Using Geospatial tools to optimize cassava agronomy trials in Nigeria and Tanzania

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Abstract

Cassava (Manihot esculenta) is an important staple crop for over half a billion people in Africa yet current yield at farmers' field is only 20% of the potential yield. The African Cassava Agronomy Initiative (ACAI) project is initiated to mitigate the yield gap through developing site-specific recommendations based on a demand-driven approach. The project responds to specific agronomy-related needs of partners already engaged in cassava dissemination and value chain activities in Nigeria and Tanzania. ACAI is developing site-specific recommendation, where processing geospatial information related to climate, soil and remote sensing data is crucial. We are using spatial multivariate analysis to delineate our partners' operational area into homogeneous clusters to ensure the representativeness of trial sites and optimize the number of trial sites for maximum operational efficiency.

Introduction

Cassava (*Manihot esculenta*) is a perennial woody shrub with an edible root which grows in tropical and subtropical areas of the world. Cassava is the third largest source of food carbohydrates in the tropics, after rice and maize (Fauquet and Fargette, 1990) and a major staple food providing a basic diet for over half a billion people (Burns et al. 2010). Despite the increasing importance, its current productivity is about 10 t/ha compared to attainable yield of about 40 t/ha. To reduce the yield gap, several studies have highlighted the need for site specific agronomic practices (input, management etc). The ACAI project strives to bridge this yield gap through developing recommendations of best agronomic practices based on the geo-spatial and environmental factors of target areas. Geospatial spatial multivariate clustering is commonly used approach to delineate homogenous zones within study area for optimal identification of agronomic trials. The technique, for instance, was used to study environmental drivers for delineating wine growing zones in Italy (Costantini et al. , 2016), to identify coffee growing zones with high potential in Colombia (García et al. , 2014) and to delineate sustainable recommendation domains for scaling maize technologies in Tanzania (Muthoni et al. , 2017). Within ACAI project, spatial analyses using 24 environmental layers are used to ensure representative and unbiased of trial site selection and maximize operation efficiency.

Materials and Methods

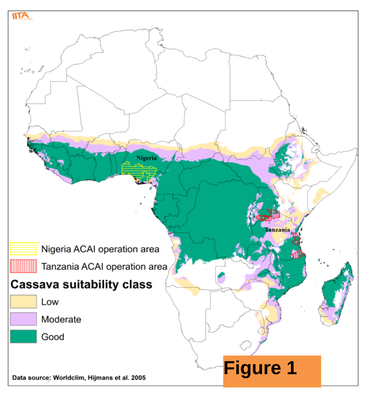

Figure 1

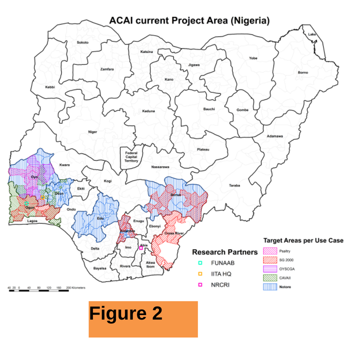

Figure 2

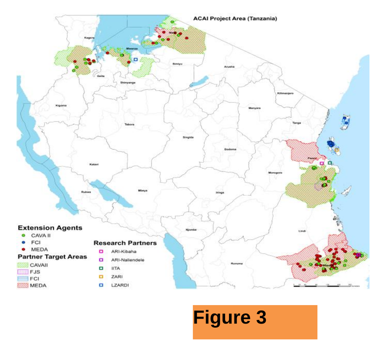

Figure 3

Study area:

Generally, the study area lie within high cassava suitability and production zones of Nigeria and Tanzania (Fig.1). Specific study areas were defined for six use cases within the operational area of the primary development partner (Fig. 2 &3). In these areas, each development partner has an established network of extension agents (EAs) for easier monitoring agronomic experiments.

Environmental covariate data

The spatial analysis was made using twenty four GIS layers downloaded from Worldclim database (Hijmans, 2005), ISRIC 2016 and AfSIS, 2016. The data include annual mean rainfall, seasonality, and variation in rainfall and temperature, Organic C, Total N, CEC, exchangeable acidity, NDVI, EVI, GPP, NPP (Fig.4). All these layers were resampled to 250 m spatial resolution and projected to "Lambert Azimuthal Equal Area projection" using ArcGIS project tool.

Spatial multivariate clustering analysis and site selection process

The iterative self-organizing data analysis technique (ISODATA) as implemented in ArcGIS 10.5 was used to cluster the bioclimatic variables, soil fertility layers and vegetation indices into environmental strata following the method of Metzger et al. (2012). The "Iso-Cluster" tool uses a modified iterative optimization clustering procedure, also known as the migrating means technique. The algorithm separates all cells into the user-specified number of distinct unimodal groups in the multidimensional space of the input bands. After the clustering analysis, a two-step GIS-assisted approach was followed whereby first, a set of extension agents are selected semi-randomly and secondly, random locations for trials are identified within a practical range (radius of 5 km) around these EAs, restricting these locations to areas that are cropped.

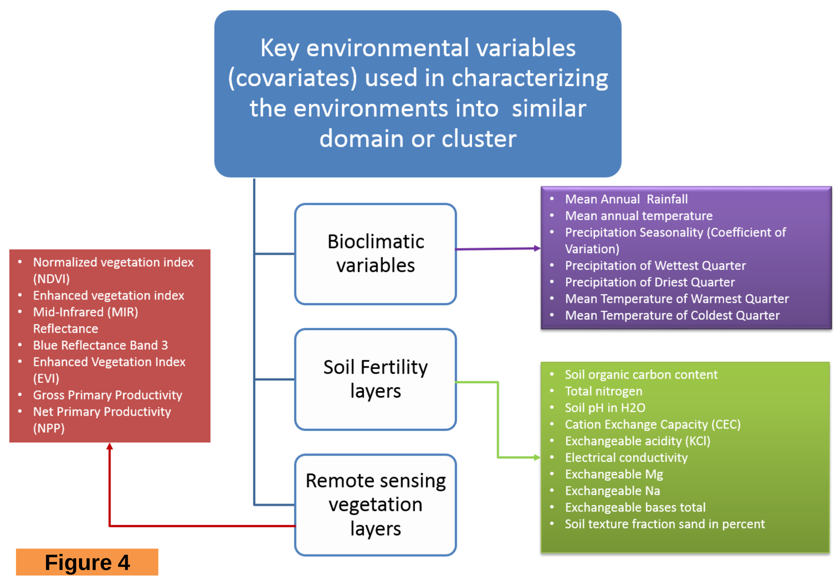

Figure 4

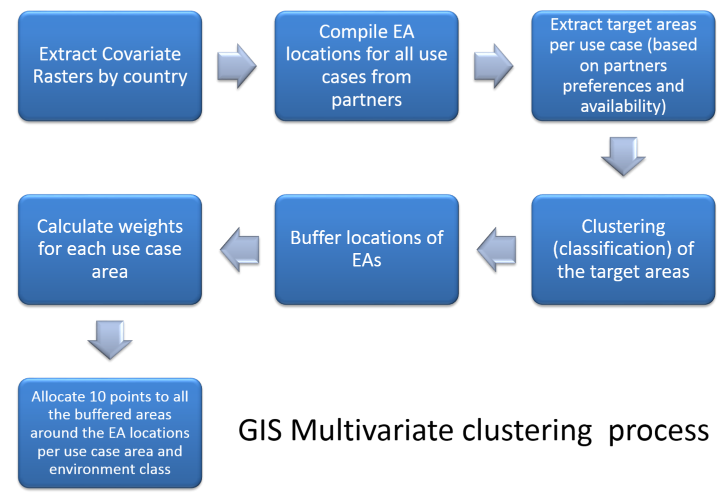

Figure 5

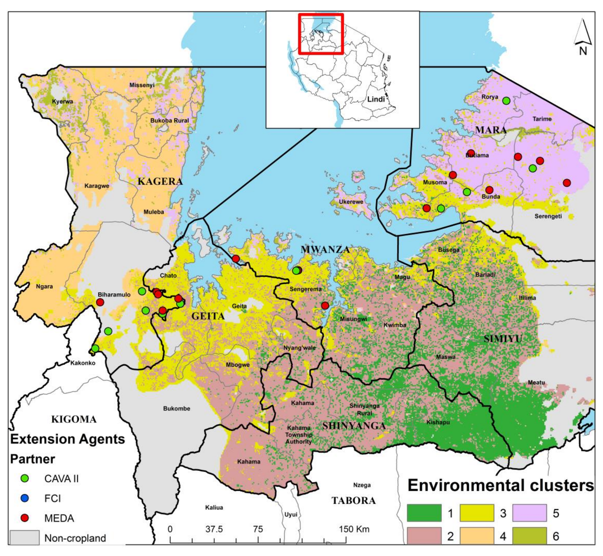

Figure 6 Lake zone, Tanzania

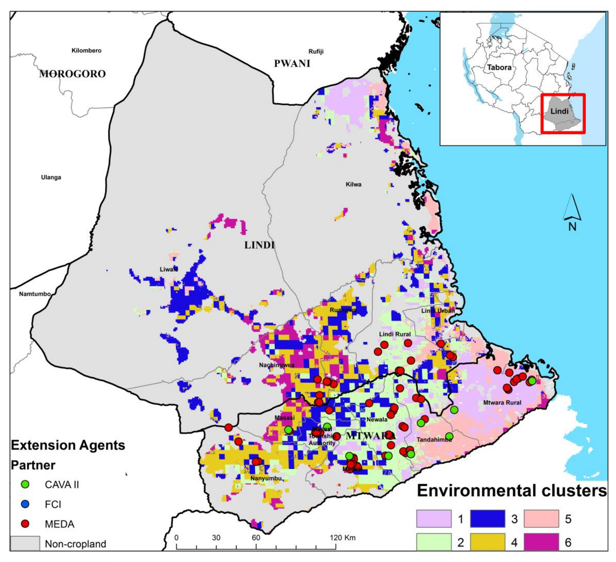

Figure 7 Southern zone, Lindi, Tanzania

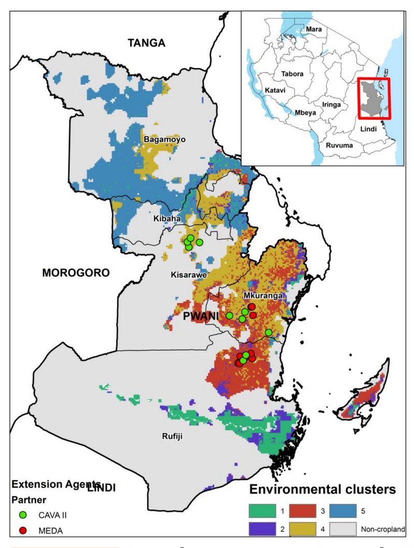

Figure 8 Southern zone, Pwani, Tanzania

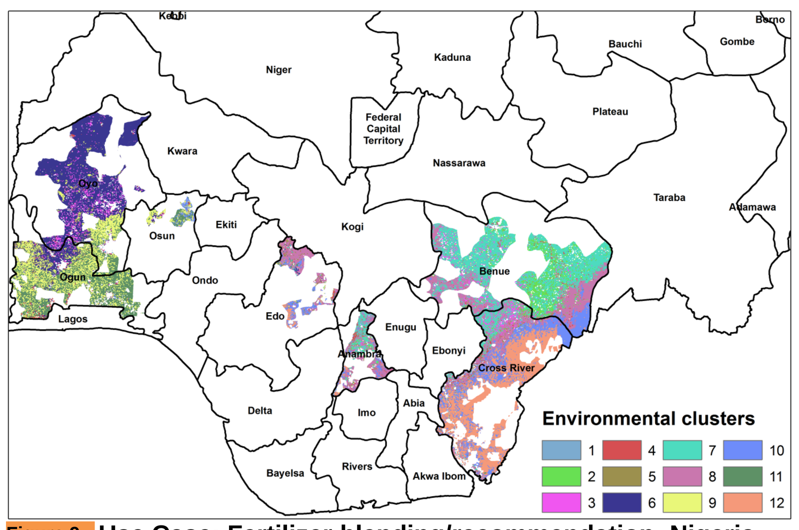

Figure 9 Use Case: Fertilizer blending/recommendation, Nigeria

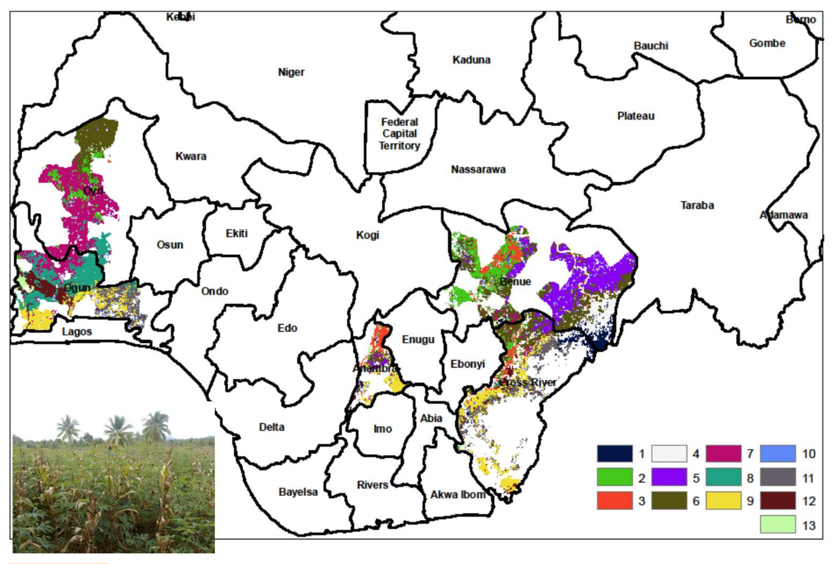

Figure 10 Use Case: Cassava intercropping, Nigeria

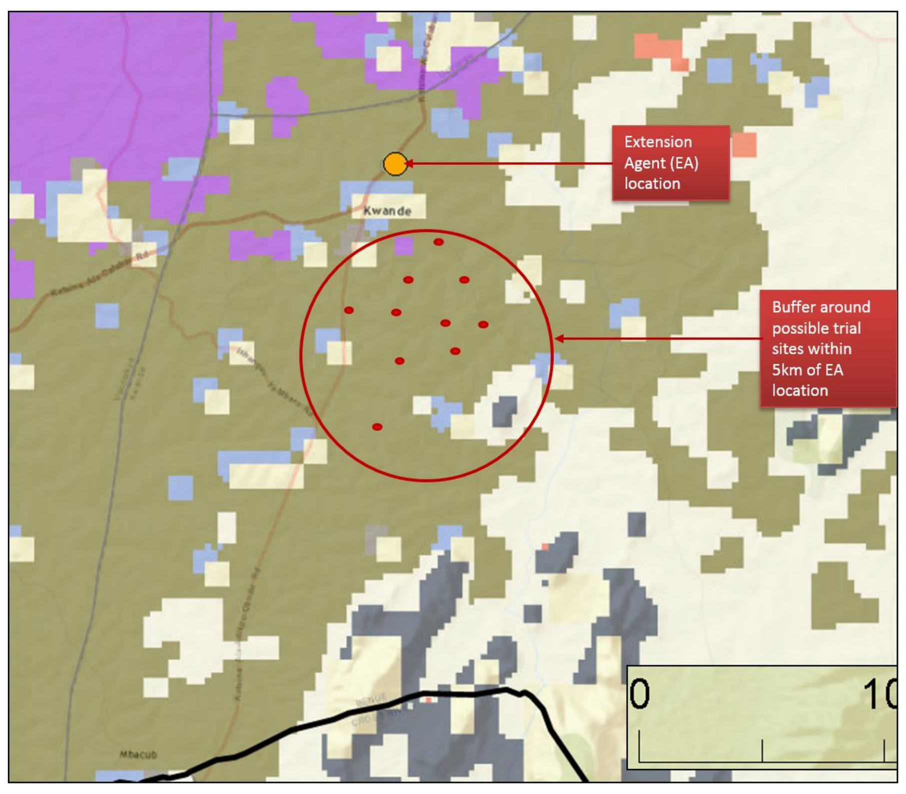

Figure 11 Candidate trial location within environmental cluster

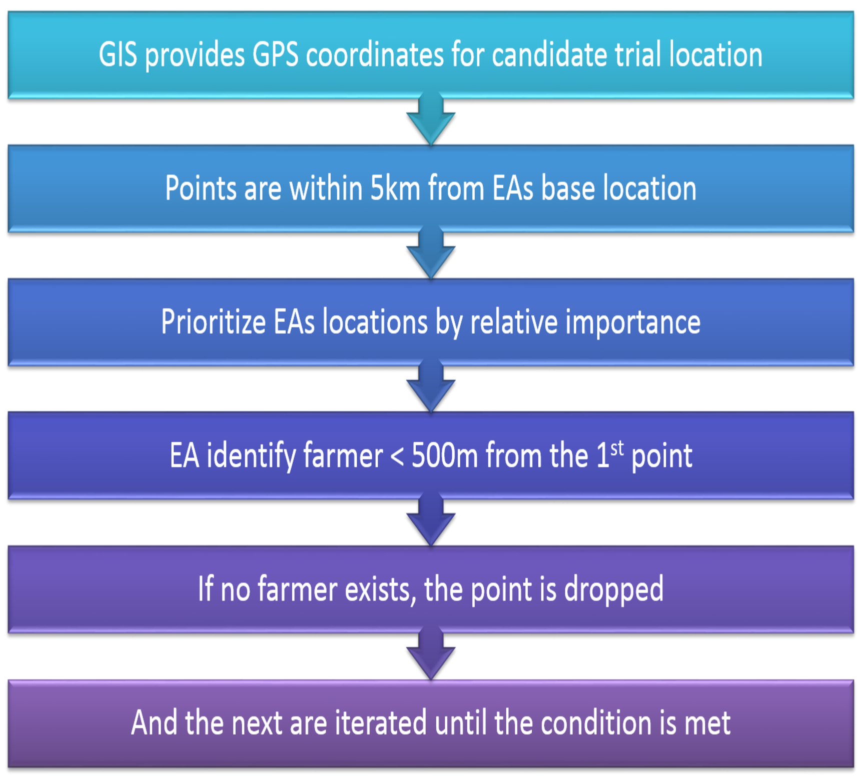

Figure 12 Trial location selection process within environmental cluster

Results and Discussion

Clustering analysis Tanzania

Six clusters that has operational significance were identified in the Lake zone of Tanzania (Fig.6). This covered a total area of about 8.4 million ha where environmental cluster 2 was the most predominant cluster. Cluster 3 and 4 occurred at the eastern and western part of lake Victoria respectively while cluster 1 to 3 occurred at the southern part of the Lake in the regions of Geita, Shinyanga and Mwanza. Fig.7 presents the result of clustering analysis where the three main development partners, MEDA,FCI and CAVAII are operating. Within the partner operational area in this region, six clusters were identified within the cropland extent covering a total area of about 2.6 million ha. Five environmental clusters were delineated in Pwani region where CAVAII and MEDA have a well established network of Extension Agents (EAs). Total area covered in this region was about 1.1 million ha.

Clustering Analysis, Nigeria

Twelve environmental clusters were identified for the operational area where fertilizer development partner concerned with the two use cases of fertilizer blending and fertilizer recommendation are working in Nigeria (Fig.9). This covers a total of about 5.8 million ha extending from south western to south eastern part of the country. The clustering analysis excluded area within forest reserve, national parks and other non-cropland land use. Figure 10 shows the result of clustering analysis for cassava intercropping use case. There were some overlaps of area covered by this use case and that of fertilizer blending mainly in the south western part and the far south eastern part. Development partner for intercropping are not present in Edo state. The process of trial location selection is illustrated in Figure 11 and 12. Trial locations around 5km from an EA base location, prioritization of EA location based on relative importance

Conclusion

Most often trials sites for agronomic experiment are chosen based on convenience and ease of access. Multivariate cluster analysis provide unbiased guides for site selection for technological innovations testing to optimally represent the target set of development environments. This approach ensures representativeness and maximizes unbiasedness while at the same time maximizing operational efficiency.

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