Figure 1 Pink grid cells represent places where soils explain the majority of variability in maize yield in rainfed production systems. (Folberth et al. 2016, ncomms11872)

CHARACTERIZING SOILS with LANDPKS
in FEED THE FUTURE ZONE OF INFLUENCE SURVEYS

Feed the Future's Zone of Influence (ZOI) Surveys collect data on soil characteristics using the US Department of Agriculture's (USDA) LandPKS application as part of the survey's agriculture component. This document explains why it is important to collect soil information in the same plots where management and yield information are collected, how the soil characterization is implemented, and who benefits from the data.

Why soil characterization in the Feed the Future ZOI Surveys? The ZOI Surveys collect information on soil characteristics, as well as agricultural practices and technologies used by farmers, to better understand the factors contributing to yields in Feed the Future countries. For example, a farmer may invest in key inputs; however, if the soils a farmer works are poor, the resulting crop yields will not reflect the investment in inputs the farmer made. The type of soil determines both the overall potential production of land and its response to fertilizer, irrigation and other inputs. It can explain why some interventions work on some farms but not others. Additionally, examining the relationships among soils, technologies, and yields allows Feed the Future to use evidence to better design future projects.

Why not use existing soil maps? Existing soil maps are helpful but not sufficient to determine soils on a specific farm. Soil map polygons predict *groups* of soils that are known to occur on a certain type of land. However, in most areas, soils vary between farms, and soil determination is necessary. Some of the newer digital soil maps attempt to extrapolate area soil predictions from known points using statistical tools. However, these are only predictions; their accuracy is limited and currently insufficient to meet the needs of the Feed the Future.

Why not collect these data separately? For associations to be examined among soil, inputs, management practices, and crop production, it is necessary for the soil data to be collected at the same location as where the data on plot management and yields are collected. It is also far more cost-effective.

What kind of time and human resources are required? The survey implementer hires agricultural specialists to administer the agricultural component of the survey; in many countries, these individuals were previously trained to determine soil texture. All agriculture interviewers are trained in soil characterization during main training; the LandPKS team is also available to provide training tips as needed. During main fieldwork, the LandPKS app provides step-by-step guidance. It requires about 20 minutes in the field to dig or auger to 70cm and complete the assessment.

How accurate do the classifications need to be? The data have 2 types of values: 1) the absolute textures and colors, and 2) whether there is any change of color or texture with depth, and at what depth significant changes occur. The classifications should be as accurate as possible; however, accuracy within a texture class or two is optimal, and it is feasible for non-soil scientists to accomplish this with minimal training (Salley et al. 2018; doi: 10.2136/sssaj2018.04.0137).

Who will benefit? There are many beneficiaries of these data, making the return on investment for this element of the survey very high:

Giving back to the farmer: Farmers receive information about their soil texture, soil characteristics that might limit agricultural productivity, their Land Capability Classification score, and the overall productive potential of their land. This information can help them make better, more sustainable choices about how to manage their land. For example, in Barjomot, Tanzania, after learning that the greatest risk to their farm was soil erosion, farmers immediately discussed possible erosion control measures including grass bunds and contour tillage. LandPKS started a dialogue with farmers in the community about how to manage their land more sustainably.

USAID Missions: USAID Missions can use the information directly for both activity evaluation and interpretation, and future activity planning. They can also reference the entire LandPKS database for project planning. The availability of an increased labor pool with experience using LandPKS can help support future activity implementation. Finally, improved soil maps resulting from the uploaded points (see "Global Public Good") will improve activity planning by reducing the number of locations where spot checks to verify soil type (e.g. for an irrigation project) are necessary.

Ministries of Agriculture: Information obtained through the LandPKS assessment is particularly helpful for agricultural extension staff as well as land use planners. For example, in Tanzania, agricultural extension agents often lack access to local soils information. The data collected through Feed the Future's ZOI Surveys can provide these agents with easily accessible information about local soils, helping them to make more informed recommendations to their farmers. In Ethiopia, LandPKS is working closely with the Ministry of Agriculture, Rural Land Administration and Use Directorate to scale up the use of the LandPKS app in Ethiopia for local level land use planning throughout the country.

A global public good: Obtaining site-specific soils information can be costly and time consuming to collect on a national or global scale. However, most soils maps are approximations of what soils might exist in an area, and do not tell you what type of soil is directly below your feet. Combining the soils data collected with LandPKS with other agricultural and socio-economic characteristics collected in the ZOI Survey is very powerful for more holistically understanding yields and agricultural productivity. Linking soils with yields and agricultural inputs will help to understand if the limiting factor for improving yields is indeed agricultural inputs, or perhaps inherent limitations of the soil. The data will also be used by the International Soil Reference and Information Centre and others to improve the accuracy of digital soil maps.