriculture since plantation crops (plantains/bananas, cash crops (cocoa) and other tree crops dominate the practice.

Table 2.1: Physiography and Soil Types of Some Selected Sites in Ghana

Ecological Zone	Location	GPS Coordinates	Soil Series	Rainfall (mm)	Vegetation	Relief	Soil Classification
Sudan Savannah	Walewale	11°3'N 0°14'E	Kpelesawgu	937	Wooded-grassland	Gentle undulating	Eutric & Dystric Plinthosol (Groundwater laterites)
Interior savannah	Wa	10°4'N 2°30'W	Kaleo	1097	Wooded Grassland	Gentle undulating	Haplic Lixisol
Interior savannah	Tamale	9°24'N 0°59'W	Nyankpala	1073	Wooded Grassland	Gentle undulating	Ferric Acrisol (FAO)
Interior Savanna	Damongo	9°5'N 1°49'W	Damongo	1200	Wooded-grassland	Gentle undulating	Savanna Ochrosol (Ferric Lixisol)
Semi-deciduous	Wenchi	7°20'N 2°20'W	Wenchi	1300	Forest-savannah transition	Hilly	Ferric-Dystric Leptosol (FAO)
Semi-deciduous	Kumasi	6°40'N 1°37'W	Kumasi	1500	Forest	Hilly	Forest Ochrosol (Orthi-Ferric Acrisol)
Semi-deciduous	Kpeve	6°41'N 0°20'E	Ziwai	1300	Forest-savannah transition	Hilly	HaplicLixisol
Rain Forest	Axim	4°52'N 2°14'W	Boi	2500	Forest	Hilly	Forest Oxysol

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Coastal Savannah	Accra	5°33'N 0°12'W	Toje	900	Wooded-grassland	Flat	Savanna Ochrosol
Coastal Savannah	Akuse	6°06'N 0°08'W	Akuse	900	Wooded-grassland	Flat	Vertisol/Tropical Black Earths
Forest-savannah Transition	Donkokrom	7.04° N 0.079° W	Ejura	1400	Forest-savannah	Gentle undulating	Haplic Luvisols (FAO)

The soils of the coastal savannah zone are dominated by the Vertisols, but patches of Acrisols can also be found. Typical example of the Vertisol is the *Akuse* series, a heavy dark clay formed from garnetic-ferrous hornblende gneiss parent material. Sand content is low in the top soils (33 %) increasing to 70 % at lower depths. The pH is neutral, with an average of 7.4 within the profile. The organic matter content is low, ranging from 0.9 % in the top down to 0.2 % at lower depths. A typical example of the coastal savannah Acrisols is the *Toje* series, which is reddish in colour developed over tertiary sands. It has a loamy texture and is well-drained, devoid of concretions. The sand content averages 80 % within the profile. The pH is medium, ranging from 6.5 at the top, increasing to 8.5 at lower depths. The organic matter content is very low, ranging from less than 0.5 % at the top down to 0.1 at lower depths.

Other patches of soils in the coastal savannah include the *Keta* series, derived from tertiary sands and located directly on levees and beaches of the Gulf of Guinea. These soils have some agricultural significance in that they are used intensively for vegetable production when manure is applied. Details of the soil profile characteristics for some selected soils in the various agro-ecological zones are given in Table 2.2.

Exhibit 2.2: Some Properties of Ghanaian Soils

1. The major different types of soils in Ghana reflect the effect of climate, vegetation, and parent material.
2. The soils can be described in terms of properties such as pH, organic matter content, texture (% sand, %silt, % clay), soil depth, presence of iron concretions, among others.
3. Most forest soils are deep and well-drained and have low pH.
4. Cultivation of the soils leads to soil organic matter decline and reduction in soil depth due to erosion.

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Walewale: Sudan savannah, <i>Kpelesawgu</i> series								Damongo: Forest-savannah transition, <i>Damongo</i> series							
Depth (cm)	% Sand	% Silt	% Gravel	pH	BD (g/cm ³)	OM %	CEC me/100g	Depth (cm)	% Sand	% Silt	% Gravel	pH	BD (g/cm ³)	OM %	CEC me/100g
10	70.3	21.0	-	6.7	-	1.86	6.26	13	91.9	3.0	-	7.3	-	1.07	4.23
23	68.4	21.4	-	6.2	-	1.07	8.58	30	92.0	3.5	-	7.4	-	0.60	2.46
33	63.4	20.8	-	5.8	-	0.71	6.32	53	92.0	3.0	-	7.2	-	0.24	1.36
53	49.9	25.5	-	5.7	-	0.67	5.04	85	91.5	3.5	-	6.4	-	0.28	2.32
120	41.6	22.2	-	6.0	-	0.31	8.63	130	84.9	4.6	-	6.0	-	0.41	4.38
165	30.9	23.7	-	5.8	-	0.17	9.55	188	73.0	4.0	-	5.7	-	0.24	4.48
205	25.9	25.7	-	5.2	-	0.15	10.52	227	68.8	5.5	-	5.7	-	0.15	-
232	18.4	28.4	-	4.6	-	0.14	28.77	280	69.2	5.5	-	5.8	-	0.10	-
260	14.9	36.7	-	4.5	-	0.12	-	-	-	-	-	-	-	-	-
Accra: Coastal savannah, <i>Toje</i> series								Kumasi: Semi-deciduous forest, <i>Kuamsi</i> series							
Depth (cm)	% Sand	% Silt	% Gravel	pH	BD (g/cm ³)	OM %	CEC me/100g	Depth (cm)	% Sand	% Silt	% Gravel	pH	BD (g/cm ³)	OM %	CEC me/100g
10	96	4	-	6.5	-	0.31	3.33	7	59.5	13.1	-	4.4	-	8.0	12.25
20	89	11	-	6.8	-	0.15	1.92	11	75.3	8.8	-	4.6	-	1.89	3.97
30	89	5	-	6.9	-	0.08	1.90	18	65.6	11.4	-	4.5	-	1.08	4.07
40	86	14	-	6.3	-	0.09	3.85	23	52.6	13.2	-	4.5	-	1.10	5.14
50	77	23	-	6.8	-	-	6.58	46	43.4	11.5	-	4.7	-	0.95	4.17

60	68	33	-	6 . 9	-	-	14.6	70	38 .6	11 .4	-	4 . 0	-	0. 65	4.83
70	62	38	-	7. 4	-	-	14.1	87	38 .5	13 .5	-	4 . 0	-	0. 76	4.96
80	90	10	-	8 . 8	-	-	9.4	114	36 .4	19 .2	-	5. 1	-	0. 69	4.51
90	-	-	-	-	-			151	38 .6	21 .4	-	5. 2	-	0. 60	5.25
100								238	24 .0	2 4	-	5. 2	-	0. 60	3.29

Table 2.2: Profile Data for some Soils of Ghana

(Source: Brammer, 1959). OM = 1.72 * OC; BD = Bulk density; CEC = cation exchange capacity; - = Not reported

Summary

Several different ecological zones can be found in Ghana. The typical ones include the savannahs, forests and forest-savannah transitions. Though the soils classified as Acrisols appear to dominate the Ghanaian landscape, there are many other types as depicted by Plate 2.1. Ghanaian soils are largely coarse-textured and lose their organic matter and productivity rapidly when the pristine lands are cleared. The extent and rate of deterioration of soil productivity will depend on harshness of the environment, the sensitivity of the soils to environmental stresses and the types of management. Minor patches of clayey soils and salt-affected soils can be found in the southern coastal savannah zones. The large differences in soil types and properties suggest that no single blanket management type may be applicable to all of them.

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Chapter Review

Review exercise 1

Study Fig. 2.1 (Soil map of Ghana) and indicate the 3 most common soil types in Ghana and the ecological zones where they are found.

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Review Question 2

Study the profile data for the soils given in Table 2.2. Indicate the agroecological zones where they are found. What can you say about the following?

- (i) Differences in soil depth among the locations,
- (ii) Variation of soil texture with depth, and
- (iii) Distribution of soil organic matter with depth.

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Chapter 3: Manifestations of Soil Productivity Change

Objectives

This chapter discusses the various ways in which soil productivity changes are manifested in agricultural fields. The chapter also introduces the methods and concepts for assessing soil productivity change. In particular, the procedure for determining the composite Soil Productivity Index (*SPI*) is presented and applied to some soils for illustration.

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THE PRODUCTIVITY AND MANAGEMENT OF GHANAIAN SOILS

Agriculture continues to contribute significantly to the development, employment and Gross Domestic Product (GDP) of most tropical African countries such as Ghana. The connection between agricultural productivity and soil productivity is, however, not obvious to many, even if there is some recognition of soil productivity decline over the years. The common notion that fertilizer application and improved seeds alone would resolve all soil productivity deficiencies is not valid because the many years of fertilizer application and improved seed policy have not increased crop yields substantially in Africa. Thus, a re-visit to the soil productivity problem and the re-assessment of the productivity dynamics of tropical soils is necessary.

My motivation to write this book stemmed from the desire to collate, as much as possible, the available information (both published and in grey literature) on Ghana's soils into a volume and analyze the changes that have occurred over time. Great emphasis is laid on the quantitative estimation of productivity indices. It is also an aim of the book to review the management technologies that are feasible for the adoption at farmer level to sustain soil productivity. The book is targeted at the tertiary level agricultural and environmental science students, drawing on examples from Ghana that readers can immediately relate to. The content of this would also benefit readers in similar tropical regions within West African and beyond.

The author, Prof. Samuel G.K Adiku is a professor of Soil Science at the University of Ghana. Prof. Adiku has researched and published extensively in many areas of soil and agronomic sciences, authoring or co-authoring more than 80 journal and edited technical papers. He has edited one book on "Climate Change, Variability and Biophysical Landuse in Ghana" which was published in 2019.

Prof. Adiku has served the University of Ghana in many administrative capacities such as Head of Soil Science, Vice-Dean of the Faculty of Agriculture, Chairman of the Volta Basin Research Project, and Director of the Academic Quality Assurance Unit.

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