Project Title: Bringing evidence to bear on negotiating ecosystem service and livelihood trade-offs in sustainable agricultural intensification in Tanzania, Ethiopia and Zambia as part of the SAIRLA program

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Report Title: Systematic Land and Soil Health Assessment in Solwezi, Zambia: Milestone 3.2

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The Sustainable Intensification of Agricultural Research and Learning in Africa (**SAIRLA**) Programme is a UK Department for International Development-funded initiative that seeks to address one of the most intractable problems facing small-holder farmers in Africa - how to engage in the market economy and to deliver sustainable intensification of agriculture, that is, which avoids negative impacts on the environment. SAIRLA will generate new evidence to help women and poor African smallholder farmers develop environmentally and financially sustainable enterprises and boost productivity. The research will focus non-exclusively on 6 countries (Burkina Faso, Ethiopia, Ghana, Malawi, Tanzania and Zambia), thus complementing other research efforts in these regions.

Suggested citation:

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Photo cover page: Participants in the LDSF Field Training in May 2017, which included ZARI staff, ICRAF staff and farmers, holding their certificate for the training.

I. Introduction to Land and Soil Health

It is important to understand to key constraints to agricultural intensification in order to identify priority interventions, conduct trade-off analysis of the various SAI options as well as monitor changes over time. It is acknowledged that there are diverse pathways for SAI across smallholder famers in Africa, and that soil health and land degradation, in general, play an important role in identifying biophysical constraints and opportunities (Vanlauwe et al., 2014). While, the concept of SAI, which aims to increase agricultural production in an environmentally sustainable way, implicitly involves trade-offs, understanding the social, economic and environmental trade-offs of SAI is inherently complex, especially across diverse agro-ecological landscapes and over time. Frameworks, highlighting this complexity using the ecosystem services approach, often call for the approaches tailored to the specific context (Bommarco et al., 2013). However, the data to inform these site-specific interventions and eventually assess the trade-offs across these various ecosystem services are needed. For example, it is widely cited that the degradation of soil and water resources further exacerbate the potential agricultural productivity across farming systems (Lal, 1987; Vågen et al., 2005; Vanlauwe et al., 2015; Verchot et al., 2005). In addition, soil provides multiple ecosystem services, e.g., as a medium for plant and agricultural production, a filter for toxins and pollutants and by regulating the hydrologic cycle (Millennium Ecosystem Assessment, 2005). This project aims to address and fill these data gaps by conducting systematic assessments of the land and soil health conduct interdisciplinary trade-off analysis of prioritized SAI interventions.

As reported in Milestone 3.1, data gaps were identified for the project sites, e.g., gaps on the effect of SAI on soil fertility and soil health and gaps in terms of geo-referenced indicators for the trade-off analysis. This milestone aimed to fill these data gaps by conducting systematic assessment of land and soil health in the Zambia project site (St. Francis, Solwezi district) using the Land Degradation Surveillance Framework (LDSF).

II. Land Degradation Surveillance Framework (LDSF)

The Land Degradation Surveillance Framework (LDSF) is a field sampling method designed to provide a biophysical baseline at landscape level, and a monitoring and evaluation framework for assessing processes of land degradation and the effectiveness of rehabilitation measures (recovery) over time (Tor-Gunnar Vågen et al., 2013). The framework is built around a hierarchical field survey and sampling protocol using sites that are 100 km^2 (10 x 10 km). Developed by ICRAF over a decade ago, the LDSF has been applied across landscapes in over 30 countries to assess key indicators of ecosystem health http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/ (Figure 1). For example, the LDSF has been used to assess the impacts of cropping systems on indicators of soil health in Tanzania (Winowiecki et al., 2016b), to map soil organic carbon stocks and its variation across land use types (Vågen and Winowiecki, 2013; Winowiecki et al., 2016a), among several other applications.

The LDSF can be applied across landscapes, including protected areas, smallholder farming systems, rangelands, mosaic landscapes, etc. Figure 2 highlights the variables measured at the plot (1000m^2) and subplot (100m^2) scales. All field data is collected using electronic data entry platforms and uploaded the ICRAF database, which is hosted on the Nairobi, Kenya campus and backed up in Oslo, Norway.

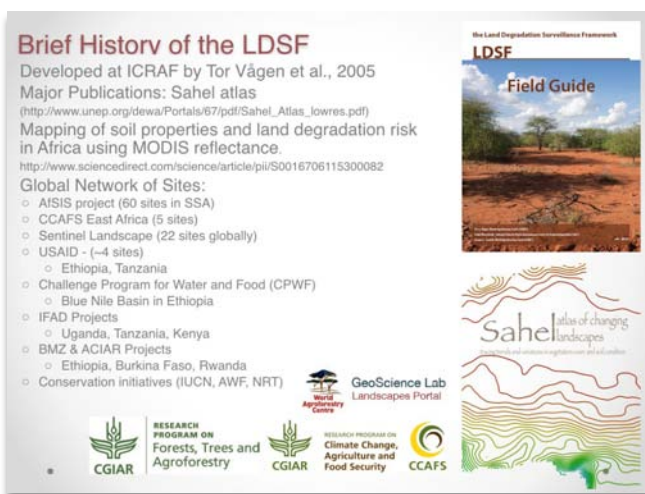

Figure 1: Brief history of the LDSF.

Variables collected in the LDSF include:

- Cultivation practices, tree and shrub densities, landscape topographic position, slope, soil erosion, soil organic carbon (SOC), soil total nitrogen (TN), soil pH, impact to habitat, assessment of soil water conservation measures, infiltration capacity, among others.

These data will be used in the trade-off analysis, providing biophysical data on ecosystem health. These data and the associated outputs will also be key input parameters for the SAI dashboard. By applying advanced data visualization and actionable data, the SAI dashboard will help facilitate communication of data and analysis between scientists and stakeholders. This will then allow for interrogation of evidence and increase the rate of discovery and help contextualize the data used. The SAI dashboard will be designed as an integrated part of the SHARED approach, which ensures that the tools developed are firmly embedded in a strong facilitation process.

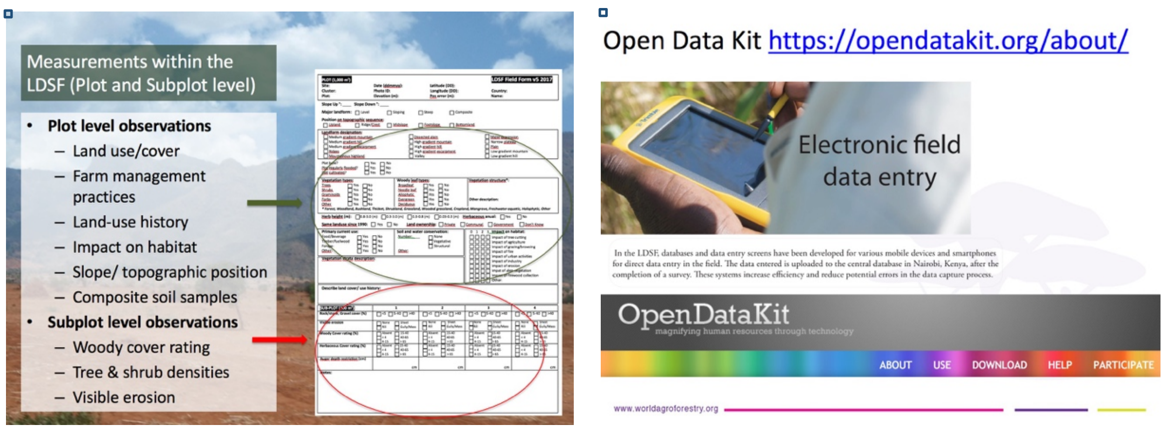

Figure 2: LDSF measurements and electronic data capture.

III. Capacity Building and Training with National Partners

The field training took place in Solwezi district, at the St. Francis LDSF site (Figures 3-4). The training was led by Dr. Leigh Winowiecki of ICRAF and co-facilitated by Dr. Patricia Masikati also of ICRAF. Staff from ZARI-Solwezi office were trained as well as farmers from the St. Francis community. Participants were trained in navigation with the GPS units, electronic data entry using Open Data Kit (ODK), as well as the specifics of the systematic land and soil health assessments. This includes, both plot and subplot level observations and measurements, including: cultivation observations, management practices, tree biodiversity surveys, slope measurements, impact to habitat assessments, erosion observations and soil sample collection.

The participants continued the survey at the LDSF site immediately after the training, for a total of one month.

Figure 3: Photo of the team in the miombo woodland, St. Francis village, Solwezi, Zambia.

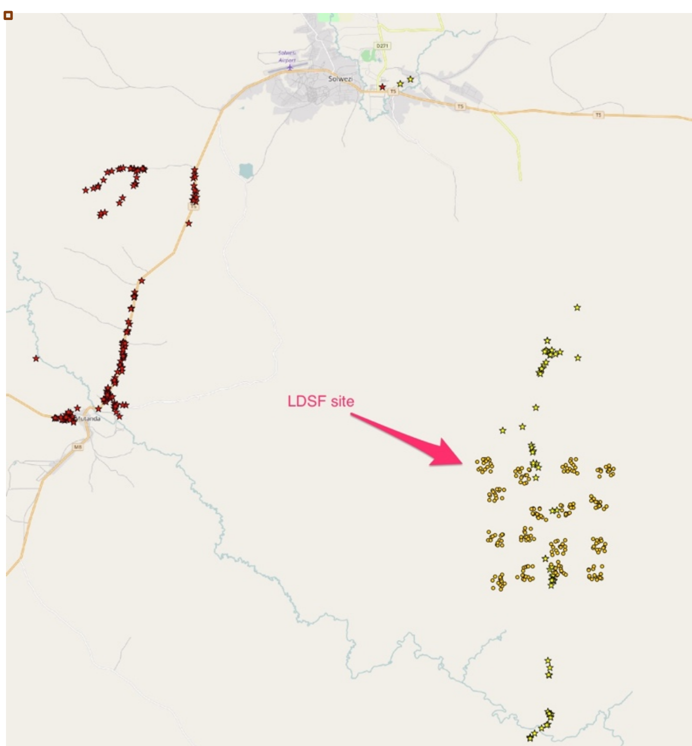

Figure 4: Location of the St. Francis LDSF site and the HH interviews conducted by the partner VIPS project.

IV. Preliminary Results

A. Cultivation

One hundred and sixty plots were sampled in the St. Francis LDSF site. Most of these plots were classified as not cultivated, with only 25 plots cultivated, ~15% of the site. The main crops were maize and beans, with additional crops including cassava, pumpkin, sweet potato, and some banana. Average age of cultivation was ~ 5 years, indicating the relatively recent cultivation. Of those 25 plots, none were reported to have incorporated farm yard manure, and 50% of the plots had inorganic fertilizer applied to the plots. Twenty-four of the 25 plots were burned annually. Figure 5 shows the location of the plots, whether they were cultivated or not and the average tree density per plot. Note the low tree densities in the cultivated plots.

While ~85% of the plots were classified as not cultivated, a majority of non-cultivated plots were naturally regenerating, having been cultivated roughly 40 years ago. This area has undergone cultivation cycles for decades, with recent influx of new inhabitants to the region.

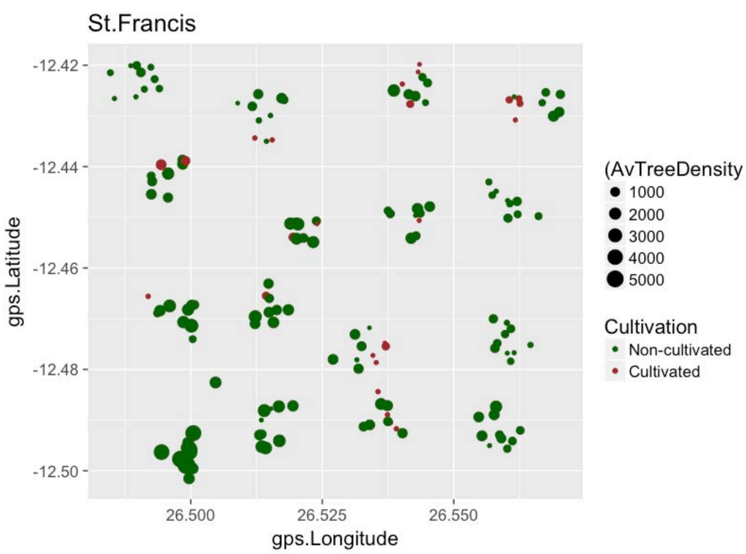

Figure 5: Location of the 160 LDSF plots at the St. Francis site, with the tree density indicated by the size of the bublle and cultivated plots in red. The photo on the right shows some of the cultivation methods in Solwezi.

Figure 6: Photos of the cultivated plots in St. Francis.

B. Land Degradation

Soil erosion prevalence is a key indicator of land degradation. Visible soil erosion as well as the classification of the erosion was conducted at each subplot (n=4) per plot, for a total of 640 erosion observations per site. The St. Francis LDSF site had 107 plots classified as having severe erosion, while only 53 plots were classified as not having severe erosion. Therefore, erosion prevalence is seen as a potential limitation to agricultural productivity and important to prevent.

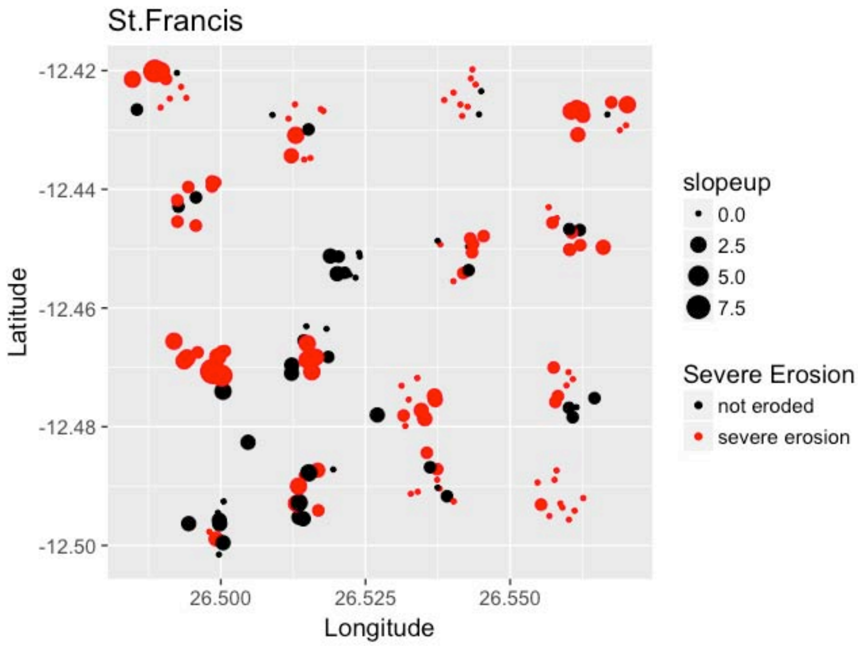

Figure 7: Erosion prevalence per plot. Note that slope is not the major driver of erosion.

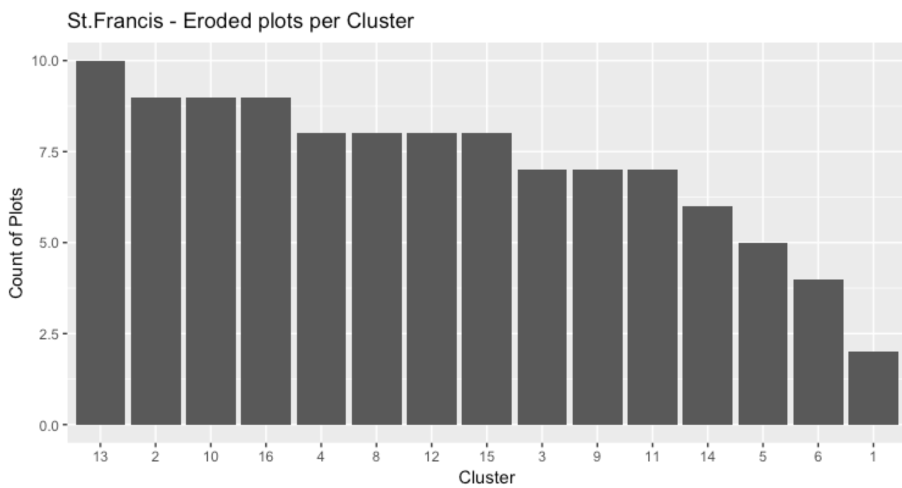

Figure 8: Number of plots per cluster classified as eroded.

Soil samples were collected at the subplot level and composited at the plot level for topsoil (0-20cm) and subsoil (20-50cm). The soil samples were processed at the local ZARI lab in Mutanda, Solwezi district. Processed soil samples were then shipped to Nairobi to be analyzed at the ICRAF Soil and Plant Spectral Laboratory. The soil analysis is still underway and results will be reported on once complete. These data will be collated into the ICRAF GeoScience Lab relational databases and prepared for input into the SAI dashboard, for example as land and sol health maps, or for use in the trade-off analysis assessing the effects of SAI practices on soil properties.

V. Cross-site Comparison

This project is working across three sites in Ethiopia, Tanzania and Zambia. LDSF surveys were conducted in Ethiopia and Zambia by partner projects, as reported in Milestone 3.1. Because the LDSF is a systematic field survey methodology, we can conduct cross-site comparisons. For example, Figure 9 demonstrates the percent cultivation across the three sites. Figure 10 shows the tree densities in cultivated and non-cultivated plots across the three sites. Note the low overall tree densities in cultivated plots across all sites. As mentioned earlier, land degradation limits overall agricultural productivity. The Alem, Ethiopia site had the highest prevalence of soil erosion, while Mahongole (Tanzania) and St. Francis (Zambia) sites had about 50% erosion prevalence (Figure 11). It will be important to encourage SAI interventions that curb the erosion to enable increased agricultural productivity.

The LDSF datasets allow for the production of maps of key indicators of soil and land health, that can aid in prioritizing interventions as well as monitoring over time. For example, maps at a resolution of 500-m are available for SSA (Vågen et al., 2016) and maps at 30-m resolution have been produced for various sites in East Africa using Landsat imagery (Tor-G Vågen et al., 2013). This project will use the LDSF data to produce maps for the project sites at a resolution of at least 30-m, which will be incorporated into the SAI Dashboard and shared with stakeholders. An example of the soil erosion prevalence map for the Ethiopia Alem site in Ziway is presented in Figure 13.

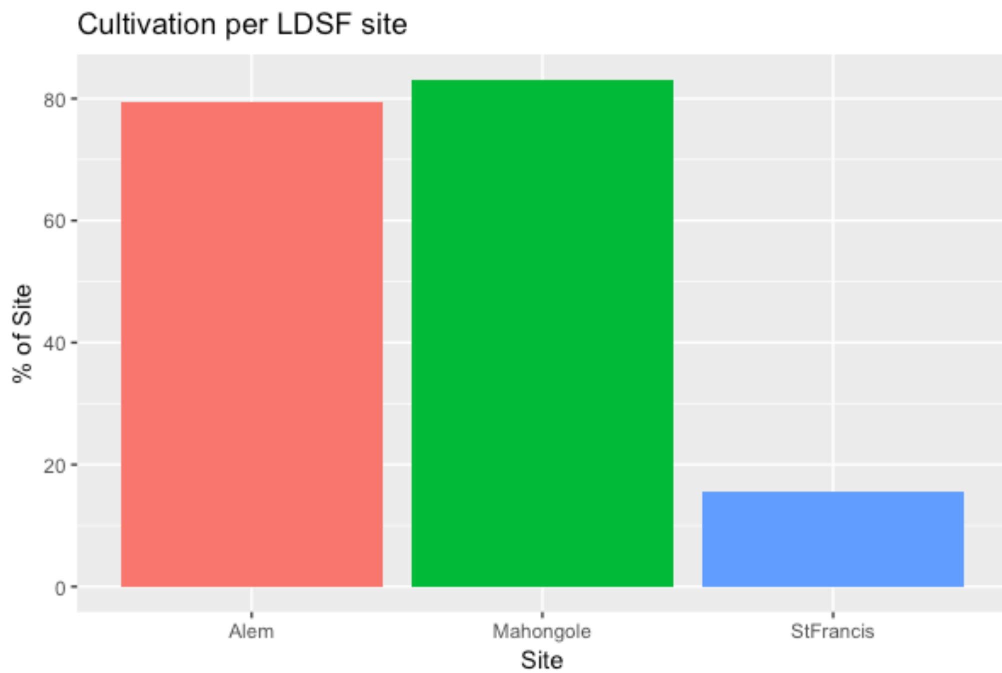

Figure 9: Percent of the LDSF site that is cultivated.

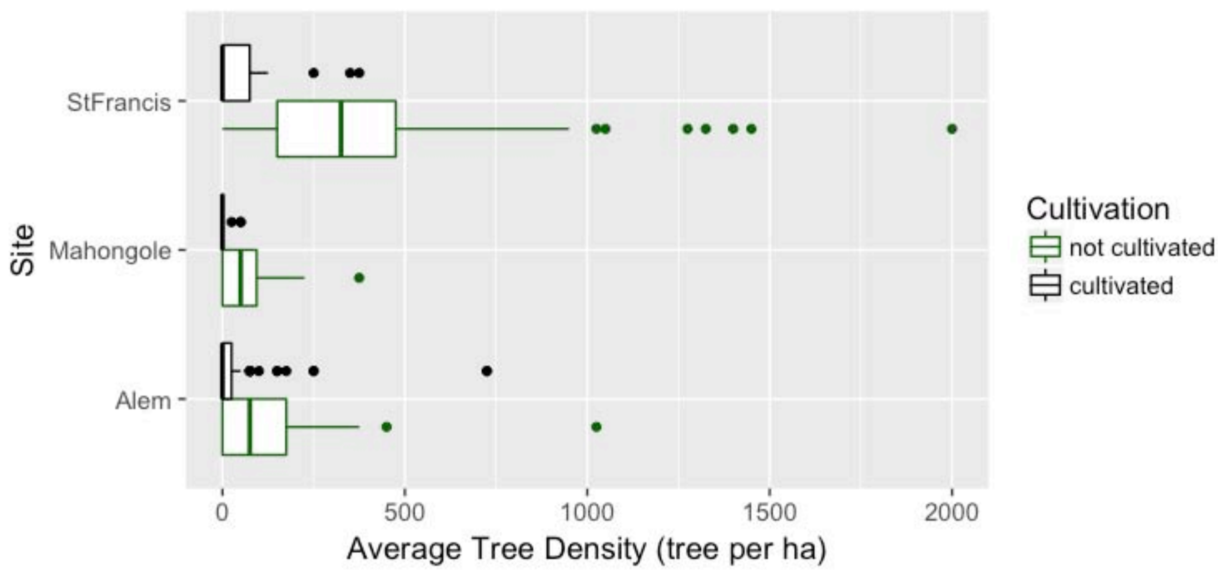

Figure 10: Tree density in cultivated and non-cultivated plots across the three sites. Note that St.Francis has the highest tree densities, and that tree densities are highest in non-cultivated plots compared to cultivated plots across all sites.

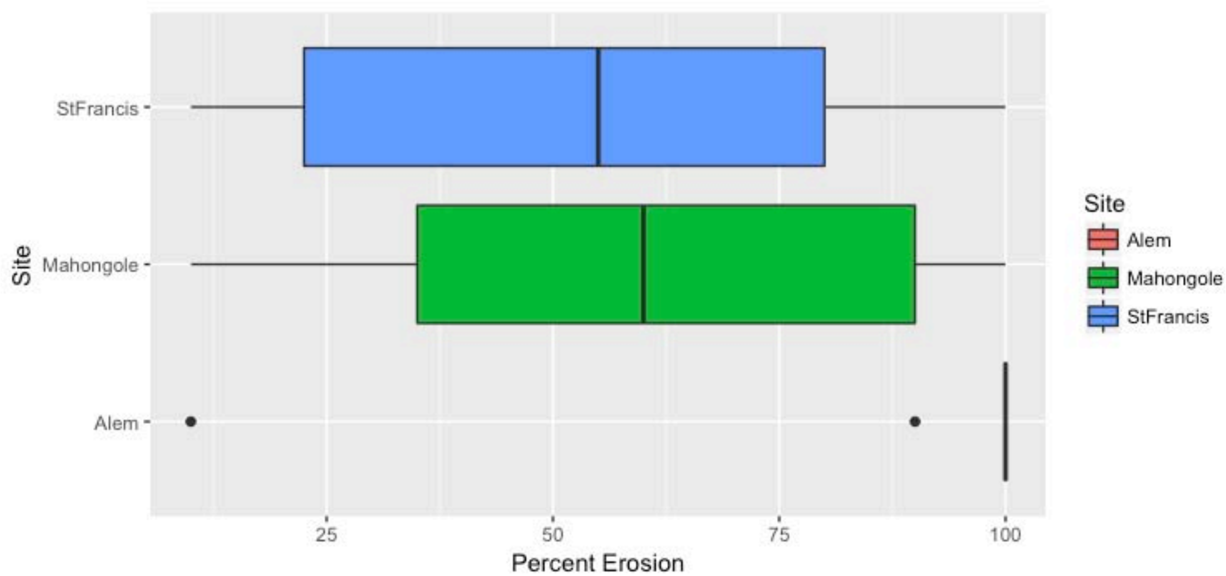

Figure 11: Erosion prevalence across the three sites. Note the high erosion at the Alem, Ethiopia site.

Despite the high erosion prevalence across the three sites, there are very few soil-water-conservation (SWC) activities (Figure 12). This could be an important component of the SAI interventions, and was highlighted during both the district-level and national-level SHARED workshops.

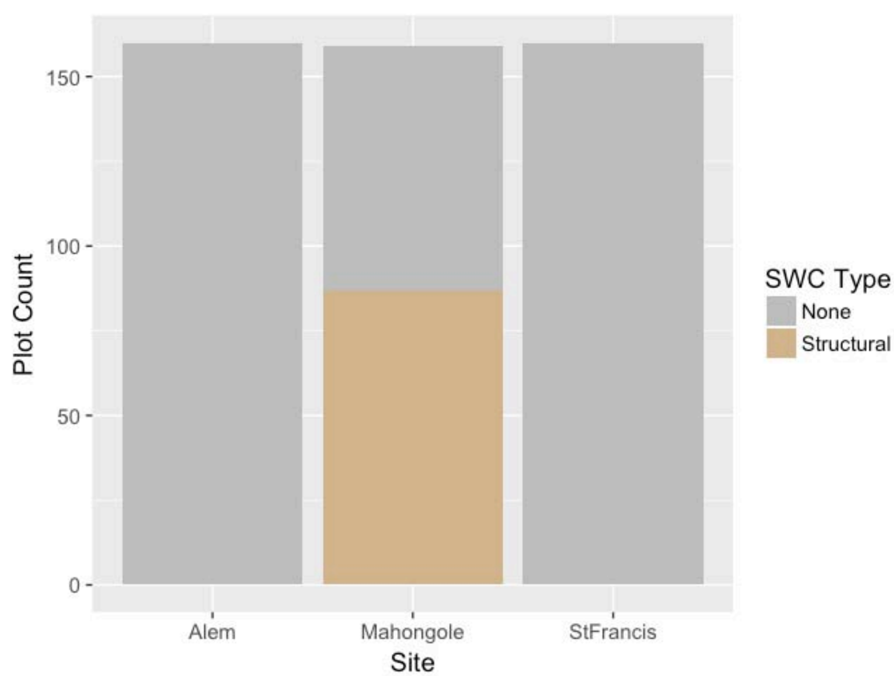

Figure 12: Soil Water Conservation (SWC) measures practiced across the 160 plots per sites.

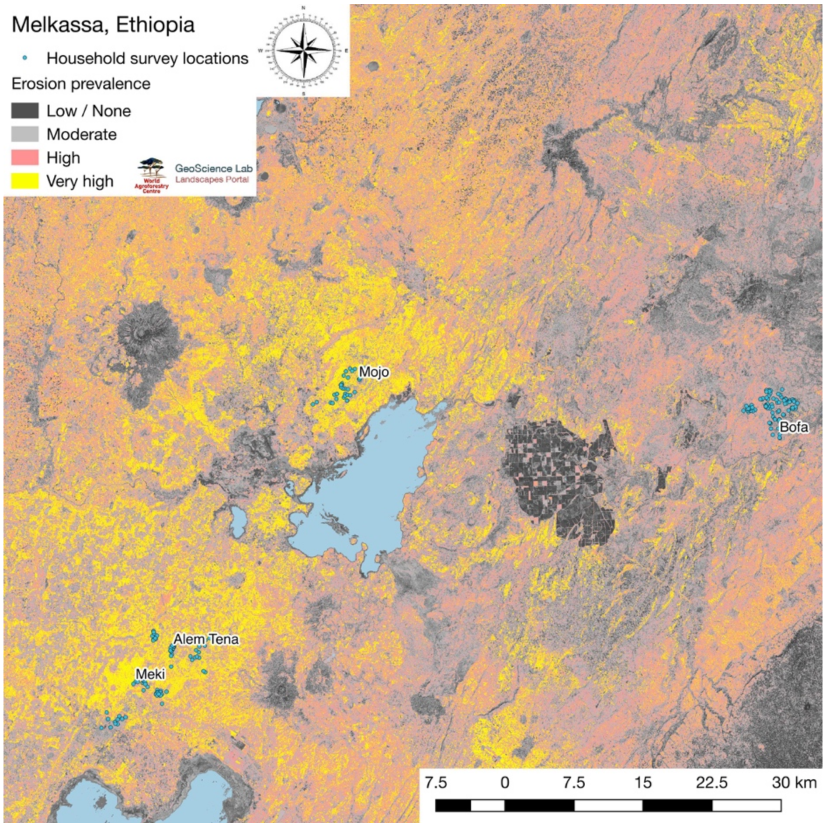

Figure 13: Map of soil erosion prevalence at the Alem Teno site in Ethiopia.

VI. Next Steps

These data are currently being compiled for incorporation in the beta version of SAI dashboard. That includes the production of maps of key indicators. For example, Figure 13 shows the erosion prevalence map of the Alem, Ethiopia site. The soil analysis of the St. Francis LDSF site are underway and should be finished shortly. These data will be incorporated into the trade-off analysis.

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VIII. Appendix A. Agenda for the LDSF Field Training

Solwezi Biophysical Baseline Assessment using the Land Degradation Surveillance Framework (LDSF) Field Training Schedule

Objective: To train National Partners on the Land Degradation Surveillance Framework (LDSF) field methodology. Local teams will use the LDSF at 1-100 km^2 LDSF site in Solwezi to conduct a biopysical baseline on soil and ecosystem health, as well as capture tree and shrub biodiversity and land use history. These data will be used in the project, "Bringing evidence to bear on negotiating ecosystem service and livelihood trade-offs in sustainable agricultural intensification in Tanzania, Ethiopia and Zambia as part of the SAIRLA program"

Project Website: http://www.worldagroforestry.org/project/bringing-evidence-bear-negotiating-ecosystem-service-and-livelihood-trade-offs-sustainable

Tentative Plan for Solwezi training 9th to 12th May 2017:

Venue: St.Francis, Solwezi LDSF site

Contact persons: Patricia Masikati (p.maskikati@cgiar.org) and Leigh Winowiecki (l.a.winowiecki@cgiar.org)

Date	Agenda	Activity
9th May 2017	Arrival of Trainers to Solwezi - Leigh and Patricia	Introduce participants to the LDSF methodology, navigation with GPS unit – conduct the LDSF in the field – finalize logistics for the acquisition of equipment
10th May 2017	Interaction with LDSF team	Field training at the Solwezi LDSF site. Navigation, soil sampling, infiltration, tree and shrub measurements, all aspects of LDSF.
11th May 2017	Interaction with LDSF team	Field training at the Solwezi LDSF site. Navigation, soil sampling, infiltration, tree and shrub measurements, all aspects of LDSF.
12th May 2017	Interaction with LDSF team and the ZARI lab	Interaction with LDSF team