5-2013

Adaptation of Regional Representative Soil Project and Soil Judging for Cameroon

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ADAPTATION OF REGIONAL REPRESENTATIVE SOIL PROJECT AND SOIL JUDGING FOR CAMEROON

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Forest Resources

by
Celestine Akuma Che
May 2013

Accepted by:
Dr. Elena A. Mikhailova, Committee Chair
Dr. Christopher J. Post
Dr. Tom O. Owino
Dr. Mark A. Schlautman
ABSTRACT

Representative regional soils have agricultural, cultural, economic, environmental, and historical importance to Cameroon. Twenty seven regional representative soils have been identified in Cameroon. A set of laboratory exercises, assignments and exam questions have been developed utilizing the Regional Representative Soil Project (RRSP) that gives students an opportunity to practice interpretation of soil series descriptions, taxonomic classes, soil forming factors, and soil physical and chemical properties. The RRSP can be further enhanced and complemented with Soil Judging. Conventional soil judging as practiced in the United States has been adapted for Cameroon by a graduate student from that country using an undergraduate-level Soil Judging course taught at Clemson University together with a regional, multi-state soil judging competition. Over the course of the study, the student from Cameroon has received training on 4 of the 8 soil orders that are present in Cameroon and also encountered in the Southeastern United States. A Southeastern Region Soil Judging Handbook has been used as a guide for the development of teaching materials (tables of soil physical and chemical properties, and scorecards) for Cameroon. Adaptation of soil judging to Cameroon requires the use of geospatial technologies (e.g. global positioning system (GPS), geographic information system (GIS) and many others) to develop geospatial materials to support potential adaptation of soil judging in Cameroon. Soil map developed by the Food and Agriculture Organization (FAO) of the United Nations, Forest Atlas of Cameroon, and Cameroon digital elevation model (DEM) were used to develop teaching materials. Step-by-step instructions have been provided to prepare the spatial soil judging teaching materials.
using ArcGIS for Cameroon. Spatial soil judging teaching materials include locations of existing soil pits, topographic maps, slope, and aspects maps. Both RRSP and Soil Judging can be incorporated into Earth Science curricula in secondary and high schools as well as bachelor’s degree programs at the university-level. With time, the knowledge gained from this project will help land managers and farmers make proper use of their land. As the project expands, it is expected that a GIS soils database and related attributes from the different regions will be used to build a soils information system database for Cameroon.
DEDICATION

To my wife Elfriede M. Akuma, my daughters Danielle N. Akuma and Gabrielle N. Akuma for your tremendous sacrifices, support and constant love. Also to my parents Joseph and Nathalia Akuma, thank you for giving me the chance to be what I am today.
ACKNOWLEDGEMENTS

I would like to thank my wife Elfriede Akuma and daughters Danielle, and Gabrielle Akuma for their unwavering love, support and many sacrifices throughout my Ph.D. degree program.

Financial support for this project was provided by the Clemson University Diversity Scholarship Fun, Fulbright Scholarship Award by U.S. Department of State to Foreign students and Dr. Joseph D.Culin. I would like to thank the following individuals for their friendship and assistance: Steven Ham, Brian Ritter, Russel Buchanan, Sam Esswein, Ryerson Pamplin, Carolyn Wakefield, Heather Irwin, Dr. Frankie O. Felder, Dr. Joseph D. Culin, Dr. Patricia Layton, Dr. John Rodgers, Dr. Ron Johnson, Dr. Greg Yarrow, Ben Willis, Lavonne Sloop, Tammy Morton, Dr. P.M. Oben, Dr. Benedicta Oben, Mr. and Mrs. Koi Christopher, Mr. and Mrs. Tenjoh Lawrence, and Mr. and Mrs. Gwanmessia. I am grateful for the support of my siblings and relatives both in Cameroon and abroad: Callistus A. Akuma, Miranda B. Ntoko, Branda M. Akuma, Terese F. Akuma, Kenneth N. Akuma, Dr. Justin C. Konje and Terence C. Konje. I want to say a big thank to my employers SIRDEP Bamenda Cameroon and to my church family in Cameroon and the USA.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>TITLE PAGE</th>
<th>ABSTRACT</th>
<th>DEDICATION</th>
<th>ACKNOWLEDGMENTS</th>
<th>CHAPTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>.................................................................</td>
<td>.................................................................</td>
<td>.................................................................</td>
<td>.................................................................</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>ii</td>
<td>iv</td>
<td>v</td>
<td></td>
</tr>
</tbody>
</table>

## CHAPTER

### I. INTRODUCTION

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Introduction</th>
<th>Materials and Methods</th>
<th>Results and Discussion</th>
<th>Conclusions</th>
<th>References</th>
<th>Appendix A</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>7</td>
<td>10</td>
<td>12</td>
<td>16</td>
<td>17</td>
<td>21</td>
</tr>
</tbody>
</table>

### II. REGIONAL REPRESENTATIVE SOIL PROJECT FOR CAMEROON

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Introduction</th>
<th>Materials and Methods</th>
<th>Results and Discussion</th>
<th>Conclusions</th>
<th>References</th>
<th>Appendix A</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>39</td>
<td>46</td>
<td>50</td>
<td>54</td>
<td>56</td>
<td>62</td>
</tr>
</tbody>
</table>

### III. ADAPTATION OF SOIL JUDGING FOR CAMEROON

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Introduction</th>
<th>Materials and Methods</th>
<th>Results and Discussion</th>
<th>Conclusions</th>
<th>References</th>
<th>Appendix A</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>77</td>
<td>79</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### IV. APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) TO SOIL JUDGING IN CAMEROON

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Introduction</th>
<th>Materials and Methods</th>
<th>Results and Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>77</td>
<td>79</td>
<td>80</td>
</tr>
</tbody>
</table>
Conclusions........................................................................................................86
References........................................................................................................87
Appendix A.....................................................................................................90

V. CONCLUSION.............................................................................................113
CHAPTER ONE

INTRODUCTION

The educational system in Cameroon is unique for Africa, consisting of both an Anglophone and Francophone sub-systems inherited from former colonial influence by Britain and France (Ayonghe 1999; Njong 2006). The Anglophone educational system consists of primary education (6 years), secondary education (5 years), high school education (2 years) and bachelors’ degree education (3 years). Since 2006, efforts have been made to harmonize both systems, especially at the basic level in charge of primary education where the duration is now 6 years for both systems. A strong focus has been given to primary education especially of the girls, as a gateway out of poverty (INS, 2001; Njong 2010). Since independence of Cameroon, the educational sector in Cameroon has allotted a significant part of the national annual budget to cover operating cost in public schools and 80% in non-public schools (private, faith and community based). Colclough (2005) states that in developing countries the social returns of primary education are much higher when compared to tertiary education.

Despite progress made in the development of the educational system in Cameroon, some weaknesses to the system still remain: the English-mediated curriculum falls short of promoting the needed emphasis on the identity and history of minority cultures (Trudell, 2015). The predominant method of instruction in most schools is teacher centered, an approach known to inhibit development of critical thinking (Trudell, 2015). Since majority of subjects are taught in English, significant effort is allocated into teaching English vocabulary instead of subject matter (Trudell, 2015).
“Teacher-centered” instruction in which learning is based on mastery of content with little development of the skills necessary for scientific inquiry is a common type of instruction from elementary to higher educational institutions in Cameroon (Trudell, 2005; Taraban et al., 2007). This is contrary to “active learning” and “project-based pedagogy” practiced in the United States and many other western countries (Taraban et al., 2007; Barak and Raz, 2000; Krajcik et al., 2007). The limited emphasis on hands activities in the educational curriculum tends to undermine the opportunity for students to reinforce theory with practical application of knowledge towards a more meaningful application to research and development. The approach of Earth sciences education in Cameroon is a good example of how a “teacher-centered” approach may limit students understanding, relevance and application to society and development.

In Cameroon earth science is taught mainly as geology with very little emphasis placed on other branches (e.g. soil science). Many environmental issues that continue to plague Cameroon and other countries south of the Sahara stem from unsustainable environmental practices such as slash and burn practices in agriculture, deforestation and cattle rearing in fragile ecosystems. The consequences of such unsustainable land use are the prevalence of water and wind erosion problems, fatalities and loss of property from hazards such as land and mudslides.

In the United States, environmental issues related to poor land management and use have reduced significantly since the time of the disastrous dust bowl that swept through the country following the settlement of people in the mid-west (Rich, 2013). The State Soil Project inspired by the Smithsonian Soil Exhibit entitled “Dig it! The Secret of Soil” (Mikhailova et al., 2009), soil judging (Karthanasis et al. 2011) and other hands on
related soil education studies have been designed to enhance sustainable land use practices.

Cameroon presents a unique opportunity to diversify and enrich earth science education through the adaptation of Regional Representative State Soil project and soil judging in the earth science curriculum in primary schools, secondary schools and universities. This potentially can positively impact many aspects of land management, development and society as a whole. For instance, soil interpretations for suitability for septic tank absorption fields, basement and road construction are some practical ways a hand-on approach to learning can be directly relevant to Cameroon.

This research explores the application of the State/Regional Soil Project and Soil Judging in the United States to Cameroon with a complementary introduction of the use of GIS in both projects. The research is organized into three main body chapters: the first topic as described in chapter two focuses on the Regional Representative Soil Project for Cameroon, adapted from the State/Representative Soil Project in the United States (Mikhailova et al., 2009). It gives students the opportunity to practice interpretation of soil series descriptions, taxonomic classes, soil forming factors, soil physical and chemical properties in a meaningful way.

Chapter three focuses on adapting Soil Judging to Cameroon by introducing newly developed soil judging educational materials. Potential introduction of soil judging in Cameroon can benefit different sectors such as health, transportation, housing and urban development and agriculture.
Chapter four focuses on complementing the Regional Representative Soil Project and soil judging with geospatial technologies such as global positioning system (GPS) and geographic information system (GIS) to develop geospatial materials.

References


CHAPTER TWO

REGIONAL REPRESENTATIVE SOIL PROJECT FOR CAMEROON

Abstract

Representative regional soils have agricultural, cultural, economic, environmental, and historical importance to Cameroon. We have identified 27 regional representative soils in Cameroon, and developed a set of laboratory exercises, assignments and exam questions utilizing the Regional Representative Soil Project (RRSP) that gives students an opportunity to practice interpretation of soil series descriptions, taxonomic classes, soil forming factors, and soil physical and chemical properties. The RRSP can be incorporated into Earth Science curricula in secondary and high schools as well as bachelor’s degree programs at the university-level. Incorporation of the RRSP in earth science education in Cameroon is expected to change the perception of soil science education and to improve enrollment of students in the discipline. With time, the knowledge gained from this project will help land managers and farmers make proper use of their land. As the project expands, it is expected that a GIS soils database and related attributes from the different regions will be used to build a soils information system database for Cameroon.

Keywords: Africa Soil Information Service, agriculture, culture, earth science, education, erosion, and Soil Information Systems.
Introduction

Development of the Regional Representative Soil Project (RRSP) was inspired by the State Soil Project (SSP) (Mikhailova et al., 2009) and the Smithsonian Soils Exhibit entitled “Dig It! The Secrets of Soil”, which opened in July 2008 (Kamps, 2005). During this exhibition, each state in the United States represented their state soil embedded in a soil monolith (Kamps, 2005). “A state soil is a soil that has special significance to a particular state. Each state in the United States has selected a state soil, twenty of which have been legislatively established. These "Official State Soils" share the same level of distinction as official state flowers and birds. Also, representative soils have been selected for Puerto Rico and the Virgin Islands (USDA/NRCS, 2008).”

State symbols are often adopted after a concerted effort by citizens, organizations or school children to have a significant item recognized for its importance to the state by making a request for a bill through the Legislative process (Shearer and Shearer, 2001). According to Mikhailova et al. (2009), feedback from students who participated in a state representative soils project was positive and students’ comments indicated that they acquired practical skills on how to use and interpret soil information (e.g., Web Soil Survey, Soil Series Description Database, Soil Data Mart, etc.).

Cameroon presents a unique opportunity to enrich soil science education through adaptation of the RRSP modeled after the SSP in the United States. Soils in Cameroon are used predominantly for subsistence farming, plantation agriculture, and cattle rearing (Yerima and Ranst, 2005). Major food crops include corn, beans, cassava, Irish potatoes, sweet potatoes, yams, plantains, bananas and sorghum. Major cash crops include cocoa, coffee, rubber, tea, and palm oil which are grown in the volcanic soils of the of the
southwest region and the western regions (Obale-Ebanga et al., 2003; Yerima and Ranst, 2005). However, soil degradation, primarily due to erosion as a result of poor farming methods, is common in Cameroon (Obalum et al., 2012). Thus, there is a dire need for land owners, farmers and the population at large to understand basic soil science.

Poor farming methods, including slash and burn, intensive shifting cultivation and heavy use of agrochemicals, have not helped improve soil fertility (Ickowitz, 2011; Mokiendje, et al. 2006; Obale-Ebanga et al., 2003; Yemefack et al., 2006; Yerima and Ranst, 2005). Soil water erosion appears to be one of the biggest factors limiting soil productivity in the tropical regions of Africa and throughout the world (Board on Agriculture, 1993; Dregne, 1990). Soil erosion in Africa, like in many regions of the world, remains one of the biggest threats to soil productivity (Nguetnkam and Dultz, 2011; Sullivan, 2004). Although rich topsoil can be lost through the activities of heavy farm machinery, water and wind erosion remain important agents causing soil erosion (Ngwu et al. 2005; Obalum et al. 2012). Soil erosion, especially in the tropics, is also considered an important source of non-point source pollution (Kjaergaard et al. 2004; Nguetnkam and Dultz, 2011). Soil erosion is particularly common in humid regions of sub-Saharan Africa such as Cameroon, where soil is under increasing pressure from human population growth, deforestation and heavy rain fall (Mbuh, et al. 2012; Obalum et al. 2012). In Sub-Saharan Africa, soil loss attributed heavily to torrential rainfall has been put at over 50 tons/ha (FAO, 1995).

In the past four decades, soil science education in Cameroon as a subject under earth sciences has never been taught as a standalone subject in the curriculum of secondary and
high schools (Ayonghe, 1999). Earth sciences as a discipline was taught only in the lone state university of Yaoundé since its creation in 1962. Today, earth science is taught in at least three of the eight public universities in Cameroon. As a result of its colonial past, Cameroon’s educational system uses French and British curricula and languages, which leads to a non-harmonized approached to teaching soil sciences among colleges and universities (Ayonghe, 1999). Although advances have been made in earth science programs in Cameroon, shortage of qualified faculty and well equipped soil science laboratories pose as major limitations (Ayonghe, 1999).

There are 10 regions in Cameroon with 8 out of 12 soil orders (Soil Survey Staff, 1998): Alfisols, Andisols, Aridisols, Entisols, , Inceptisols, Oxisols, Ultisols, and Vertisols (Yerima and Van Ranst, 2005). A variety of soils in Cameroon provide a unique opportunity to create various practical exercises to be incorporated in soil science education to stimulate enthusiasm in the subject matter (Sulzman, 2004). Each student in the soil science course will be assigned to a representative regional soil to be researched through a series of in-class laboratory exercises, and take-home assignments given throughout the semester and the results of these “inquiry-based” projects will be summarized in a regular or electronic folder called “The Regional Representative Soil Project.” Student’s accomplishments in mastering soil science knowledge will be tested with exams that use non- representative/regional soil descriptions carefully selected by the instructor from available databases such as FAO, UNSECO, USDA/NRCS.

“Teacher-centered” instruction in which learning is based on mastery of content with little development of the skills necessary for scientific inquiry is a common type of
instruction in Cameroon (Taraban et al., 2007). However, studies have shown that “student-centered” or “inquiry-based” approaches are more effective methods to promote student learning in the Science, Technology, Engineering and Mathematics (STEM) disciplines, including earth science and its sub-disciplines such as soil science (http://www.nga.org/cms/stem). The RRSP can enhance soil science education in Cameroon by incorporating “active learning” and “project-based pedagogy” (Taraban et al., 2007; Barak and Raz, 2000; Krajcik et al., 2007). “Active learning” is a “student-centered” instruction where learning is active and constructive, involving inquiry and hands-on activities as opposed to teacher-centered pedagogy. Project-based pedagogy is a nonprescriptive, nonlinear approach to science instruction, which makes science learning meaningful and more focused on learning science by doing science (Barak and Raz, 2000; Krajcik et al., 2007).

The objectives of the RRSP are to provide students with an opportunity to practice soil science knowledge in a meaningful context, and to establish a framework for a GIS data base of regional representative soil in Cameroon.

**Materials and Methods**

These exercises require a computer lab equipped with personal computers (Pentium 2.8 GHz processors and a dedicated 128 MB video card) and ready access to the internet. Both internet and computer laboratories are available in most universities in Cameroon.
Description of map creation

This map was created using ArcMap10.1 software. To define the projection of the data frame, first a shapefile layer of the hydrology of Cameroon with the desired projection Clarke_1880_UTM_Zone_32N was added. Next another shapefile of the administrative region of Cameroon was added to the data frame and then exported and its projection projected to Clarke_1880_UTM_Zone_32N. The FAO soils map data of Africa was added, and clipped to the administrative boundaries of Cameroon. Using the editing tool, a reclassification of the FAO soils groupings was done to conform to USDA soil taxonomy. The decoding from FAO to USDA classification used the following resource: “Major soil classification systems used in the tropics: soils of Cameroon and world class data set of soil derived properties by FAO-UNESCO soil unit for global modeling (Batjes, 1997; Van Randst, 2005). The editing tool was used to add the abbreviated names of the regions of Cameroon on the map. Finally, the soil pits locations were added directly on the final map using the XY coordinate tab on the ArcGIS formatting tool bar.

Courses Background

The RRSP can be incorporated in various soil science courses currently taught in Cameroon (Ayonghe, 1999):

University of Yaoundé: Structure of Sub-soil (ST 202), Weathering and Pedology (ST 309), Classification and Evolution of Soils (ST 313), Structural Analyses and
Pedogeneses in Tropical Areas (ST 436), and Structural Analyses and Pedogeneses in Tropical Zones (ST 528).

University of Douala: Weathering and Pedology (ST 313), Classification and Mapping of Soils (ST 314), and Morphology of Soils and Classification (ST 415).

University of Buea: The Geology of Cameroon and Pedology (Elective).

**Learning Management System**

Modular Object-Oriented Dynamic Learning Environment (Moodle) is a free source e-learning software platform, which can be used for storing course materials, and assessing student’s learning via electronic quizzes and tests (https://moodle.org/).

**Results and Discussion**

In the context of Cameroon, regional soil names could be adapted based on the extent of soil types, the most common use of soil in a region, and historical and cultural heritage values of a region. Currently there are 10 administrative regions in Cameroon, formally called provinces, which encompass 27 soil groups. These soil groups belong to 8 out of 12 soil orders: Alfisols, Andisols, Aridisols, Inceptisols, Oxisols, Ultisols, and Vertisols (Soil Survey Staff, 1998; Table 1). Climate and parent materials stand out as the most important soil forming factors. Rainfall and temperature are the two most significant components of climate, while humidity and evapotranspiration play a rather indirect influence on vegetation (Yerima and Ranst, 2005).
Cameroon has a growing predominantly youthful population of over 19.4 million people (Table 1) based on 2010 national demographic statistics. Out of the ten administrative regions in Cameroon (Figure 2) 2 are English speaking and the remaining 8 French speaking. French and English have remained the official languages of instruction in schools across the country since colonial times (Ayonghe, 1999; Che, 2008). Education of children remains a priority for the government, as continued investments are being made in new infrastructure and equipping of schools and laboratories (Amin, 1994). Each of the 10 regions has been in turn divided into administrative Divisions and Subdivision. All administrative Divisions across the Cameroon have at least one government secondary and high school, usually with a host of other private and faith based school institutions. These secondary and high schools which typical have yearly enrollments ranging from a few hundreds to a few thousands, offer a ready platform for potential implementation of the RRSP model. The North West Region has been earmarked as potential host of the pilot regional representative soil project for a number of reasons: First, this region has one of the best secondary and high schools in Cameroon where earth sciences (geology) have been taught for several decades. Second, there are at least 5 recognized institutions of high learning (Table 1) based in the North West Region. Third, soil profile data already exist in Fundong Boyo division (Yerima and Ranst, 2005). Additionally one of the 3 government owned nutrient analysis laboratories in Cameroon is only 45 minutes away from the North West Region (Table 1). Lastly, the North West Region is predominantly covered by one main soil order, (Oxisols; Table 1, Figure 1), when compared to other regions such as the Adamawa region with 4 main soil orders: Alfisols, Entisols, Oxisols and Ultisols. It is
hoped that dealing with fewer soil orders would make the pilot representative soil project a less tedious first experience for students, coaches and soil judges. The soils map of the ten regions of Cameroon would be a useful tool in decision making regarding local soil orders and groupings especially in the RRSP. The FAO soils layer of Cameroon includes soil subgroup details for the whole country which may serve as a guide to determine dominant soils types in a particular locality in a region (Figure 1). For instance working in the South Region of Cameroon which is predominantly oxisols, classifying any soil as vertisols (only found in North Cameroon) would be suspicious and may need further investigation. Figure 1 may also be important in determining which representative regional soil order to choose for a region based on spatial extent. The attribute table of the FAO soils map layer has quantifiable data on the different soil groupings that can be verified for spatial extent.

Five assignments and exam questions have been created to give to students. Assignments can be done at variable times. Some can be take home assignments and others could be done during the 2-hour lab period. Descriptions of the assignments and exam questions are shown in Tables 3 to Table 5. Result of using RRSP can be compiled in a three-ring or electronic folder entitled Regional Representative Soil Project and used this information to practice for the exams, and to create power point presentation/ poster summarizing the knowledge they have acquired as a result of the project. Exams are related to the RRSP, except that the Soil Description used for the exam questions will be different from representative soil descriptions (Table 4).
Amin et al. (1994) posed a strong argument that Cameroon must be alerted to the urgent need for continual educational reforms if realistic progress is hoped to be attained past its present stage in development. Such a change in the educational sector will require boldness, resolve and initiative, because it involves changes in a system that basically has not shifted from what was inherited during pre-colonial times. Amin et al. (1994) emphasized that such a system must place a strong emphasis on sciences and technology, and secondary school students, especially girls who must be encouraged to devote more time for the sciences. Within this context and framework, the RRSP could be a great way of fostering science and development in Cameroon for the future. However, the anticipated impact in the long run will ultimately depend on several other factors including the cooperation and backing of the ministry of higher education in Cameroon.

Perhaps one of the most critical aspects of lasting reform in education is the role of teachers (Amin, 1994). Faculty in the Geology/Earth Science departments in the University of Buea, Yaoundé II, Dschang and a host of other higher institutions in Cameroon form an important base for the potential introduction and adaptation of the regional representative soil project to Cameroon. These three universities remain of strategic importance as they host departments which train hundreds of teachers for primary, secondary, and high schools every year. Precedence for the RRSP could be taken from the design of the geology degree program in the University of Buea; contrary to similar programs in Cameroon, it was carefully designed to suit the geology of Cameroon and Sub-Saharan regions of Africa (Ayonghe, 1999). Cameroon currently possesses the basic infrastructure and technology needed to start this project even at a
small scale. Adaptation and interpretation of RRSP should take into account cultural transferability and cross-cultural educational development pointed out by other researchers (Zajda, 2004).

**Conclusions**

In order for the establishment of the RRSP to be a success in Cameroon, the long term goal of the project must be brought into perspective; which is to provide students with an opportunity to practice soil science knowledge in a meaningful context, and to establish a framework for a GIS data base of regional representative soil in Cameroon. Undergraduate enrollment for earth sciences programs in Cameroonian universities combined may range up to several hundreds. A RRSP course potentially offers great opportunities for rapid and easy digitized data collection of soil types, soil nutrient data and detail classification of the specific soil orders and groupings. The GPS coordinates of each soil sample taken, will enable these data to be given a spatial reference, and thus contributing in ongoing efforts for a GIS soils information system for Africa. In this way, RRSP will be not only offer helpful information to some immediate beneficiaries such as farmers and other land owners, but also providing digitized soils information on the World Wide Web for research, education and development.
References


Clemson University, 2006-2007. Undergraduate announcements. Clemson Univ., Clemson, SC.


Education and Society 22(1), 83-95.
Table 1. General information about regions of Cameroon (Source: Institut National de la Statistique Cameroun, 2010.

<table>
<thead>
<tr>
<th>Region</th>
<th>Capital</th>
<th>Population (2010)</th>
<th>Area (km²)</th>
<th>Population density (people/km²)</th>
<th>Higher education institutions (with soil/geology sciences)</th>
<th>Government or private soil analysis laboratories</th>
<th>Common land-use practices in the region</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adamawa</td>
<td>Ngaoundéré</td>
<td>1,015,600</td>
<td>63,701</td>
<td>16</td>
<td>1</td>
<td>N/A</td>
<td>Grazing, building construction</td>
</tr>
<tr>
<td>2. Centre</td>
<td>Yaoundé</td>
<td>3,525,700</td>
<td>68,953</td>
<td>51</td>
<td>7</td>
<td>1</td>
<td>Logging, timber, industry, subsistence farming, commerce</td>
</tr>
<tr>
<td>3. East</td>
<td>Bertoua</td>
<td>802,000</td>
<td>109,002</td>
<td>7</td>
<td>N/A</td>
<td>N/A</td>
<td>Logging, timber, mining, timber, building, fishing</td>
</tr>
<tr>
<td>4. Far North</td>
<td>Maroua</td>
<td>3,480,400</td>
<td>34,263</td>
<td>102</td>
<td>N/A</td>
<td>N/A</td>
<td>Tourism, building, subsistence farming</td>
</tr>
<tr>
<td>5. Littoral</td>
<td>Douala</td>
<td>2,865,800</td>
<td>20,248</td>
<td>142</td>
<td>3</td>
<td>N/A</td>
<td>Major industrial zone, commerce, building, fishing, subsistence farming</td>
</tr>
<tr>
<td>6. North</td>
<td>Garoua</td>
<td>2,050,200</td>
<td>66,090</td>
<td>31</td>
<td>1</td>
<td>N/A</td>
<td>Tourism, building, subsistence farming</td>
</tr>
<tr>
<td>7. Northwest</td>
<td>Bamenda</td>
<td>1,804,700</td>
<td>17,300</td>
<td>104</td>
<td>5</td>
<td>N/A</td>
<td>Subsistence farming, small businesses and crafts, building, quarry</td>
</tr>
<tr>
<td>8. South</td>
<td>Ebolowa</td>
<td>692,100</td>
<td>47,191</td>
<td>15</td>
<td>N/A</td>
<td>N/A</td>
<td>Logging, timber, subsistence farming</td>
</tr>
<tr>
<td>9. Southwest</td>
<td>Buea</td>
<td>1,384,300</td>
<td>25,410</td>
<td>55</td>
<td>4</td>
<td>1</td>
<td>Plantation and subsistence farming, building</td>
</tr>
<tr>
<td>10. West</td>
<td>Bafoussam</td>
<td>1,785,300</td>
<td>13,892</td>
<td>126</td>
<td>2</td>
<td>1</td>
<td>Plantation and subsistence farming, industry, trade and commerce</td>
</tr>
</tbody>
</table>

Note: N/A = not available.
### Table 2. Soil regions of Cameroon

<table>
<thead>
<tr>
<th>Region</th>
<th>Ecological regions</th>
<th>Soil Map Symbol</th>
<th>Soil Group Name</th>
<th>Soil Order (Soil Survey Staff, 1998)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adamawa Ngaoundéré</td>
<td>Ao2</td>
<td>Haplic Acrisols in association with Haplic Ferralsols</td>
<td>Ultisols</td>
<td>Oxisols</td>
</tr>
<tr>
<td></td>
<td>Fo1</td>
<td>Haplic Ferralsols</td>
<td></td>
<td>Oxisols</td>
</tr>
<tr>
<td></td>
<td>Fo3</td>
<td>Haplic Ferralsols in association with Haplic Acrisols</td>
<td>Oxisols</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fr1</td>
<td>Rhodic Ferralsols in association with Haplic Ferralsols and Rhodic Nitisols</td>
<td>Oxisols</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>Leptisols</td>
<td></td>
<td>Entisols</td>
</tr>
<tr>
<td></td>
<td>Lg1</td>
<td>Gleyic Luvisols in association with Planosols</td>
<td>Alfisols</td>
<td>Alfisols/Oltisols</td>
</tr>
<tr>
<td></td>
<td>Nd2</td>
<td>Rhodic Nitisols in association with Ferralsols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rd1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Centre Yaoundé</td>
<td>Ao2</td>
<td>Haplic Acrisols in association with Haplic Ferralsols</td>
<td>Ultisols</td>
<td>Oxisols</td>
</tr>
<tr>
<td></td>
<td>Fo1</td>
<td>Haplic Ferralsols</td>
<td></td>
<td>Oxisols</td>
</tr>
<tr>
<td></td>
<td>Fo4</td>
<td>Haplic Ferralsols in association with Haplic/Rhodic Nitisols</td>
<td>Oxisols</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fo5</td>
<td>Haplic Ferralsols in association with Humic Gleysols/Histosols</td>
<td>Oxisols and Histosols</td>
<td></td>
</tr>
<tr>
<td>3. East Bertoua</td>
<td>Ao1</td>
<td>Haplic Acrisols</td>
<td></td>
<td>Ultisols</td>
</tr>
<tr>
<td></td>
<td>Ao2</td>
<td>Haplic Acrisols in association with Haplic Ferralsols</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td>Location</td>
<td>Soil Type</td>
<td></td>
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<td>---------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gh1: Regosols in association with Leptisols and Luvisols, Alfisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re1: Regosols in association with Leptisols and Luvisols, Entisols</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Je1: Eutric Fluvisols in association with planosols/Gleyic Solonetz, Entisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vp1: Eutric Vertisols in association with Gleysols, Fluvisols and Arenosols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vp3: Eutric Vertisols, Vertisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ws1: Planosols in association with Gleyic Luvisols, Vertisols/Ultisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ws2: Planosols in association with Gleyic Luvisols, Vertisols/Ultisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Littoral</td>
<td>Douala</td>
<td>Fr1: Rhodic Ferralsols in association with Haplic Ferralsols and Rhodic Nitisols, Oxisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fo1: Haplic Ferralsols, Fo4: Haplic Ferralsols in association with Haplic/Rhodic Nitisols, Oxisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gd1: Dystric Gleysols in association with Dystric Fluvisols, Inceptisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. North</td>
<td>Garoua</td>
<td>Ig1: Leptosols, Entisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lg1: Gleyic Luvisols in association with Planosols, Alfisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lf1: Ferric Luvisols in association with Acrisols and Regosols, Alfisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rd1: Regosols in association with Leptisols and Luvisols, Entisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re1: Regosols in association with Leptisols and Luvisols, Entisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vp1: Eutric Vertisols in association with Gleyic Luvisols, Vertisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vp2: Eutric Vertisols in association with Planosols and Luvisols, Vertisols</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td>Location</td>
<td>Code</td>
<td>Soil Type</td>
<td>Terrain Type</td>
</tr>
<tr>
<td>------------</td>
<td>----------</td>
<td>------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>7. Northwest</td>
<td>Bamenda</td>
<td>Fo2</td>
<td>Haplic Ferralsols in association with Rhodic Ferralsols</td>
<td>Oxisols</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fh1</td>
<td>Humic Ferralsols</td>
<td>Oxisols</td>
</tr>
<tr>
<td>8. South</td>
<td>Ebolowa</td>
<td>Fo5</td>
<td>Haplic Ferralsols in association with Humic Gleysols/Histosols</td>
<td>Oxisols</td>
</tr>
<tr>
<td>9. Southwest</td>
<td>Buea</td>
<td>Nd3</td>
<td>Rhodic Nitisols in association with Acrisols</td>
<td>Alfisols/Ultisols</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ne1</td>
<td>Haplic Nitisols in association with Ferralsols</td>
<td>Alfisols/Ultisols</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ne2</td>
<td>Haplic Nitisols in association with Rhodic Nitisols</td>
<td>Alfisols/Ultisols</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>Andosols in association with Leptosols</td>
<td>Andisols</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>Leptosols</td>
<td>Entisols</td>
</tr>
<tr>
<td>10. West</td>
<td>Bafoussam</td>
<td>Fo1</td>
<td>Haplic Ferralsols</td>
<td>Oxisols</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nd2</td>
<td>Rhodic Nitisols in association with Ferralsols</td>
<td>Alfisols/Ultisols</td>
</tr>
</tbody>
</table>
OBJECTIVES AND TASKS FOR LABORATORY EXERCISES

Assignment 1

Objective: To find assigned regional representative soil and identify the soil order it belongs to;

Task: Find assigned Regional Representative Soil in Yerima and Van Ranst (2005).

Assignment 2

Objective: To identify six soil forming factors (parent material, climate biota, topography, time, land use) from the soil description;

Task: Find Regional Representative Soil profile description in Yerima and Van Ranst (2005). Write a report with a paragraph on each soil forming factor.

Assignment 3

Objective: To identify soil physical properties (texture, structure, consistence, and drainage and permeability) from the soil group description and quantitative data from Yerima and Van Ranst (2005);

Task: Write an interpretive report with a paragraph on each soil physical property.

Assignment 4

Objective: To identify soil chemical properties from the soil group description and quantitative data from from Yerima and Van Ranst (2005);

Task: Write a report with a paragraph on each soil chemical property.

Assignment 5

Objective: To decode the taxonomic class and explain the meaning of their derivatives, connotation of formative elements and major characteristics;

Task: Write one-page report.
Table 4. Example of questions related to the Regional Representative Soil used in the Exams.

EXAMPLE OF QUESTIONS FOR EXAMS RELATED TO SOIL GROUPS

LOCATION  Fundong Subdivision North West Region  
(Lat. 6° 33’ 15”, Long. 10° 27’ 50”)

Source: FAO/UNDP, 1987

Fo2 (Soil Map Symbol)

The Fo2 group consists of very deep, well drained soils that formed in residuum weathered mostly from migmatite of the undulating lands. Slopes commonly are 2 to 8 percent.

CLASSIFICATION:


TAXONOMIC CLASS: Sols Ferrallitique, fortement desatures, typiques mondaux, sur migmatite

TAXONOMIC CLASS: Haplustox, clayey

TYPICAL PEDON: Clayey Haplustox - cropped. (Colors are for dry soil.)

Ap—0 to 28 cm; yellowish red (5YR 4/6 dry) fine sandy clay loam; moderately strong fine and subangular blocky structure, breaking into very fine granular; soft, slightly sticky, slightly plastic; few strongly weathered fine grained basement rock; many fine, few medium pores, many fine, common medium, few coarse roots; clear smooth boundary.

BA—28 to 50 cm; Dark red (2.5YR3/6) clay loam to clay; somewhat weak medium sub angular blocky structure; slightly hard, sticky, slightly plastic; many fine, few medium pores common fine, few medium and coarse slightly, hard, sticky, slightly plastic; many fine, few medium and coarse roots; clear smooth boundary.

Bo1—50 to 95 cm; red (2.5RS5/8, moist) clay; moderate coarse subangular blocky structure; friable, sticky, slightly plastic; many fine, few medium pores; common fine roots, few medium roots; gradual smooth boundary.

Bo2—95-150 cm; Red (2.5YR-10YR 4/8, moist) clay; moderate coarse subangular blocky
structure; friable, sticky, slightly plastic; many fine few medium pores; few fine roots; gradual smooth boundary.

**Bo3**-150 to 200 cm: Red (10R4/8, moist) clay; somewhat weak coarse and very coarse subangular blocky structure; friable, sticky, slightly plastic many fine pores; few fine and medium roots.

**GEOGRAPHIC SETTING:** Ferralsols have good physical properties and poor chemical properties. They are comparatively less susceptible to erosion than many other soils because of their great depth, high permeability and stable microstructure (Yerima and Van Randst, 2005). Hapli-Rhodic Ferralsols in Fundong Subdivision North West Region is located along the road from Tricorners Ketambo to Fonfukka (Lat. 6° 33 ’15”, Long. 100 27’ 50”). The topography is undulating land with a slope of 2% to 8%. The landform has low planation surface and relief. Parent material is made of magmatite. Yearly rainfall is about 3031 mm (Kimbi).

**DRAINAGE AND PERMEABILITY:** Well drained.

**USE AND VEGETATION:** Mountane forest. Cleared areas are used for maize, sweet potato, groundnuts, oil palm, coffee, and some eucalyptus.

**DISTRIBUTION AND EXTENT:** The Northwest region. The soil group is of large extent.

**SOURCE OF DATA:** Yerima and Van Ranst, 2005

**GROUP ESTABLISHED:** FAO/UNDP, 1987.

**QUESTIONS**

1. What is the soil map symbol for the above soil? Fo2
2. What is the soil order for the above soil? Oxisols
3. What is the soil moisture regime for the above soil? Ustic
4. What is the soil texture in the BA horizon? Clay loam to clay
5. What is the soil structure in the Bo1 horizon? moderate coarse subangular blocky structure
6. What is the soil consistence in the Bo2 horizon? friable, sticky, slightly plastic
7. What is the soil boundary in the BA horizon? clear smooth boundary
8. In which region(s) do you find this soil? Fundong Subdivision North West Region
9. What are the six soil forming factors for the above soil?

   a. Parent material: migmatite; b. Topography: Undulating lands. Slopes commonly are 2 to 8 percent; c. Climate: Ustic, Temp: ?; d. Biota: Montane Forest; e. Time: Highly weathered; f. Land-use: cropland with maize, sweet potatoes, oil palm etc.

10. In which soil horizons do you expect maximum illuviation? Bo1, Bo2, Bo3 (o=oxides)

11. Which horizons indicate parent material? Not indicated in the soil profile.

12. Which horizons indicate true soil? Ap, BA, Bo1, Bo2, Bo3

13. Which horizons indicate regolith? Ap, BA, Bo1, Bo2, Bo3

14. Parent material belongs to what kind of rock (e.g. igneous, metamorphic, sedimentary, igneous/metamorphic)? Igneous/metamorphic

15. Is parent material formed in place or transported? Residuum (formed in place).

16. What is (are) the name(s) of colloid(s) found in this soil? Iron oxides

17. What is the type of colloids (e.g. 1:1, crystalline, 2:1, amorphous, sesquioxide clays)? sesquioxide clays

18. What kind of predominant “charge” does this colloid have (e.g. permanent, pH-dependent) and why? pH-dependent charge

1. **Objective:** To reinforce representative regional soil project laboratory exercises taught throughout semester.

   **Task:** Retrieve and organize data collected from previous exercises to be included in the presentation.

2. **Objective:** To learn to effectively present data in an electronic presentation format.

   **Task:** Create ten slides in Microsoft Power Point as follows:

   1. Title Page
   2. What is a Representative Regional Soil?
   3. (Your Region Soil) Profile
   4. Geographic Extent of (Your Region Soil)
   5. (Your Region Soil) is a Function of…
   6. Soil Taxonomy
   7. Soil Physical Properties Table
   8. Graph 1
   9. Graph 2
   10. Land Use

3. **Objective:** To learn to effectively present data in a tabular format.
Task: Choose three interesting soil physical or chemical properties and create a table in Microsoft Power Point displaying the chosen properties for each soil depth.

4. **Objective:** To learn to effectively present data in a chart.

   **Task:** Choose one property from soil physical or chemical properties that would be interesting to display graphically and create a chart in Microsoft Power Point.

5. **Objective:** To learn to effectively present data in a pie chart.

   **Task:** Choose a soil depth and create a pie chart to display the soil texture (% sand, % silt, % clay) for that depth.
Figure 1. Generalized regional (EN=Extreme North, N=North, A=Adamawa, E=East, S=South, C=Center, L=Litoral, W=West, SW=South West, NW=North West) and soil (with ten soil pit locations) map of Cameroon.
North West Region Representative Pilot Soil Project

Prepared by,
Celestine A. Che
Ph.D Candidate
Clemson University

What is a North West Regional Soil?

- Has special significance to that region with respect to:
  - Used to build houses (sun-dried building blocks), and create pottery;
  - Arabica coffee grows on this soil;
  - Occupies most of the North West region.

Figure 2. Example of Regional Representative Soil Project for North West Region of Cameroon.
North West Region Representative Soil Profile

TYPICAL PEDON: Cherno-Haplaque - mapped (Colour as for soil.)

Ap 0-2 cm, yellowish red (7.5YR 4/6) 1 cm sand clay; loam, moderately wet, fine and angular block structure, breaking into very fine granular soil, slightly vesicular, slightly plastic, very strongly weathered fine granular texture, medium fine, few medium pores, many fine, common medium, few coarse roots, clear smooth boundary.

2A-0.50 to 5 cm, dark red (2.5YR 3/2) clay loam to clay, somewhat loose medium to angular block structure, slightly hard, sticky, slightly plastic; many fine, few medium pores, common fine, few medium and coarse, slightly hard, sticky, slightly plastic; many fine, few medium and coarse roots, clear smooth boundary.

Bt 0-50 to 65 cm, yellow (2.5YR 6/6), medium dense, moderately loose subangular blocky structure, slightly hard, sticky, slightly plastic; many fine, few medium pores, common fine, few medium and coarse, slightly hard, sticky, slightly plastic; many fine, few medium and coarse roots, clear smooth boundary.

Bt 65-150 cm, red (2.YR 5/8), medium dense, moderately loose subangular blocky structure, slightly hard, sticky, slightly plastic; many fine, few medium pores, common fine, few medium and coarse, slightly hard, sticky, slightly plastic; many fine, few medium and coarse roots, clear smooth boundary.

Bt 150 to 200 cm, red (2.5YR 6/6), medium dense, somewhat weak subangular very coarse subangular blocky structure, slightly hard, sticky, slightly plastic; many fine, few medium, few coarse roots, clear smooth boundary.


Geographic extent of soils of North West Region

Source: Geada.com

Figure 2. Example of Regional Representative Soil Project for North West Region of Cameroon.
Figure 2. Example of Regional Representative Soil Project for North West Region of Cameroon.
Figure 2. Example of Regional Representative Soil Project for North West Region of Cameroon.
Figure 2. Example of Regional Representative Soil Project for North West Region of Cameroon.
CHAPTER THREE

ADAPTATION OF SOIL JUDGING FOR CAMEROON

Abstract

Adaptation of Soil Judging to Cameroon can significantly enhance soil science education in the country. This may not only impact schools but also several government sectors such as public health, agriculture, housing and town planning and the transportation sector. A study was conducted on how to adapt conventional soil judging as practiced in the United States for Cameroon by a graduate student from that country using an undergraduate-level Soil Judging course taught at Clemson University together with a regional, multi-state soil judging competition. Over the course of the study, the student from Cameroon received training on 4 of the 8 soil orders that are present in Cameroon and also encountered in the Southeastern United States. A Southeastern Region Soil Judging Handbook was used as a guide for the development of teaching materials for Cameroon. Soil judging teaching materials prepared for Cameroon included tables of soil physical and chemical properties, topographic maps, and scorecards. Newly developed teaching materials can significantly enhance soil science education in Cameroon which may be part of an important long term solution to mitigate ineffective land use management.

Keywords: Africa, agriculture, education, environment, field, sustainability.
Introduction

Mcloughlin (1999) wrote that a student’s understanding of a subject is aided when teaching is student centered and they take an active part in the course planning. Quesada-Pineda et al. (2011) concurred that students are more likely to buy into such an approach. Since 1956, soil judging among college and university students in the Southeastern United States has provided great opportunities to build field experience and critical thinking skills (Aide, 1989; Karathanasis et al. 2011). Soil judging in the United States has evolved into numerous local contests and six regional contests, with the finalists from each region competing at the national soil judging competition in a designated host state (Hill et al. 1984). Hill et al. (1984) stated that soil judging adds a valuable “hands on” experience for hundreds of students who take courses in soil science and other soils-related disciplines. Hill et al. (1984) stated that soil judging remains a very effective method of teaching soil classification to thousands of students.

In the United States, soil judging has reached typically students majoring in the soil sciences, geology, geography, natural sciences, agronomy, forestry, horticulture, education, economics, animal sciences and environmental studies (Cooper, 1991). Soil judging competitions offer students the opportunity to apply soil science as a solution to growing challenges in soil use and management. Soil profile properties and interpretations to determine soil infiltration rate, hydraulic conductivity, available water, soil wetness class, slope, and site position are some critical indicators to land suitability for the cultivation of specific crops. Soil use interpretation may enable students to determine soil use suitability for construction of dwellings with basements, septic tank absorption fields, and local roads and streets (Karathanasis et al. 2011). It is possible to
improve land use and management in the tropics through the introduction of soil judging competitions in the soil science curriculum.

Cameroon presents a unique opportunity to enrich soil science education graduates and other land use professionals through adaptation of soil judging competition in schools, colleges and universities. Like most countries in the tropics, soil degradation in Cameroon due to harsh environments, fragile soils, ignorance, inappropriate land use, and inadequate and often nutrient poor farm land, compounded by increasing human population pressure on limited land remains a major concern (Kjaergaard, et al. 2004; Bationo et al. 2006). Soil judging competitions can potentially offer a long term solution to some of the land use problems in Cameroon by educating students and planners about important soil properties related to land use such as soil infiltration rate, hydraulic conductivity, available water, soil wetness class, suitability for dwellings with basements, septic tank absorption fields, slope, erosion potential, and position of site.

**Soil infiltration** determines how much water from rainfall, irrigation, or a contaminant spill enters the soil and how much becomes runoff or overhead flow (Reynolds and Elrick, 1991). Mbuh et al. (2012) indicated that morphoclimatic information of the Mount Cameroon coastal landscape shows that it is being degraded continually. The high infiltration rates, abundant rainfall, oceanographic factors and the dynamics of the water masses, are some important factor responsible for influencing the transgression and progression of the coastline (Mbuh et al. 2012). According to Ayonghe et al. (2004) rainfall was a contributing factor to triggering the June 27th 2001 fatal landslides in Limbe Cameroon. It was hypothesized that due to prolonged rainfall the pore pressure above the normal water table was altered, making a landslide more likely
High annual rainfall characterizes the South West Region of Cameroon which encompasses landslide prone areas in Limbe. Unpublished data from CDC-Cameroon Development Corporation meteorological center indicate yearly precipitation varying from 1500 to 6000 mm within the last 34 years (Che et al. 2012).

**Hydraulic conductivity** is the ability of the soil to transmit water (Reynolds and Elrick, 1991). Hydraulic conductivity is used to determine septic suitability. Ruoyan et al. (2010), reports that health care/waste management has been known to be a significant public health and environmental problem particularly in Cameroon. In Cameroon, over 60% of the population lack access to safe drinking water and have turned to springs wells and rivers for their daily water consumption needs (Ateba et al., 2012). Ako et al. (2009) and Djuikom et al. (2009) added that rapid population growth and unplanned urbanization and their consequences have led to surface and ground water degradation in major cities of Cameroon in the last 20 years. In Yaoundé and other major cities in Cameroon, streams and rivers are often used for disposal of solid and liquid waste. The seepage of feces from poorly constructed pit latrines only makes the situation worse, making these water ways heavy with bacteriological and other pollutants (Ateba et al. 2012). Previous studies carried out in Yaoundé highlighted the issue of fecal contamination of waterways frequently used by inhabitants of the city (Kemka, 2000; Djuikom et al., 2009; Kuitcha et al. 2010). Ground water is a primary source of water for domestic use, agricultural and industrial uses in Cameroon, it is therefore not surprising that its contamination has been recognized as one of the most serious problems in Cameroon (Ako et al, 2011).
Available water capacity is the water held in a soil between its field capacity and its permanent wilting point. It is the maximum amount of plant-available water that a soil can provide (Parr and Bertrand, 1960). The north of Cameroon is located in the Sahel region and experienced droughts in 2009 and 2011 and floods in 2010 (FAO/WFP, 2012). Each of these years has resulted in a high degree of crop failure, leaving the population with limited or nonexistent stocks for the lean season and increasing the gap between food production and food needs. An estimated 5.5 million people are living in the Far North region of Cameroon and the majority are farmers or agro-pastoralists or both (FAO/WFP, 2012). This region of Cameroon is characterized by limited rainfall, poor soils and food insecurity. A joined government/FAO/WFP food security survey conducted in 2010, in the North of Cameroon’s drought and flood prone Logone Basin suggested that food accounted for more than 40% of household income. This study also indicated that about 124000 of the 216000 people in the Logone and Chari Basins needed immediate food assistance (FAO/WFP, 2012).

Soil wetness class is a reflection of the rate at which water is removed from the soil by both runoff and percolation to a specified depth (Karathanasis et al. 2011). Significant factors that influence soil wetness class include slope gradient, landscape position, infiltration rate, surface runoff, and permeability. Barret (2004) states that ground water quality may be affected by overlying land use. Typhoid fever and diarrhea represent respectively 32 and 43% of waterborne disease that affect the population of Cameroon (Kramkimel et al. 2004). Sanitation in cities of Cameroon, like in majority of other African cities is generally unsewered (Kuitcha et al., 2008). In the southern sector of Cameroon and adjacent city of N’Djamena in the Lake Chad basin, the depth of wells
varies from less than 2 m to about 15 m, and the depth of bore holes from 20 to 60 m (Ngatcha and Daira, 2010). Ngatcha and Daira, (2010) stated that ground water can be found in Cameroon and Chad varying from 1.0 m to 40 m below soil level, thus making ground and surface water contamination a significant risk factor.

**Suitability for dwellings with basements** is a rating that can be slight, moderate or severely limiting (Karathanasis et al., 2011). Such suitability is based on soil properties that affect the soil wetness class, capacity of the soil to support a load without movement, and on the properties that affect excavation and construction cost (Karathanasis et al. 2011). Examples of the soil properties affecting suitability for dwellings with basements include flooding or ponding frequency, slope, depth to seasonally high water table, depth to soft rock, and depth to hard rock.

In Cameroon, permitting for construction is provided by the local councils and other related government ministries such as the ministry of town planning and housing. The majority of dwellings for family housing are constructed without basements. However, stricter regulations are required on permits for buildings in industrial districts, for example, hotels, classic restaurants and government office buildings, some of which have basements. Soil judging will teach important techniques to students in Cameroon on how to determine properties that affect the ease and amount of excavation which includes: the depth of water table, consistence (rupture resistance) of the soil, ponding, flooding, slope, depth to bedrock, hardness of bedrock and the amount and size of rock fragments. Soils that have a shallow soil wetness class are more likely hosts to vectors that require standing water during part of their life cycle, and must be identified to the public. Regardless of the stipulated permit and construction standards that companies or
individuals seeking to construct buildings must adhere to in Cameroon, monitoring for compliance is hardly ever enforced.

**Slope** is an important factor influencing runoff, erosion, and landslides. Landslides are historically some of the worst known natural disasters. Landslides are common natural hazards along the Cameroon Volcanic Line, and are most frequent during heavy rainstorm evens between June and October (Lambi, 1991). Between 1988 and 2001, 64 human fatalities have been recorded as a result of landslides along the Cameroon Volcanic Line, and many more landslides events without fatalities are known to have occurred which have not been recorded (Ayonghe et al. 2004). Lambi (1991) reported that these fatal landslides events frequently occurred on steep slopes of cones formed from loose pyroclastic ejecta from different episodes of volcanic eruptions of Mount Cameroon. Findings from Thierry et al. (2008), on a multi-hazard risk mapping assessment study on an active volcano in the Mount Cameroon area, indicated that 3.6 % and 3.2 % of 50,000 buildings are in very high and high hazard risk areas, respectively. These areas are threatened by landslides. As a component of soil judging students are taught how to measure the slope of a site, and to determine how it influences infiltration rate, surface runoff and soil erosion potential (Karthanasis et al. 2011). Such knowledge would be relevant to addressing the challenges caused by land degradation and landslides in Cameroon and risk mitigation.

**Soil water erosion** involves detachment and transport of particles by raindrops and surface runoffs, followed by deposition. The principal mechanisms of detachment include the disintegration of aggregates by slacking, cracking, dispersion and shearing by raindrop impact or runoff (Barthès et al. 2000). Soil erosion is a significant problem in
Cameroon. Four million of the 15 million inhabitants of Cameroon live within 60 km of its coastline (Asangwe, 2002). This means more than 25% of the population is settled on approximately 6.5% area of the coast land (Asangwe, 2002). Human pressures on such sensitive zones which involves seasonal reworking and reshuffling of its sandy beaches have led to increased erosion and other environmental problems (Mbuh et al. 2012). Surface runoff and soil erosion potential determination are important skills that students acquire during soil judging competitions, which may be relevant when addressing environmental issue related to erosion in Cameroon.

The position of site describes the landform on which the soil pit is located. A topographic map may be an additional resource to help determine the position of a pit on a landscape during soil judging competitions (Karthanasis et al. 2011). In the North of Cameroon, the Yaere flood plain is prone to yearly flooding caused by rainfall and Logone River overflow (Bench, 1992; Delclaux et al. 2010). According to Bench (1992), Yaere plains are flooded when discharge exceeded 1,200 m3/s at Bongor, a site located on the Logone River. Knowledge gained on slope and site position on a landscape from soil judging competition may be important during flood and landslide risk assessment and mitigation.

Cameroon, like most developing countries, is facing huge challenges with high rates of urbanization, estimated at about 4% annually, compared to an annual population growth rate of about 2.7% (Ahmed and Ali, 2004; World Bank, 2002). Overcrowding in cities already experiencing socio-economic pressures often characterized by inadequate housing poor sanitation and waste management have led to the decline in health (Frumkin, 2010). Soil interpretation skills acquired in soil judging training would be
relevant to the ministry of town planning and housing who regulate housing in
Cameroon. While the introduction of soil judging completion in schools, colleges and
universities in Cameroon may not have an immediate impact on land use practices, it
does offer hope through the students and university graduates for future generations.

The objectives of this study are to adapt Soil Judging to Cameroon and to provide
students with an opportunity to practice soil science knowledge in a meaningful context.

**Materials and Methods**

**Study area:** Cameroon is found between West and Central Africa at the far northeast end
of the Gulf of Guinea but is also considered to be in the central African sub-region. It
lies between latitude 2° and 13° N, extending from the Gulf of Guinea to Lake Chad over
a distance of 1200 km and between longitude 8° and 16° E and extends over a distance of
800 km at the widest portion (Ako et al., 2010). It has a total surface area of about
475,650 km² with a mainland surface area of 466,050 km² and a maritime surface area of
9,600 km² (Ako et al., 2010). The urban and rural populations are about the same size,
although urbanization is increasing by 4.7% per year on average, about 35% of the urban
population lives in the economic capital Douala, or the administrative capital, Yaoundé
(Ako et al., 2010).

In order to judge (describe and interpret) any soil and site properties, pre-field
preparations will be mandatory and this must also take into account access to and
affordability of tools (Figure 1). Score cards used for grading in soil judging
competitions must be designed based on the knowledge of expert groups in a particular
region (Figure 2, 3). Also topographic maps of the soil pit sites could be produced from
the internet while specific chemical data for each site could be obtained from the analysis of soil samples from any equipped soil nutrient analysis laboratory (Figure 4, 5, 6). Of the 12 soil orders known according to US soil taxonomic classification, eight have been described in Cameroon (Alfisols, Andisols, Entisols, Histosols, Inceptisols, Oxisols, Ultisols and Vertisols). Training for a 2012 soil judging competition in Lexington Kentucky enabled a graduate student from Cameroon to become familiar with four of the 8 soil orders in Cameroon that are also present in the Southeastern United States (Alfisols, Entisols, Inceptisols, and Ultisols).

*Equipment needed for Soil Judging and costs and availability in Cameroon:*

A set of tools that must be provided for each student involved in a soil judging completion includes: A blank description sheet (score card), acceptable guidelines, clinometer or slope degree measuring tool, knife or excavation tool, bucket, clip-board, soil collection trays, water bottle, measuring tape, two calibrated wooden poles, a calculator, a pencil, a Mussel color chart, a hammer, nails and a portable seat if desired (Figure 1; Table 2). All items needed for an ideal soil judging kit can be purchased locally in Cameroon (Table 2).

*Sampling: When students arrive on site for a soil judging competition, they are given instructions and then split into four groups with students mixed from all the participating schools to minimize the possibility of cheating. The students then take turns in a predetermined order, this time in smaller groups, to observe and describe the different soil profiles in different soil pit locations. For each soil pit, chemical data will be
displayed for all students to see (Figure 4). Usually this is attached on a pole out of the pit for all to see clearly. Also two calibrated poles will be planted at a suitable location apart from each other to get the slope readings of the pit location. Depending on how long competing students are permitted to be on site at each pit, students will be split into small groups to use the pit alternately so as to avoid overcrowding. Students will collect soil samples, describe the soil and site morphology and enter responses on their individual score cards. Fifty to sixty minutes may be allowed as the maximum time allowed for the completion of scorecards for each pit. However during an actual competition sufficient time is allocated for practice sessions to allow students to become familiar with soil orders of that particular region. This is normally done for the first three to four days of the competition week, in preparation for the actual competition on the last day. The number of sites to be judged by students during any competition will be determined by the officials and coaches long before the competition begins. While the competition is in progress, judges will begin marking the scores cards collected from students from pits that have been judged already. At the end of the day, student may wait to get the final results of the competition and appropriate awards.

**Laboratory analysis:** Soil samples to provide vital chemical data for the students could be analyzed in any one of the three soil nutrient analysis laboratories in Cameroon (Table 1): Dschang, Ekona and Yaounde.

**Topographic maps:** A shapefile of Cameroon administrative boundaries was overlaid on a DEM layer of Cameroon (ESRI, 2012). These layers were first converted to raster
format using the polygon to raster tool. The projections of the DEM and country outline were changed from geographic coordinate system to projected coordinate system Clarke_1880_UTM_Zone 32N. This was done with the help of the project tool. Using the contour spatial analyst tool, contour lines were created from the DEM layer. Different contour intervals were used ranging from 50m to 1500m depending on the amount of detail and extent of coverage desired. The contour lines were then clipped to fall within the Cameroon boundary lines. A base map of the West Central Africa was then overlaid as background to situate Cameroon on the African continent (Figure 5, 6).

**Courses Background:** Soil judging course and contest can be incorporated in various soil science courses currently taught in Cameroon (Ayonghe, 1999):

University of Yaoundé: Structure of Sub-soil (ST 202), Weathering and Pedology (ST 309), Classification and Evolution of Soils (ST 313), Structural Analyses and Pedogeneses in Tropical Areas (ST 436), and Structural Analyses and Pedogeneses in Tropical Zones (ST 528).

University of Douala: Weathering and Pedology (ST 313), Classification and Mapping of Soils (ST 314), and Morphology of Soils and Classification (ST 415).

University of Buea: The Geology of Cameroon and Pedology (Elective).

Sectors that stand to benefit directly in Cameroon include, the agricultural sector, housing and town planning, transportation, health and agricultural sectors.
**Learning Management System**: Modular Object-Oriented Dynamic Learning Environment (Moodle) is a free source e-learning software platform, which can be used for storing course materials, and assessing student’s learning via electronic quizzes and tests ([https://moodle.org/](https://moodle.org/)). Computer laboratories and ready access to the internet are available in most universities in Cameroon.

**Results and Discussion**

For Cameroon, soil judging can be relevant in many different sectors. This may include schools (middle and high schools, colleges and professional schools, and universities), the agricultural, health, transportation, housing and town planning sectors.

The soil judging competition model in colleges and universities in the United States has proven to be an effective approach to teaching and reinforcing soil morphology and classification to many students across several disciplines (Hill et al. 1984). For students and their coaches, the competition serves as a positive motivating factor for learning soil sciences (Hill et al., 1984).

All the equipment needed by students to prepare and participate in a soil judging competition can be purchased from local bookstores and other specialized electronic stores in some big cities in Cameroon such as Douala, Yaoundé, Baffousam, Kumba and Bamenda. Additionally, soil nutrient analysis laboratories are available in Dschang, Ekona and Yaoundé, in the West, South West and Center Regions for carrying out soil nutrient analysis to provide physical and chemical data which are vital for soil judging competitions. Similar to the United States, the most likely students to take interest in soil judging in Cameroon might be Earth Science- or natural resource-related majors.
(Geology, Agriculture, Forestry, Land-use planning). Geology has been taught as a subject in most high schools in Cameroon for several decades. This subject is usually accompanied by practical field hands on experiences. Students get familiar with the use of instruments such as the clinometer, measuring tape, hammer and the Mussels color chart. It is hoped that the introduction of soil judging competitions to Cameroon will equip future graduates with knowledge and skills to help their families, communities and nation at large to make informed decisions that can help prevent losses or additional spending to fix problems that could have easily been avoided. Determination of soil erosion potential, surface runoff potentials, hydraulic conductivity, infiltration rates, available water and soil wetness class could equip graduates with the skills to make good judgment on which soil condition is best for cultivation, the type of plants to cultivate and recommended farming techniques.

Many studies the world over, have shown a link between poor environmental conditions and disease (Ross, 2011). Lack of proper sanitation, unsafe disposal of storage waste in and around living quarters, may provide habitat for vectors of various diseases such as typhoid fever, diarrhea, and dysentery (Fitzpatrick and Lagory, 2000). According to Dominique-Torres and Foster (2011) only 35% of Cameroonians have access to improved sanitation. Cholera outbreaks in 2011 in Douala and other cities of Cameroon have been linked to contaminated water (Epule et al. 2011). The knowledge of soil interpretations such as suitability for septic tank absorption fields acquired during soil judging competitions could be helpful in determining the best sites for their construction. The knowledge of soil texture, parent material, position of site and
infiltration rates are important parameters to determine site suitability for latrines, and septic tank construction.

Several other sectors in Cameroon can benefit from soil judging training skills. The increasing trend and severity of natural hazards such as flash floods in Bamenda (Nyambod, 2010), landslides along the Cameroon Volcanic Line and intense city flooding in the Northern regions of Cameroon (Ayonghe et al. 1999; Che et al. 2012) underscore the importance of site considerations and other risk factors when engaging in construction projects. Pettang et al. (1997) stated that most developing countries, like Cameroon, have a disorganized urban housing construction sector. Soil interpretation calculations which are a component of soil judging can offer information that is revealing of site suitability for building. The texture of the soil, soil wetness class, position of site in relation to risk of flooding, and infiltration rates are all diagnostic information that can help determine construction site suitability. Soil judging skills can also be taught to state employees in the ministry of housing and town planning in Cameroon to broaden their criteria in evaluating house construction plans submitted to the local town municipal officials. The Cameroon government’s local ministries of transport and agriculture staff could be given periodic soil judging refresher trainings courses to equip them be more effective at executing their services, too. This may be very beneficial training for the local agricultural extension workers who work directly with individual farmers and farming groups especially in the rural areas of Cameroon.

In order to successfully adapt and interpret soil judging to Cameroon, it is necessary to train qualified personnel. This article gives an actual example of how a
graduate student from Cameroon was trained in soil judging by participating in a soil judging course (FNR 493) and Southeastern Regional Soil Judging Competition in Lexington KY in the fall of 2012. Celestine Akuma Che was trained on how to: collect soil samples, determine slope, interpret topographic maps, determine texture by feel, land use interpretation, chemical and physical properties, soil wetness class, infiltration rate, hydraulic conductivity, and available water (Figures 7-11).

Materials and skills needed for a successful implementation of soil judging in school, colleges and other professional institutions have been developed. The score cards have been designed with specific adaptations to the different possible soil orders, epipedons, subsurface horizons and characteristics that may be found in Cameroon (Figs 2 & 3). Other score cards specific to individual regional competitions will be adapted from the master score cards for Cameroon. Students and faculty shall be trained on how to judge soils using the score cards prior to organizing regional competitions. This may begin with pilot trials at a local scale, and then the module will be evaluated and adjustments made to suit local realities to Cameroon.

Chemical properties data shall be made available for every pit in the different regions both for soil judging practice sessions and for actual competitions (Figure 4). The nutrient analysis laboratories present in Ekona (South West Region), Dschang (West Region) and Yaoundé (Center Regions) would be very vital to get these data for soil judging. Students and future coaches shall be trained on how to use these data to interpret and judge different soils in Cameroon. This would need cooperation from the Ministries of Agriculture, Education, and Scientific Research in Cameroon.
Sample topographic maps (Figure 6) shall be produced for each location using GPS coordinates obtained from simple GPS units, or cellphones or digital Cameras with special enhanced capabilities. The topographic maps will be produced from computers with any version of ArcGIS, ArcView (ESRI, Redlands California, 1969) which are available in Cameroon. Students and coaches shall receive training on how to interpret a site position based on information on a topographic map. A site position could be a depression, drainage way, flood plain, foot slope, stream terrace or upland. This can be determined by looking carefully at patterns on the isoline elevation. For example, on Figure 6 there is a depression on the middle left of the map. This conclusion is correct because the isolines elevation decreases progressively from outside to inside.

Other resources that may be needed to effectively teach and share knowledge for this project includes a website with sample demonstrations on how to conduct soil judging, and lecture notes and power points needed to teach soil judging as a course. Moodle® may be used to help students access and download information. Graduate student from Cameroon received training on how to use these resources and also has a website with information and tools to help implement soil judging in Cameroon.

Conclusions

The introduction of soil judging to Cameroon may serve as a low cost nontraditional way of teaching students and government workers simple and efficient techniques of land management and use. Cameroon has the basic infrastructure for a successful introduce of soil judging competitions to schools (middle and high schools,
colleges, and universities), and various government sectors such as agriculture, health, road construction and building and town planning sectors. Soil nutrient analysis data can be got from any of the three soil nutrient analysis laboratories in Cameroon thus facilitating soil morphological descriptions. Soil judging may serve as a way of reinforcing the application of earth science taught mainly as geology, in high schools, colleges and universities in Cameroon.
References


Frumkin, H., 2006. Cities, suburbs, and urban spawl: their impact on health, in:


Ross, D.E, 2011. Safeguarding public health, the core reason for solid waste management. Waste Management and Research, 29(80), 779-780.


Figure 1. Soil Judging equipment.
Figure 2. Front side of scorecard for Cameroon Soil Contest (adapted from Karathanasis et al., 2011).
<table>
<thead>
<tr>
<th>Position of Site (5)</th>
<th>Epipodons (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td>Anthropic</td>
</tr>
<tr>
<td>Flood Plain</td>
<td>Folistic</td>
</tr>
<tr>
<td>Footslope</td>
<td>Histic</td>
</tr>
<tr>
<td>Stream Terrace</td>
<td>Melanic</td>
</tr>
<tr>
<td>Upland</td>
<td>Mollic</td>
</tr>
<tr>
<td></td>
<td>Ochric</td>
</tr>
<tr>
<td></td>
<td>Plaggen</td>
</tr>
<tr>
<td></td>
<td>Umbric</td>
</tr>
<tr>
<td>Parent Material (5)</td>
<td></td>
</tr>
<tr>
<td>Alluvium</td>
<td></td>
</tr>
<tr>
<td>Colluvium</td>
<td>Subsurface Horizons and Characteristics (5 each)</td>
</tr>
<tr>
<td>Residuum</td>
<td>Agric</td>
</tr>
<tr>
<td></td>
<td>Sombric</td>
</tr>
<tr>
<td></td>
<td>Albic</td>
</tr>
<tr>
<td></td>
<td>Spodic</td>
</tr>
<tr>
<td></td>
<td>Argillic</td>
</tr>
<tr>
<td></td>
<td>Lithologic Discontinuity</td>
</tr>
<tr>
<td></td>
<td>Calcic</td>
</tr>
<tr>
<td></td>
<td>Lithic Contact</td>
</tr>
<tr>
<td>Soil Slope (5)</td>
<td></td>
</tr>
<tr>
<td>Nearly Level (0 to 2%)</td>
<td>Cambic</td>
</tr>
<tr>
<td>Gently Sloping (&gt;2 to 6%)</td>
<td>Paralithic Contact</td>
</tr>
<tr>
<td>Sloping (&gt;6 to 12%)</td>
<td>Cambic</td>
</tr>
<tr>
<td>Moderately Sloping (&gt;12 to 20%)</td>
<td>Paralithic Contact</td>
</tr>
<tr>
<td>Strongly Sloping (&gt;20 to 30%)</td>
<td>Paralithic Contact</td>
</tr>
<tr>
<td>Steep (&gt;30%)</td>
<td>Cambic</td>
</tr>
<tr>
<td></td>
<td>Paralithic Contact</td>
</tr>
<tr>
<td>Surface Runoff (5)</td>
<td></td>
</tr>
<tr>
<td>Ponded</td>
<td>Natric</td>
</tr>
<tr>
<td></td>
<td>Oxic</td>
</tr>
<tr>
<td>Slow</td>
<td>Petrocalcic</td>
</tr>
<tr>
<td>Medium</td>
<td>Petrogypsic</td>
</tr>
<tr>
<td>Rapid</td>
<td>Placic</td>
</tr>
<tr>
<td>Very Rapid</td>
<td>Salic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Erosion Potential (5)</th>
<th>Order (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>Oxisols</td>
</tr>
<tr>
<td>Low</td>
<td>Entisols</td>
</tr>
<tr>
<td>Medium</td>
<td>Alisols</td>
</tr>
<tr>
<td>High</td>
<td>Andisols</td>
</tr>
<tr>
<td>Very High</td>
<td>Inceptisols</td>
</tr>
<tr>
<td></td>
<td>Vertisols</td>
</tr>
<tr>
<td></td>
<td>Ultisols</td>
</tr>
<tr>
<td></td>
<td>Histisols</td>
</tr>
</tbody>
</table>

| Part C Score | Part D Score |

Figure 3. Back side of scorecard for Cameroon Soil Contest (adapted from Karathanasis et al., 2011 and Yerima and Van Ranst, 2005).
Practice Pit 1

Number of horizons: 5

Depth to be described: 200 cm

Nail in 3rd horizon @ 70 cm

<table>
<thead>
<tr>
<th>Horizon</th>
<th>OC (%)</th>
<th>BS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.4</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>2.3</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>1.1</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>0.9</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>0.7</td>
<td>56</td>
</tr>
</tbody>
</table>

Flooding: NONE    Ponding: NONE

Figure 4. Soil physical and chemical properties for one of the soil profiles in Fundong Subdivision, North West Region, Cameroon (FAO/UNDP, 1987) as it is used during Soil Judging practice and competition.
Figure 5. Locations of ten soil pits with determined soil physical and chemical properties (Yerima and Van Ranst, 2005).
Figure 6. Topographic map for Practice Pit 1 located in Fundong Subdivision, North West Region, Cameroon (FAO/UNDP, 1987) (Yerima and Van Ranst, 2005, p. 186-187).
Figure 7. Soil sample collection from Ultisols in Simpson Agricultural Station in Pendleton, SC.
Figure 8. Interpretation of soil chemical and physical properties during 2012 Southeastern Regional Soil Judging Competition in Lexington, KY.
Figure 9. Slope determination during 2012 Southeastern Regional Soil Judging Competition in Lexington, KY.
Figure 10. Texture by feel during 2012 Southeastern Regional Soil Judging Competition in Lexington, KY.
Figure 11. Clemson University Soil Judging team (Celestine Che, graduate student from Cameroon is far right) 2012 Southeastern Regional Soil Judging Competition in Lexington, KY.
Table 1. General information about regions of Cameroon (Source: Institut National de la Statistique Cameroun, 2010).

<table>
<thead>
<tr>
<th>Region</th>
<th>Capital</th>
<th>Population (2010)</th>
<th>Area (km²)</th>
<th>Population density (people/km²)</th>
<th>Higher education institutions (with soil/geology sciences)</th>
<th>Government or private soil analysis laboratories</th>
<th>Common soil-related uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adamawa</td>
<td>Ngaoundéré</td>
<td>1,015,600</td>
<td>63,701</td>
<td>16</td>
<td>1</td>
<td>N/A</td>
<td>Grazing, building construction</td>
</tr>
<tr>
<td>2. Centre</td>
<td>Yaoundé</td>
<td>3,525,700</td>
<td>68,953</td>
<td>51</td>
<td>7</td>
<td>1</td>
<td>Logging, timber, industry, subsistence farming, commerce</td>
</tr>
<tr>
<td>3. East</td>
<td>Bertoua</td>
<td>802,000</td>
<td>109,002</td>
<td>7</td>
<td>N/A</td>
<td>N/A</td>
<td>Logging, timber, mining, timber, building, fishing</td>
</tr>
<tr>
<td>4. Far North</td>
<td>Maroua</td>
<td>3,480,400</td>
<td>34,263</td>
<td>102</td>
<td>N/A</td>
<td>N/A</td>
<td>Tourism, building, subsistence farming</td>
</tr>
<tr>
<td>5. Littoral</td>
<td>Douala</td>
<td>2,865,800</td>
<td>20,248</td>
<td>142</td>
<td>3</td>
<td>N/A</td>
<td>Major industrial zone, commerce, building, fishing, subsistence farming</td>
</tr>
<tr>
<td>6. North</td>
<td>Garoua</td>
<td>2,050,200</td>
<td>66,090</td>
<td>31</td>
<td>1</td>
<td>N/A</td>
<td>Tourism, building, subsistence farming</td>
</tr>
<tr>
<td>7. Northwest</td>
<td>Bamenda</td>
<td>1,804,700</td>
<td>17,300</td>
<td>104</td>
<td>5</td>
<td>N/A</td>
<td>Subsistence farming, small businesses and crafts, building, quarry</td>
</tr>
<tr>
<td>8. South</td>
<td>Ebolowa</td>
<td>692,100</td>
<td>47,191</td>
<td>15</td>
<td>N/A</td>
<td>N/A</td>
<td>Logging, timber, subsistence farming</td>
</tr>
<tr>
<td>9. Southwest</td>
<td>Buea</td>
<td>1,384,300</td>
<td>25,410</td>
<td>55</td>
<td>4</td>
<td>1</td>
<td>Plantation and subsistence farming, building</td>
</tr>
<tr>
<td>10. West</td>
<td>Bafoussam</td>
<td>1,785,300</td>
<td>13,892</td>
<td>126</td>
<td>2</td>
<td>1</td>
<td>Plantation and subsistence farming, industry, trade and commerce</td>
</tr>
</tbody>
</table>

Note: N/A = not available.
Table 2. Soil judging equipment per person and cost in Cameroon.

<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment/supplies</th>
<th>Cost in US $</th>
<th>Cost in Franc CFA as of 12/13/12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Abney level, clinometer, or other hand level</td>
<td>300</td>
<td>150,524.35</td>
</tr>
<tr>
<td>2.</td>
<td>Knife</td>
<td>5</td>
<td>2,508.69</td>
</tr>
<tr>
<td>3.</td>
<td>Water bottle</td>
<td>1</td>
<td>501.738</td>
</tr>
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<td>6.</td>
<td>Calculator</td>
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<td>7.</td>
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<tr>
<td>8.</td>
<td>Measuring tape and nail</td>
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<td>9.</td>
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CHAPTER FOUR

APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) TO SOIL JUDGING IN CAMEROON

Abstract

Adaptation of soil judging to Cameroon requires the use of geospatial technologies (e.g. global positioning system (GPS), geographic information system (GIS) and many others). The study was conducted to develop geospatial materials to support potential adaptation of soil judging in Cameroon. Soil map developed by the Food and Agriculture Organization (FAO) of the United Nations, Forest Atlas of Cameroon, and Cameroon digital elevation model (DEM) were used to develop teaching materials. Step-by-step instructions were provided to prepare the spatial soil judging teaching materials using ArcGIS for Cameroon. Spatial soil judging teaching materials include locations of existing soil pits, topographic maps, slope, and aspects maps. Newly developed spatial teaching materials can significantly enhance soil science education in Cameroon.

Keywords and abbreviations: Africa, aspect, digital elevation model (DEM), drainage, erosion, Geographic Information Systems (GIS), land-use planning, slope
Introduction

Geographic Information Systems (GIS) consists of a powerful set of tools for collecting, retrieving, analyzing and communicating spatial data. The application of GIS in education can become a very important tool in soil judging competitions, earth science education, conservation, forestry and other relevant areas in Cameroon both as a teaching tool and a means of analyzing and presenting spatial data. Despite the numerous benefits and applications of GIS in education, research and development, GIS information technology infrastructure and use in science education in Cameroon is very limited (Mangoua, 2005). The official school curricula approved by the ministries of secondary education, secondary and superior education does not place a strong emphasis on GIS information technology (Mangoua, 2005). Costs and a lack of adequately trained personnel are some main constraints to the use of GIS in education in Cameroon. Software is relatively expensive in relation to budgets of most educationally institutions; however with the expansion of GIS use this cost might decrease (Mangoua, 2005). The lack of skills in GIS by educationist, researchers, students and natural resource managers in Cameroon limits their capabilities to effectively manage and share spatial data and its applicability to addressing relevant issues in Cameroon (Mangoua, 2005). This also limits management and research options that can be conducted with relatively fewer resources using GIS models and remote sensing and data interpretation tools for a relatively shorter period of time. In the past decade and a half, the accessibility and emphasis on computer training and internet use in basic, secondary and tertiary education in Cameroon is gaining grounds. The use of computers and the internet is mostly limited to
communication, research and networking. In Cameroon, more than 80% of students’
professionals and technicians in various surveying and mapping organizations are still
using analog technology and equipment (Mangoua, 2005). This was especially true prior
to 1992 (Mangoua, 2005). This is in sharp contrast to universities in the United States and
Europe, companies and other institutions around the world that have been using GIS,
remote sensing and the internet as basic tools for communication, and sharing of
information for a long time.

Even though the use of GIS is still relatively new to Cameroon, this technology is
mostly used by NGO’s in conservation, health professionals and researchers in academia.
Among the many aspects of GIS, GPS application in research appears to be the most
popular use of GIS in Cameroon. Global positioning system was used to track cattle
migration along the Logone Floodplain (Yaayre) in 2011 (Moritz et al., 2012). Moritz et
al. (2011) also examined spatiotemporal patterns in grazing intensity in the Logone
floodplain, using a combination of spatial and ethnographic methods and analysis. Ojang
(2012) used SAGA GIS and 30 \times 30 m and 90 \times 90 m resolution SRTM to derive cross
longitudinal profiles as well as other morphological and hydrological parameters, for the
morphological characterization of the elephant valley in Mount Cameroon. Since 2009
the World Health Organization was using GIS to create a geographic database of human
African trypanosomiasis to map and determine endemicity, which included data from
seventeen African countries including Cameroon (Cecchi et al., 2009). Geographic
information has been used in several studies involving landslides, earthquakes, larva flow
and risk along the Cameroon Volcanic line (Benne et al., 2008; Che et al., 2012; Che et al., 2011; Epada et al. 2012; Thierry et al. 2008).

While GIS is not a magical solution to all the information difficulties in Cameroon, it remains a powerful too capable of transforming the way in which spatial and other types of information is being managed. One way of preparing Cameroon for more innovative research and development in a fast technologically advancing world is by introducing GIS in the general educational curriculum of students in secondary, high, professional schools and universities. While this seems easy to do, comprehensive structure, syllabi and outline for such GIS courses are yet to be developed. Geographic information systems package to be application to soil judging in Cameroon will present an opportunity for to introduce GIS skills to students in Cameroon for the first time. The GIS package which will be offered to complement soil judging, has the additional advantage of providing hands on application to students, which is a great way of reinforcing theory and laboratory exercises. Assignments such as the creation of soil maps, contour, slope and aspect maps would introduce specific set of skills to students which may serve as the bases for a further study on GIS.

The objectives of this study are to create instructions and exercises for soil judging to Cameroon using GIS.

**Materials and Methods**

**Study area:** Cameroon is found between West and Central Africa at the far northeast end of the Gulf of Guinea but is also considered to be in the central African sub-region. It
lies between latitude 2° and 13° N, extending from the Gulf of Guinea to Lake Chad over a distance of 1200 km and between longitude 8° and 16° E and extends over a distance of 800 km at the widest portion (Ako et al., 2010). It has a total surface area of about 475,650 km² with a mainland surface area of 466,050 km² and a maritime surface area of 9,600 km² (Ako et al., 2010). The urban and rural populations are about the same size, although urbanization is increasing by 4.7% per year on average, about 35% of the urban population lives in the economic capital Douala, or the administrative capital, Yaoundé (Ako et al., 2010).

**Geospatial databases and tools:** Spatial data sources and descriptions are listed in Table 1. The following tools were used: ArcGIS 10 (ESRI Inc., 2010).

**Results and Discussion**

**Regional Map of Cameroon:** First the right environment was set (Figure 1, 2), and then the following shape files of Cameroon administrative boundaries, surface hydrology and the soils layer were overlaid in GIS ArcMap 10.1 (Figure 3). Using the clipping tool, the soils layer was clipped to the administrative and national boundaries of Cameroon. The polygon to raster tool was used to convert the shapefiles in polygon format (soils and administrative layer) to raster format. The administrative layer was hallowed with no color, with a bold dark outline and overlaid on the soils layer for clear demarcation of the administrative regions. Using the regional names on the attribute table of the administrative map layer, each of the 10 regions of Cameroon was labeled, from Extreme
North (Far North) to the South West Region. The transparency tool was set at 55% to reduce the intensity of the soils layer so the administrative boundaries could be more prominent. A base map of West Central Africa was then used as a background to situate Cameroon on the African continent.

Regional boundaries are important to help in the prioritization in collecting soil information in Cameroon. Figure 4 indicates that the soil pits are concentrated in the North West, South West and Extreme North Regions. There is therefore a need to collect more soil information in other regions such as: Center, Litoral, West, South, East, Adamawa, and North regions (Figure 4).

**Soil map of Cameroon:** This map was created using FAO soils layer of Africa (Figure 5), the administrative regional layer and the surface water hydrology layers of Cameroon. The soils layer was clipped using the clipping easy processing of data (Figure 6). Next the administrative regional layer and the soils of Africa map layers were converted first to a raster as needed and then projected to the projected coordinate system with the projection Clarke_1880_UTM_Zone_32N. The FAO soils of Africa layer was then clipped to the administrative boundaries of Cameroon. Next, the administrative boundary layer of Cameroon was hallowed and it’s outlined bolded and overlaid on the soils layer to demarcate the different administrative regions. The FAO soils layer with ninety six different soil groupings was converted to the USDA taxonomy depicting 12 world soil orders. This was done using the editing tool to add a new field to the soils layer attribute table. The different symbologies for various soil groupings used in the original map layer were rename in this new column to eight of the twelve possible soil orders of the USDA
soil taxonomy (Figure 7, 8). This included, Alfisols, Andisols, Aridisols, Entisols, Inceptisols, Oxisols, Ultisols and Vertisols. Using unique categories under symbology, and all values included the new reclassified map was created.

The general soil map of Cameroon will be helpful in identifying predominant soil types in the respective regions, for example for the Representative Regional Soils Project (RRSP). This information would be important in the development of specific regional score cards for the respective soil judging completions. Initial steps of setting the right environment and the addition of the administrative boundary layers for Cameroon are the same.

**Soil Pits Locations:** Three basic layers in shapefile format were used to create this map: The soils layer of Africa, the administrative boundaries of Cameroon and the surface water hydrology layer. The convert from polygon to raster tool was used to change these layers from polygon to raster as needed. Both the soils and the administrative boundary layers which were both in the geographic coordinate system were projected to the projected coordinate system with projection Clarke_1880_UTM_Zone_32N using the export function. Once the map was created and the right transparency of the soil layer determined, the longitude and latitude coordinates of soil pits were then added directly to the map using the Go to XY function. This was done after the transformation of these coordinates from the degree minutes and second format to Decimal degree format. A base map of West Central Africa was used as a background to situate Cameroon on the African continent. Location of soils pits will be used by competing schools, students and faculty to locate and judge soil pits (Figure 8).
Topographic maps: A shapefile of Cameroon administrative boundaries was overlaid on a DEM layer of Cameroon (Figure 9). These layers were first converted to raster format using the polygon to raster tool. The projections of the DEM and country outline were projected from geographic coordinate system to projected coordinate system Clarke_1880_UTM_Zone 32N. This was done with the help of the project tool. Using the contour spatial analyst tool, contour lines were created from the DEM layer (Figure 10, 11). Different contour intervals were used ranging from 100m to 1500m depending on the amount of detail and extent of coverage desired. The contour lines were then clipped to fall within the Cameroon boundary lines. A base map of the West Central Africa was then overlaid on as a background to situate Cameroon on the African continent.

Topographic maps will be useful in determining the positions (e.g. depression, drainage way, floodplain, foot slope, stream terrace and others) of soil pits on the landscape for soil judging competitions. Additionally, these maps could be used for research and development by the related ministries and agencies in Cameroon (Figure 11). Labeling of iso-lines and the identification of the soil pit

Slope maps: A shapefile of Cameroon administrative boundaries was overlaid on a DEM layer of Cameroon. These layers were first converted to raster format using the polygon to raster tool. The projections of the DEM and country outline were projected from geographic coordinate system to projected coordinate system Clarke_1880_UTM_Zone 32N using the project tool. Using the geoprocessing tool, the DEM was clipped to the administrative boundaries of Cameroon. The slope spatial analyst tool was then used to create a slope map. The default slope intervals was reclassified into six categories,
namely: nearly level (0 to 2%), gentle sloping (>2 to 6%), sloping (> 6 to 12%),
moderately sloping (>12 to 20%), strongly sloping (>20 to 30%) and steep (>30%).
These intervals would be very important in describing site position and to determine
different soil interpretations such as, dwelling with basements, septic tank absorptions
fields and local roads and streets (Figure 12, 13). Slope measurements were used by Che
et al. (2011) in their study on landslide documentation in Cameroon. To estimate pre
slope gradient and orientation of areas which experienced landslides, the gradient and
orientation of the slides-adjacent slopes were taken using a Silva compass/clinometer.
Che et al. (2011) indicated that most of landslides in Limbe, were transitional and /or
rotational landslides with a mean width of 24 m. Combinations of factors were attributed
to the slides which included: the presence of steep slopes, thickness of soil cover,
proximity to stream channels and prolonged rainfall. During the month of recorded slides
rainfall data indicated that a mean annual average ranged from 2100 to 4600 mm.
Rainfall measurements for June to July were approximately 400 mm to 680 mm, while 24
hours prior to the 2001 slides severe rains rainfall reached up to 180 mm (Ayonghe et al.
2004; Zogning et al. 2007). An Etrex GPS receiver was used to map out the outline of the
slide scar. Slope position, slope shape and other measurements such as aspect, were used
in soil moisture variation studies in relation to topography and land use in the Loess
plateau, China (Qiu et al., 2001). Qiu et al. (2001), found a significant correlation
between averaged soil moisture in his study with relative elevation, slope gradient and
aspect. Temporal variability of mean soil moisture also had a significant correlation with
slope shape. Ojang, T.A. (2012; MS thesis), used SAGA GIS and 30M SRTM to create
slope maps for elephant valley (Mount Cameroon) in a morphological characterization study.

**Aspect maps:** A shapefile of Cameroons administrative boundaries was overlaid on a DEM layer of Cameroon. These layers were first converted to raster format using the polygon to raster tool. The projections of the DEM and country outline were projected from geographic coordinate system to projected coordinate system with the projection Clarke_1880_UTM_Zone 32N. This was done with the help of the project tool. With the aid of a clipping tool, the DEM layer of Cameroon was clipped to the administrative boundaries. The aspect spatial analyst tool was then used to create an aspect map from the country DEM layer (Figure 14). Aspect can have a strong influence on temperature. This is because aspect affects the angle of the sun rays when they come in contact with the ground, and therefore affects the concentration of the sun's rays hitting the earth. Aspect is an important aspect that controls soil water content or moisture. Moore et al. (1988), stated that aspect may be an important factor in semiarid zones where solar radiation is more intense than in humid areas. In the case of Cameroon, aspect would be more important in the North and Extreme/Far North Regions where the region is dry and semi-arid.

Figures 15–20 are examples of maps which were developed using GIS for two different soil pit locations (Yerima and Van Ranst, 2005), which can be potentially used for Soil Judging and other educational activities.
Conclusions

The development of geospatial products using GIS will serve as a useful tool in presenting and managing spatial information which will also compliment the understanding and teaching of soil judging. Since the application of GIS is diverse, GIS maps and other applications such as remote sensing may be useful to other sectors in Cameroon such as natural resource conservation, wild life management, agriculture, health and disease control, natural disaster management and mitigation, and academic research studies. Geocoding of soil samples may also be beneficial for precision agriculture. Finally, the application of GIS in soil judging and RRSP may be one of the few or if not the first packaged formal GIS class to be introduced to primary, secondary, high schools and universities in Cameroon. This suggests that the complimentary GIS course that will accompany the teaching of soil judging and the RRSP may potentially become the foundation of advanced GIS courses to be later developed in schools in Cameroon.
References


http://www.wri.org/project/interactive-forest-atlas-cameroon

Kanwischer, D., Quennet, F., 2012. Distance education and spatial citizenship in Africa
challenges and prospects. Review of International Geographic Education Online 2(1),
96-117.

transfer in developing countries at the beginning of the 21st Century: The case of
Cameroon. ASPRS 2005 Annual Conference: Geospatial Goes Global: From your
neighborhood to the whole planet.


integrated approach to modeling grazing pressure in pastoral systems: The case of the
Logone Floodplain (Cameroon). Human Ecology 38, 775-789.

Ojang, T.A, 2012. Morphological characterization of the Elephant Valley (Mount
Cameroon) using SAGA GIS and 30M SRTM (MSc. Thesis, Ghent University
Belgium).

mapping and assessment on an active volcano: the GRINP project at Mount
Cameroon. Natural Hazards 45, 429-456.
APPENDIX A
Figure 1. Screen captions showing the defining the correct coordinate system.
Figure 2. Screen caption of choosing the right extensions.
Figure 3. Screen caption of addition of administrative boundary layer.
Figure 4. Generalized regional (EN=Extreme North, N=North, A=Adamawa, E=East, S=South, C=Center, L=Litoral, W=West, SW=South West, NW=North West) and soil (with ten soil pit locations) map of Cameroon.
Figure 5. Screen caption of addition of FAO soils layer to data frame.
Figure 6. Screen captions of clipping of soil layers.
Figure 7. Screen captions of reclassification of soils groupings to from FAO/UNESCO to USDA soil taxonomy.
Figure 8. Screen caption of the use of “Go to XY” function to identify soil pit location.
Figure 9. Screen caption of addition and exportation of DEM to the same projection as the data frame.
Figure 10. Screen captions of using of contour tool to create iso-lines.
Figure 11. Screen captions of labeling of iso-lines and the identification of the soil pit.
Figure 12. Screen captions of using slope tool to create slope map of Cameroon.
Figure 13. Screen captions of reclassification of slope categories and intervals based on score cards.
Figure 14. Screen captions of using the aspect tool to create aspect map.
Figure 15. Example of a topographic map for soil pit in Tole South West Region Cameroon.

Figure 16. Example of a slope (%) map for soil pit in Tole South West Region Cameroon.
Figure 17. Example of an aspect map for soil pit in Tole South West Region Cameroon.
Fig. 18. Example of a topographic map for soil pit in Fundong Region of North West Region Cameroon (Yerima and Van Ranst, p. 186).
Fig. 19. Example of a slope (%) map for soil pit in Fundong Region of North West Region Cameroon (Yerima and Van Ranst, p. 186).
Fig. 20. Example of an aspect map for soil pit in Fundong Region of North West Region Cameroon (Yerima and Van Ranst, p. 186).
Table 1
Spatial data sources and descriptions used in Soil Judging and soil science instruction in general.

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<td>African Water Resource Database</td>
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<td><strong>Digital Elevation Model (DEM)</strong></td>
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<td>Cameroon DEM</td>
<td>Africa Soil Information Service, 2013</td>
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<td>Hydrologically Corrected / Adjusted SRTM Digital Elevation Model (AfrHySRTM), Aug. 2008</td>
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<td><a href="http://www.africasoils.net/data/rsdownload">http://www.africasoils.net/data/rsdownload</a></td>
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* All data layers projected to Clarke_1880_UTM_Zone_32N.
CHAPTER FIVE

CONCLUSION

This research explores how the State/Representative Soil Project (Mikhailova et al., 2009) and Soil Judging (Karathanasis et al., 2011) can be adapted to teach earth sciences in the schools and colleges in Cameroon.

Chapter two describes the methodology of adaptation of Regional Representative Soil Project (RRSP) in Cameroon. It provides educational materials to practice interpretation of soil series description, taxonomic classes, soil forming factors, and soil physical and chemical properties in a meaningful way to education, research and development. In this chapter about 27 regional representative soils in Cameroon are identified, in addition to supporting resources such as soil nutrient analysis laboratories for soil testing.

Chapter three focuses on adaptation of soil judging in Cameroon and how it can significantly enhance earth science education and different sectors in development and research. Score card is produced for potential soil judging competitions in Cameroon.

Chapter four focuses on the use of geospatial technologies such as geographic information systems (GIS) and global positioning systems (GPS) to complement Regional Representative Soil Project (RRSP) and soil judging in Cameroon. Several maps such as soil maps, aspect maps and slope maps are produced and presented for potential use as teaching aids in soil judging training.
A conceptual framework exists to make science and education relevant to the social, economic and cultural development of Cameroon. This is apparent in the focus of educational ministries in Cameroon and the vision of key academic institutions funded by the government, such as Cameroon Academy of Science. Its vision is “to be the prime mover of science and technology synthesis, making scientific knowledge available to decision and policy makers about investments and priorities in science and technology and promoting the use of science and innovation in the economic, social, and cultural development of Cameroon.” (http://www.nationalacademies.org/asadi/PDFs/CAS.pdf).

It has long been established that investment in education and human capital formation are essential in economic growth and poverty reduction (Njong, 2010). The introduction of RRSP and Soil Judging to Cameroon could be one way to transmit simple but innovative approaches in education and development. This can be done by using the Science, Technology, Engineering and Mathematics (STEM) approach in the United States where STEM is used to generate ideas and translate them into innovative products and services. Policy makers in the United States felt the need for greater awareness for educators as they work to learn more about STEM education and how teachers at all levels – elementary, middle and high school can contribute to the preparation of scientifically and technologically literate citizens and STEM workers, to foster innovation research and development (http://www.nga.org/cms/stem). This would be completely relevant in Cameroon as the impact of poor land management practices continue to abound. However taking a more integrated and proactive approach which embodies strategies for the long term future will be key addressing land management
issues through education. The RRSP and Soil judging to Cameroon are potential projects that if successfully implemented could bring about a shift in paradigm towards making science integral in development.

In spite of the merits of what RRSP and Soil Judging could bring to Cameroon, lack of a clear strategy or vision for its implementation could limit the impact of this project. For a successful implementation, it is important to consider which educational sectors to target first. It seems reasonable that a potentially workable strategy to impact education, development and research in Cameroon with the RRSP and soil judging will be to focus heavily on the basic and secondary educational sectors. This would mean investing in training teachers to tailor simple teaching packages for soil judging and local regional representative soil projects with the goal of training students with to have a basic understanding of soil properties and their land use interpretation. Such an endeavor would involve the three government ministries influencing educational policy in Cameroon: namely, the Ministries of Basic Education, Secondary education and Secondary and Superior Education.

Another strategy would be to introduce and train workers in sectors and government ministries in which their activities or influence will impact the way land is used or managed in general. Certain aspect of land use interpretation in soil judging may be beneficial to the housing and town planning sectors, the agricultural sector and the health and public transport sectors. The RRSP and soil judging training could be
designed differently for different sectors to emphasize the different areas of concern for workers and extension staff.

Of all the suggested strategies to implement RRSP and soil judging in earth science education in Cameroon, a key piece is to engage the government and other departments to recognize and support these projects. Meetings, workshops, and sourcing of funds from relevant government ministries and other international agencies such as USDA will be very important. By broadening the applicability and relevance of soil judging to different sectors in Cameroon such as precision agriculture, it is likely to improve chances of securing funding for more integrated local projects. For instance, geocoding soil samples and soil pit locations from the RRSP and soil judging could merge such data to other projects in agriculture and farming. Another way of making RRSP and soil judging relevant to development would be to complement the results of land use interpretation using score cards with actually test such as soil percolations tests, available water capability and infiltration rate.
References


