Building Capacity for Decision Makers in Ghana for Sustainable Land Use Planning using Earth Observations and Open-Source GIS Tools

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Abstract

The total population of Ghana has tripled between 1960 and 2015. During the same period, the urban population, however, grew more than 11 times. Rapid urbanization and large increase in population dramatically changed the land cover of the West African country. For example, agricultural land expanded from occupying 13% in mid-1970s to more than a third of Ghana's total land area today. In the meantime, forests and savannas face a huge pressure of being converted to agricultural or urban land uses. The Ghana Land Use Project (GALUP) aims at enhancing the country's capacity in dealing with these challenges. The project engages both institutions and government agencies in Ghana to deliver a series of training workshops focused on remote sensing and geospatial technologies that can facilitate the formulation of sustainable land use plans. In-person workshops were planned initially, but because of travel restrictions due to the COVID-19 pandemic, the first GALUP workshop—Land-Use Suitability Analysis with QGIS Tools—was conducted online. Such means of capacity building presented an exceptional opportunity to explore novel methods for transferring knowledge while also forging strong partnerships that are easier with in-person meetings. The 3-month long workshop was delivered in a hybrid mode featuring synchronous and asynchronous components. This hybrid mode was unusual for both trainers and the 41 trainees from four organizations including the Land Use and Spatial Planning Authority (LUSPA), the Center for Remote Sensing and Geographic Information Services (CERSGIS), the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) and the Agro-Hydrological and Meteorological Centre (AGRHYMET) in Niger. The synchronous component involved weekly meetings and discussion session, and the asynchronous component consisted of a GitHub repository. The repository contained (a) fourteen open-source GIS tools developed for land-use suitability modeling, (b) a discussion channel for Q&A and idea-sharing, and (c) four modules of training materials, each equipped with customized videos and multiple exercises to boost the learning process. The repository has received over 13,000 views since the beginning of the workshop.

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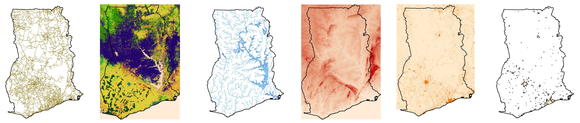
Introduction

The total population of Ghana has tripled between 1960 and 2015. During the same period, the urban population, however, grew more than 11 times. Rapid urbanization and large increase in population dramatically changed the land cover of the West African country. For example, agricultural land expanded from occupying 13% in mid-1970s to more than a third of Ghana's total land area today. In the meantime, forests and savannas face a huge pressure of being converted to agricultural or urban land uses. The Ghana Land Use Project (**GALUP**) aims at enhancing the country's capacity in dealing with these challenges. The project engages both institutions and government agencies in Ghana to deliver **a series of training workshops** focused on *remote sensing* and *geospatial technologies* that can facilitate the formulation of **sustainable land use plans**. This poster describes the capacity building effort made by the first GALUP workshop—***Land-Use Suitability Analysis with QGIS Tools*** (see Fig 1). In-person workshops were planned initially, but because of travel restrictions due to the COVID-19 pandemic, the first GALUP was conducted online. Such means of capacity building presented an exceptional opportunity to explore novel methods for transferring knowledge while also forging strong partnerships that are easier with in-person meetings. The workshop was delivered in a hybrid mode featuring synchronous and asynchronous components. This **hybrid** mode was unusual for both trainers and the **41 trainees** who are professional planners, practitioners, and researchers from multiple local agencies and institutes.

- **Synchronous** component: regular meetings and "office-hour" sessions via Zoom.
- **Asynchronous** component: training content published on a **GitHub repository**.

The repository contained (a) fourteen open-source GIS tools developed for land-use suitability modeling, (b) a discussion channel for Q&A and idea-sharing, and (c) four modules of training materials, each equipped with customized videos and multiple exercises to boost the learning process. The repository has received about **28,000 views** since the beginning of the workshop.



(a) Roads (b) Land cover (c) Hydrology (d) Elevation (e) Population (f) Cities

Fig 1. Example criteria used for land-use suitability modeling in the workshop.

Workshop Description

Goals & Objectives

The workshop aimed at core concepts and techniques used in land-use suitability analysis, that inform land-use decision making. Specific objectives include:

- Understand key concepts in land use analysis.
- Perform spatial analysis using **QGIS**.
- Create models for suitability analysis using **Graphical Modeler** in QGIS.
- Use Multi-criteria Decision making (**MCDM**) techniques to make land-use decisions.

The geospatial analysis was conducted using QGIS plugin, **PyLUSATQ**, developed by the GALUP team. By the end of the workshop, the trainees could be expected to independently visualize GIS data, conduct geospatial analysis, interpret results of suitability analysis, and identify suitable areas for a particular land use.

Workshop Content

The workshop consisted **four training modules** that included **video demos** and tailored **exercises** to facilitate learning.

Module 1 - Software and data preparation
- *Install QGIS and PyLUSAT, and loading PyLUSATQ plugin in QGIS,*
- *Visualize GIS data and creating maps in QGIS.*

Module 2 - Introduction to PyLUSATQ
- *Learn when and how to use different tools in PyLUSATQ,*
- *Use the tools to answer planning-related questions.*

Module 3 - Create suitability models with QGIS Graphical Modeler
- *Understand the workflow of suitability modeling,*
- *Get to know the QGIS Graphical Modeler,*
- *Learn how to build suitability models with PyLUSATQ in the Graphical Modeler,*

Module 4 - Aggregate results to make land-use decisions
- *Understand the LUCIS workflow and hierarchical structure,*
- *Integrate row crop model into the LUCIS framework,*
- *Understand and run the Analytic Hierarchy Process (AHP) using PyLUSATQ.*

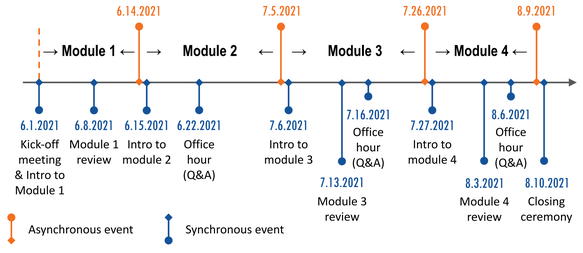
Surveys

Three types of survey were conducted for the workshop as follows:

1. **Pre-training survey** (anonymous) was conducted a week before the workshop to understand participants' interests, professional background and experience, and workshop expectations.
2. **Post-module surveys** (non-anonymous) were conducted after each module to get feedbacks about new skills and knowledge learned as well as difficulties face
3. **Post-training survey** (anonymous) was conducted to learn participants overall evaluation of the workshop content and instructors.

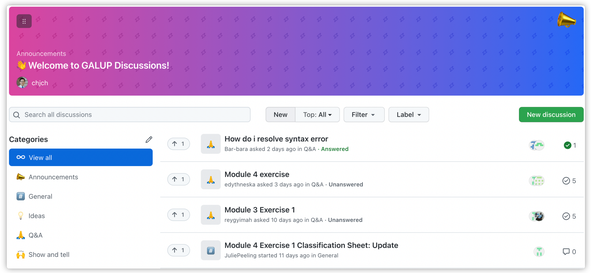
Timeline

Comparing to in-person training, the agenda of an online capacity building workshop was much more accommodating and flexible. The training offered by the first GALUP workshop included over **12 hours** (in total) of synchronous instructions via Zoom teleconferences accompanied by **20 hours** of asynchronous materials and exercises on the GALUP GitHub repository.



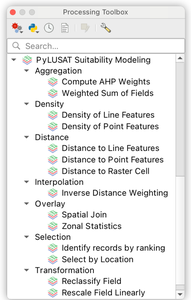
GitHub Platform

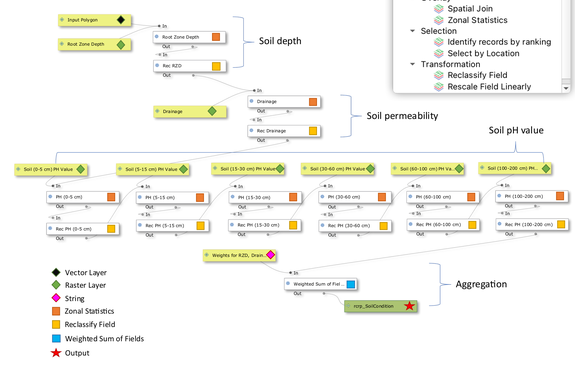
A GALUP GitHub repository (https://github.com/SERVIR-WA/GALUP) was the portal for all training workshops to (a) host training materials, (b) distribute PyLUSATQ, (c) receive exercise submissions and provide feedbacks about them, (d) engage with trainees through the **Discussion** channel.



Open-source Geospatial Tools

- **PyLUSATQ**: A QGIS Plugin for land-use suitability analysis.
  - Consists of 14 tools for vector-based GIS analysis
  - Multi-criteria decision making (MCDM)
  - Integrated into QGIS's ***processing framework***
- Available at https://plugins.qgis.org/plugins/pylusatq
- For details visit: https://github.com/chjch/pylusat-qgis

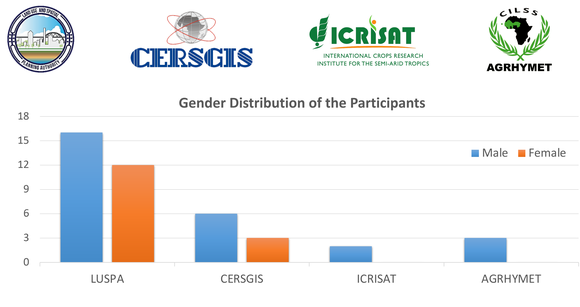




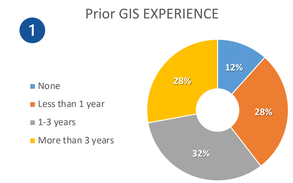
Participation

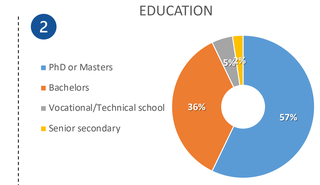
There were **41 trainees** representing **4 organizations**:

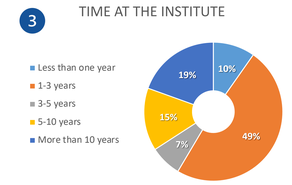
1. Land Use and Spatial Planning Authority (**LUSPA**),
2. Center for Remote Sensing and Geographic Information Services (**CERSGIS**),
3. International Crop Research Institute for Semi-Arid Tropics (**ICRISAT**),
4. Agro-Hydrological and Meteorological Centre (**AGRHYMET**).



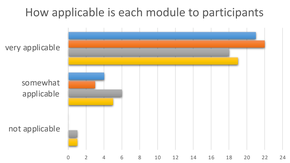
Results



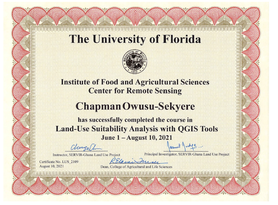




1. Almost half of the trainees have less than 1 year GIS experience.
2. More than 90% of the trainees has a Bachelor degree or higher.
3. More than half (59%) of the trainees are in early career (less than 3 year at the institute).



At the conclusion of the workshop participants who met all requirements earned a course completion certificate.



Key Takeaways

- Combination of synchronous and asynchronous components delivers effectiveness for online capacity building.
- A GitHub organizational account has been established for **SERVIR-WA** to be used for workshops by the entire West Africa Hub.
- Not just for developers, the GitHub platform is an **efficient** and **versatile** platform for online capacity building.
- Surveys indicated (1) the **video demos** with step-by-step instructions, (2) the **readiness** of the GALUP team to assist them, and (3) the **flexibility** built in the workshop schedule were the most helpful features for the participants.
- **Institutional support** from our primary stakeholder, LUSPA, was critical for the workshop's success.

Acknowledgement

The GALUP project and the capacity building efforts along with it is made possible by a SERVIR Award, grant # **80NSSC20K0153**. We thank the support from all our partners including NASA, USAID, SERVIR, LUSPA, and CERSGIS.