Soils Laboratory Improvement Program, First-Visit Report

submitted to

Department of Soil and Geological Sciences, Sokoine University of Agriculture

and

Catholic Relief Services

submitted by

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Farmer to Farmer volunteer consultants

3 March 2017

Refer to Farmer to Farmer East Africa—Tanzania, assignment code TZ92

Background and Goal

We (Drs. Taskey and Dick) were invited as Farmer to Farmer (F2F) volunteer consultants to provide organizational assistance to the Sokoine University of Agriculture (SUA) Department of Soil and Geological Sciences (DSGS). This assignment begins the first phase of a proposed six-phase project to assist DSGS faculty and staff in improving the department's laboratories for commercial services, research, and teaching. An eventual goal of the Department is to fulfill the requirements for laboratory accreditation under ISO 17025. Please refer to the revised Scope of Work submitted to CRS in August 2016 by Dr. Ronald Taskey and Mr. Craig Stubler (attached). (Because of scheduling conflicts, Mr. Stubler was unable to participate in this phase of the project.)

The project's six phases are as follows:

1. Problem and resource assessment and overall plan development
2. Technician training
3. Laboratory adaptation/renovation
4. Commercial laboratory for soil and plant analytical services
5. Develop a funding plan
6. Develop a business and marketing plan; provide training in customer service

This report outlines our findings and recommendations derived during our first visit to SUA. Future assignments, either by us or other F2F volunteers, will be able to address subsequent phases of the overall project.

Dates of the volunteer assignment: Dr. Dick, 21 Feb to 1 Mar 2017; Dr. Taskey, 21 Feb to 3 Mar 2017 (excluding travel and CRS orientation).

Procedures

The findings and recommendations presented herein are based on our personal observations of the Department's facilities and equipment and on interviews with the following people:

SUA Administration

Dr. Susan Nchimbi Msolla, Principal (Dean), Faculty of Agriculture

DSGS Faculty

Dr. Ernest Marwa, Head of Department
Dr. Consolatha Mhaiki
Dr. John Msaky
Dr. Hamisi Tindwa
Dr. Boniface Massawe
Dr. Shitindi J. Mawazo
Dr. Balthazar Msanya
Dr. John Massawe
Dr. Method Kilasara
Dr. Daniel Isadory
Dr. Jerome Pelee Nrema
Dr. Ernest Semu
Dr. Johnson Semoka

DSGS Laboratory Technical Staff

Mr. Eliah Kamwela, principal technologist
Mr. Amour Suleiman
Mr. Alphonce Mgina
Mrs. Mtanke
Ms. Evelyn Twalyo
Apologies to those we were not able to meet

iAGRI* Staff

Dr. David Kraybill, project director
Mr. Simeon Digennaro

Other F2F Volunteers and CRS Staff

Ms. Cheryl Wick, research associate
Department of Food Science and Technology
The Ohio State University
Columbus, OH 43210 US

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Phase 1: Problem and Resource Assessment and Overall Plan Development

Needs and Issues

Most (but not all) of the Department's needs and issues listed below were outlined by Dr. Ernest Marwa during our initial visit on 21 February 2017. We concur with Dr. Marwa that each of these issues must be resolved if the Department's functions for teaching, soil analysis, and research are to remain viable and contribute to meeting Tanzania's rapidly increasing demands for food and fiber production, environmental quality, and academic excellence. The Department requires significant improvement in the following twelve areas, each of which pertains to ISO 17025 standards and guidelines.

- student, worker, and client safety, including chemical handling, transport, storage and disposal
- maintaining functional reliability—instrument calibrations and related requirements
- maintenance and repair of analyzers, pumps, high pressure units, and other equipment
- laboratory organization, inventories, record keeping; procedures for continual updating
- protocols for routine laboratory operations, including handling of samples and supplies
- conflict resolution, primarily related to competition for laboratory use by academic, service, and research needs
- ensuring proper soil sample collection by clients
- sample flow and tracking within the system
- expeditious sample analysis and response to clients
- laboratory correlations and field calibrations for commercial soil testing
- continuous management of laboratory-produced data
- cost and price analyses for commercial clients and budgeting
- complying with ISO 17025 standards

Criteria and Guiding Principles

- Maintain or enhance laboratory functions: teaching, research, service.
- Laboratory improvement for one purpose should not degrade usefulness for another purpose.
- Proposed changes must be needed & justifiable, reasonable & achievable.
- The commercial enterprise should be run as a business, education should be run for education.
- Likewise, commercial clients are customers; students are not—they are students.
- For optimum functioning, commercial services must be separated from academic uses.
- Worker, student, and client health and safety are high priority.

Recommendations

We recommend that the DSGS Head of Department call a meeting of all teaching and technical staff to discuss the conditions and recommendations listed below. The main questions to decide should be What? Who? When? Individuals should be identified to address each area listed (obviously, some areas can be subdivided). The important outcome of the meeting should be Who will accomplish what, and when will it be done. Schedule additional meetings each month to document progress. Avoid this statement: "We can't do this because...."; rather, say "We must figure out how to do this because...."

Address immediate needs and opportunities first. Identify programmatic opportunities, challenges, and constraints. Define all aspects of the problem or goal, set achievable objectives, assign priorities, outline methods, and identify responsible personnel. Previously accomplished work can be inserted into the plan wherever appropriate. The plan should be considered flexible—once they begin, the responsible personnel should make adjustments as needed.

ISO 17025: One of the Department's goals is to conform to the international operation and quality standards for laboratories as specified in ISO 17025. In our view, ISO 17025 guidelines are well-thought, helpful, and reasonable. We agree that steps toward ISO compliance should be given high priority.

RECOMMENDATION: We strongly recommend the following: (i) that each member of the Department—faculty and technicians alike—become familiar with ISO 17025, (ii) that a series of cooperative department meetings be scheduled to discuss the ISO guidelines, and (iii) that each member answer the following question for themselves and their colleagues: **"What are three things that I can do to help move our laboratory closer to ISO compliance?"** Once the question is answered, set a time for accomplishment.

We recommend that the departmental discussions involve all faculty, technical staff, and four student representatives (one each female and male student from the undergraduate and the postgraduate student body). Our experiences have shown that including students in these types of discussions is an excellent way of drawing on student power. Also, it strengthens the students' sense of pride and ownership in their education as well as their loyalty to the department. Students eventually become alumni, and every university needs alumni support. We suggest that the student representatives be awarded academic credit toward their independent-study requirements; a graduate student might develop a master's degree thesis based on the experience.

Training Laboratory Analytical Technicians: Although the Department's ten technicians have had adequate education and training to carry out their assigned tasks, their skills in laboratory

organization, routine facility and equipment maintainance, and troubleshooting should be broadened and strengthened.

RECOMMENDATION: Invite an experienced individual to conduct a one- to three-week training course in general laboratory organization, operations, maintenance, and safety. This might be done through continuation of the F2F volunteer program, if that option remains available.

Equipment-Service Technician: The Department lacks a technical-service expert to properly maintain and repair the laboratory's analyzers, pumps, drying ovens, distillers, and related equipment. Currently, specialized service technicians are hired at significant cost and delay from companies outside the university, often from Dar es Salaam.

RECOMMENDATION: Identify the currently-employed technician who has the highest potential for filling this role; provide that person with intensive training in maintaining, servicing, and repairing electrical systems, analyzers, motors, pumps, distillers, ovens, and other equipment. Alternatively, this technician might be hired at the university or college level and serve multiple departments. Whichever option is chosen, the technician should be knowledgeable in each of the following:

- mechanical, electrical, plumbing, and high-pressure systems used in modern analytical and teaching laboratories
- general laboratory and chemical safety
- accessing and understanding online repair manuals and service bulletins
- ordering and installing replacement parts (except those of a highly specialized nature, which would require assistance from a manufacturer's representative)
- assisting and advising faculty in selecting and ordering new and replacement equipment
- needs of the faculty for teaching students in the laboratory
- record keeping and basic computer skills
- reading and speaking fluent English (most repair manuals and service bulletins are written in English)

The service technician also must have the foresight to anticipate problems that typically develop in a functioning laboratory. Although the technician must continually communicate with faculty and other staff, the technician should not be expected to continually seek out the needs of others; rather, faculty and other staff should take the initiative to keep the technician informed of all needs in a timely and reasonable manner.

Initial training of the equipment-service technician could be conducted concurrently with the training of the Laboratory Analytical Technicians mentioned above.

Laboratory Analytical Procedures Manuals and Protocol Handbooks: These are incomplete and not readily available to all technical staff and faculty. For example, analytical procedures are compiled into a methods manual, which appears to be very good but which apparently exists only as a single copy in paper format. As a result, the manual's flexibility for updating and its availability to all are severely limited; moreover, it is poorly suited for referencing in peer-reviewed scientific journals.

RECOMMENDATIONS: Begin by electronically scanning the existing manual and converting the scanned images into a word-processing format for reproduction and easy updating. **Dr. Dick has offered to assist with this effort.**

Manual of guidelines for routine laboratory operations, technician's duties, and quality control: Given that the Department employs 10 technicians, oversees multiple laboratory rooms, and operates a range of equipment and analyzers, a set of written operating guidelines would be helpful to all.

RECOMMENDATION: Identify two people to draft such a manual. Keep it simple but informative, useful, and easy to update. Possible items to include: organizational chart, location and responsible person for each piece of equipment, general protocols that apply to all laboratories, technicians' areas of responsibility and duties, academic vs. commercial needs and requirements, contingencies for times of work overload or illness, flow chart for handling of soil samples. See ISO 17025, section 16 for suggestions.

Inventory sheets and related documentation: These should answer the questions What do we have, what is it used for, where is it, and when will we need more? They must be complete, kept up to date, and be readily available to all. Inventory books should be kept for academic, research, and service functions. A full accounting of chemical reagents is especially important.

RECOMMENDATION: Put a person in charge, and begin compiling these into a computer spreadsheet.

Employee and student health and safety: Laboratories abound with hazards, ranging from minor to serious. We saw no health or safety manuals in the laboratories. Hazards multiply as laboratory users and types of uses increase.

RECOMMENDATION: Identify laboratory hazards (most will be related to broken glass, acids, volatile compounds, other chemical reagents, electrical systems, high pressure units, heating elements or small fires, and dust or soil contaminants). Post safety rules and guidelines in each laboratory room and enforce them. Provide eye-wash stations, eye protectors, face masks, chemical neutralizers (e.g., baking powder to neutralize acids), fire extinguishers, containers for broken glass). Teach students about laboratory and field safety and require them to abide by the rules (teachers and staff also must heed the rules).

Handling, transport, storage, and disposal of hazardous chemicals: This as a major concern, and should be addressed as soon as possible.

RECOMMENDATION: If a knowledgeable person is not available in the Department, recruit a chemist to help inventory the full chemical supply. Use caution, many containers are old and unlabeled. Refer to the Material Safety Data Sheets (MSDS) (Assistance from the university library might be needed.) Seek specialized professional expertise for proper disposal.

Soil sample collection in the field: Currently, there seems to be no protocols for field collection of soil samples to analyzed in the laboratory.

RECOMMENDATION: Develop a short program designed to educate farmers and other users of the soil-testing program on proper sampling of soils in the field. Several DSGS professors have adequate expertise to conduct such a program.

Soil sample storage: Currently, soil samples for clients are held for 6 months after completion of analyses. Old research samples date back 5 years or more. Holding several thousand samples for this length of time requires considerable space that could be used to greater advantage.

RECOMMENDATION: Shorten post-analysis sample-holding time from six months to one month for analytical clients. Inform clients of the time limit when they submit samples. Research samples should be stored by the researcher.

Space competition and conflicts: Competition for space and equipment among teaching, research, and service functions presents a major obstacle to efficiency and having a successful enterprise.

RECOMMENDATION: We don't know where they are, but facilities must be found to give the soil-testing laboratory a home of its own, separate from the teaching facilities. Meanwhile, laboratory demand might be decreased by reevaluating laboratory teaching requirements to determine if any activities can be accomplished in the field. We strongly suspect that laboratory crowding could be significantly decreased, but we did not have opportunity to document this.

Preparing and marking students' final examinations: This might appear to have nothing to do with laboratory constraints, but we feel that it is relevant because of the extraordinary amount of resources and teaching faculty time that currently is devoted to marking examinations by multiple people. The current system does not improve student learning; rather, it merely is a form of policing highly educated and highly qualified professors. Undoubtedly, the present system costs far more than it is worth. We suggest that resources and time spent on preparing and marking examinations could better be spent on alleviating the serious laboratory limitations.

RECOMMENDATION: Arrange a meeting to begin discussing this problem. Universities outside of East Africa have been using less burdensome, more efficient systems for many decades, while still maintaining fairness and impartiality. We are aware that a major change would be fighting a strong tradition, but the time has come.

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Sokoine University of Agriculture Soil Laboratory Improvement Program
Farmer to Farmer, East Africa
Project Assignment Code TZ-92

Overall Goals of the Project:

1. Improve efficiency of the current DSGS laboratory for teaching, research, and consultancy.
2. Develop and conduct a technician-training program in laboratory procedures, maintenance, and protocols.
3. Develop a program for commercial soil-analytical services.

Suggested Approach:

The background information and issue description in the original TZ92 scope of work suggest programmatic challenges as well as technical needs. We suggest that the project be divided into phases, each having a scope of work that identifies the responsible personnel (SUA and F2F consultants), and outlines the goal, specific objectives, projected timelines, and desired outcomes.

As consultants, F2F volunteers should collaborate with SUA faculty, staff, and administration to develop effective mechanisms for implementing, correlating, and administering the competing programmatic and laboratory functions. Depending on needs, F2F volunteers would assist (3-week assignments) with each phase.

We recommend that at least one undergraduate student and one graduate student be allowed to participate in each phase. Also a potential outside client for the proposed soil-analytical services program might be invited to participate in phase 4. In addition to providing helpful perspectives, students and potential clients could help to promote the improvement efforts and ensure their success.

Proposed Key players

Undergraduate-1CRs

Postgraduate-1CRs

Client-representative from research institutions

F2F volunteers

SUA College

DSGS teaching and technical staffs, and administration

Phase 1. Problem and Resource Assessment and Overall Plan Development

Address immediate needs and opportunities first. Identify programmatic opportunities, challenges, and constraints. Define all aspects of the problem or goal, set achievable objectives, assign priorities, outline methods, and identify responsible personnel. Previously accomplished work can be inserted into the plan wherever appropriate. The plan should be considered flexible—once they begin, the responsible personnel should make adjustments as needed.

1. Identify immediate and anticipated needs (space, durable equipment, expendable supplies, safety protocols, and maintenance and repair items, responsible personnel) for each of the following:
   A. teaching courses—soil chemistry and fertility, soil microbiology and biochemistry, soil physics and Field experimentation. What is needed is Lecture room and laboratories. They are all available. Soil physics equipment need repair. Responsible personnel: F2F will do the teaching. Lab and equipment will be provided by DSGS (Chief Technician, Dr. Mhaiki)

B. Research support: Research formulation and Management: F2F
C. Training of laboratory technical staff: F2F will provide training & DSGS will provide technician

(Note: To minimize complications, the commercial soil-testing laboratory is addressed later.)

2. Inventory on-hand and potentially available (e.g., possibility of sharing) resources (space, equipment, supplies, and field areas) for each of the following:
   A. teaching courses: Existing laboratory manuals at DSGS, lecture room available
   B. research support: Analytical labs, demonstration plot (one acre) and two screen houses are available
   C. training of laboratory technical staff: 9 laboratory technicians available for training
3. Identify and assess limitations and constraints (physical, financial, institutional, and social) that might hinder success in each of the three areas (teaching, research, and training).

   Availability of financial resources from SUA to support purchase of chemicals for analytical lab and combining teaching of technicians and students at the same time can be a problem.
4. Estimate improvement costs for each area and prepare a preliminary budget.
   - Estimated cost for staff compensation allowances of 30,000/= per day for each trainee
   - Estimated costs for (stationery) 250,000/=
   - Estimated costs for training materials (chemicals & consumables) 3,500,000/=
   - Estimated costs for spare parts if needed should be pre purchased
   - **NB** Key player Head DSGS should ask for availability financial resources from SUA administration
5. Look ahead to Phases 2-5. Expand and refine the provisional scopes of work outlined below, and outline a provisional budget for each. For phases 3 and 4, identify potential clientele and outline needs for a soil (and crop?) testing program to be developed in phase 4. Begin to develop a system for setting priorities and reconciling competing demands.
6. Prepare for phase 2, Technician Training.

Phase 2. Technician Training

Develop and deliver training courses for laboratory technicians to help them improve proficiency in operating and maintaining laboratory equipment. Courses should address ISO standards and current performance requirements, preventive maintenance, and troubleshooting, as well as laboratory safety, chemical handling and storage, and efficient laboratory organization. Course sessions should include at least the following:

1 Quality assurance and control, and compliance to ISO 17025 quality standards

   F2F should assist to acquire/subscribe for reference standards from recognized source
2. Training in the operation, maintenance, and troubleshooting of spectrophotometers UV VIS, FTIR Spectrometry, AAS/GF Spectrophotometers and more specifically the following:
   A. Kjeldahl Foss Tecator 2000 series
   B. Bruker FTIR Spectrometry IR SPEC
   C. Bio-Mate 6 UV-Visible Spectrometry (scan and quant modes)
   D. Varian AAS FS 220 (NOTE: The Varian company is no longer in business and this model no longer is produced. Parts and service might not be readily available)

There is a need for DSGS/F2F to approach Agilent ahead of the training to seek for the possibility of acquiring spares for varian

E. Thermo Scientific iCE 3000 AAS-GF spectrophotometers

3. Laboratory safety for students, staff, and visitors. Acquisition of protective gear lab coats & gloves are needed.
4. Developing and testing standard solutions, making dilutions, and analyzing samples at various concentrations.
5. Efficient organization to meet the demands of competing purposes.
6. Improve data processing by acquiring software for laboratory information management systems that can solve problems of reception (tagging), registry, quality assurances, tracking and reporting (introducing the application of LIMS software application of IT in lab management and reporting). (NOTE: This probably should be addressed in a later phase.)
7. Use of statistical quality control charts and their application in data acquisition in the lab. There is a need for DSGS to purchase or assisted by F2F to acquire those charts

Phase 3. Laboratory Adaptation/Renovation

(Note: This phase is expected to meet special challenges. Findings and determinations from phases 1 and 2 should help set a course of action.)

Adapt and refit the present laboratory to accommodate commercial soil-analytical services as well as teaching and research—all in one laboratory. This goal is expected to meet with special challenges stemming from competing purposes and space requirements, differing operational requirements and protocols, and time and scheduling constraints. A single laboratory room may prove inadequate.

In addition, the increasing demands for teaching and research and pressure to accommodate consultancy services are exceeding infrastructure capabilities, while also stretching technical-staff expertise and faculty workload. Some of these challenges could be addressed (at least preliminarily) in phase 1.

Numerous factors must be considered to renovate the laboratory for the proposed multiple uses. Here is a partial list:

- spaces for receiving, coding, and storing samples
- equipment and supply storage (rearranging equipment and supplies for different purposes could be time consuming)
- separation of dusty (e.g., sieving, grinding) from clean activities
- evaluation of water, gas, and electrical availability
- properly operating fume hood
- safety station
- student seating and work areas
  Final consideration should be based on site assessment and evaluation.

Phase 4. Commercial Laboratory for Soil (and Plant?) Analytical Services

The following components and activities should be considered in developing the soil analysis and testing programmer:

- employee/ training of personnel
- quality assurance and control

- different requirements, protocols, and outcomes for different purposes (e.g., agronomic crop production, forestry, soil survey)
- evaluations of field conditions, crop-management practices, and the client's goals
- protocols for field sampling at possibly different scales (Macro sampling vs Micro sampling)
- a system for initial processing and longer-term storage of samples
- calibration of nutrient-extraction solutions and methods
- correlation of laboratory analyses with field applications and crop responses, and provision for feedbacks
- client initiation and good long-term working relations with clients
- recommendations to clients
- system for processing and storing data (e.g., Laboratory Information Management Systems)
- relations with suppliers of fertilizers and amendments (sometimes a delicate business because of potential conflicts of interest)
- how to anticipate and deal with special problems (e.g., soils or crops that do not respond to normal fertilizer inputs and management activities)

Under current conditions (as described in the SoW), scheduling and space conflicts for the various purposes probably will limit the ability to provide quick results to clients.

Note: A separate account for the lab has been opened and provisional manager for the lab has been appointed, but he needs training on how to handle commercial lab.

Phase 5. Develop a Funding Plan

This phase should be initiated during phase 1 and further developed through succeeding phases. A specialist having expertise in international funding opportunities and grant writing should be engaged. This will be necessary to implement phases 3 and 4. There is also a need for stakeholders to approach different potential donors).

Phase 6. Marketing and Training in Customer Service

Specialists in business, marketing, and customer service should be engaged to offer expertise in these areas.