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SITE IDENTIFICATION FOR RECESSIONAL IRRAGATION FARMING AROUND DADIN KOWA DAM GOMBE STATE, NIGERIA

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ABSTRACT

The use of floodwater for agricultural purposes is practiced worldwide. Mostly on small-scale, farmers practice methods to cope with the annually occurring floods and use them for their benefits. This study is aimed at identifying suitable site(s) for floods recessional farming around Dadin kowa dam. Two dataset of Santinel-2A of 2017 and soil data were analyzed using band ratio and overlay analysis techniques. The finding of this research shows that the total flood recessional area covers 107.037 km^2. Upon which 25.32% attributed to very low suitable class, 4.13% belongs to low suitable region, 39.75% goes to moderate suitable area and high suitable zone takes the proportion of 30.80% of the total recessional area. The finding shows that there is appreciable suitable land for recessional farming around Dadin kowa dam. Finally, it is recommended that State Agricultural Development Project should introduced and directed the identified sites to local farmers, so as to improve socio-economic well-being of the farmers.

Keywords: recessional farming, band rationing, suitability.

INTRODUCTION

Evaluating the suitability of land is critical to the development of productive and economically viable dry season farming systems (FAO, 1985 and CSIRO, 2017). The use of floodwater for agricultural purposes is practiced worldwide. Mostly on small-scale, farmers practice methods to cope with the annually occurring floods and use them for their benefits. Farmers practice recessional agriculture by planting in the flooded areas after the waters retreat. Thus recessional farming serves as a rudimentary form of irrigation (Kellman and Tackaberry, 1997). Recession of the flood not only exposes new alluvial material in which new planting is easy but also leaves it which residual soil moisture that would last some time even in a dry climate (Harold, 2012 and Nederveen, 2015). Flood recessional farming is still practiced in many areas today and has been adopted even by people who are new to farming (Harold, 2012). Soil type is an important consideration in recessional agriculture. Clay rich soils are especially suitable for recessional agriculture because, it retains the most amount of water due to its impermeable for infiltration to deeper aquifers and its richness in organic matter (Naderveen, 2012). Another soil class formed by the annual deposit of fine-grained material and organic matter brought in by the floods which creates a fertile soil on the floodplains and lake margins is also considered suitable for recessional farming (Eyasu *et al.*, 2015). It is indicated that flood recession farming is site specific and based on only the experience of the farmers (Eyasu *et al.*, 2015 and Endalamaw, 2015).

There is a widely acceptance of “the Green Alternative” agricultural policy of both rain fed and non-rain fed farming systems in Nigeria, especially in the northern region (Nigerian Finder, 2017). According to Abdur-rashid (2017), hundred thousand hectares of land are now put under intensive irrigation farming mostly on wetlands, along river banks and lake margins such as Dadin Kowa dam. In the last two years, immediately at the end of rainy season, farmers from nearby villages and towns are coming down to Dadin kowa dam shows to benefit from the two practicing methods (normal irrigation and recessional farming) of dry season farming. Lack of knowledge about the newly recessional farming method of where, when and how to plant drastically affect many farmers in 2016 and 2017 dry season farming, which thrown them in great lost. Therefore, this study address the issue of identifying suitable areas favorable for recessional farming around Dadin Kowa dam using remote sensing, Geographic Information System (GIS) and multi-criteria evaluation techniques. Site suitability identification is the evaluation and grouping of specific areas of land in terms of their suitability for a defined use (Abdel-Gaffar *et al.,* 2012). Hence, suitability is a measure of how well the qualities of a land unit match with the requirements of a particular form of land use (FAO, 2003).

Numerous image processing methods have been introduced in recent decades for the extraction of water features from satellite data (Rokni *et al.,* 2014). Single-band methods utilize a selected threshold value to extract water features. In this type, errors are common because of overlapping of water pixels with those of different cover types (Rokni *et al.,* 2014 and Du *et al*., 2012). A band rationing method such as Modified Normalized Difference Water Index (NDWI) was employed to extracts surface water boundary using Landsat imagery, this method accurately delineate surface water and non-water feature by suppressing errors from built-up land as well as vegetation and soil more than the other indices methods such as Modified Normalized Difference Water Index (MNDWI), Water Ratio Index (WRI), Normalized Difference Vegetation Index (NDVI), and Automated Water Extraction Index (AWEI) (Xu, 2006; Xu *et al.,* 2010; Rokni *et al.,* 2014). Researchers such as Muthigani, (2011); Nederveen, (2011) and Eyasu *et al.* (2015) used remote sensing and GIS to estimates potential sites for flood-based farming in their respective study locations. While, Abdel-Gaffar *et al.* (2012) and Sarkar *et al.* (2014) employed multi-criteria analysis to identify suitable lands for irrigation and wheat farming respectively. To achieve that, both used soil and climatic data as well as satellite imageries such as Landsat and SRTM data.

STUDY AREA

The Dadin Kowa Dam is in Yamaltu/Deba local government area of Gombe State in the north east of Nigeria which lies between longitude 11°24' and 11°37' E and latitude 10°19' and 11°51' N. The dam was completed in 1984, with the goal of providing irrigation and electricity for the planned Gongola sugar plantation project. The reservoir has a capacity of 800 million cubic meters of water and a surface area of 300 km^2 (Timawus, 2010). The study area has a semi-arid climate with a single rainy season from May to October which has the mean annual rainfall of 850 mm; and dry season covers the months of November to April. The minimum and maximum average daily temperature of the study area is 17.32 ºC in January and 36 ºC in April respectively, with an annual average temperature of 27.62 ºC (Jibril *et al.*, 2017). Relative humidity has same pattern being 94% in August and dropping to less than 10% during the harmattan period.

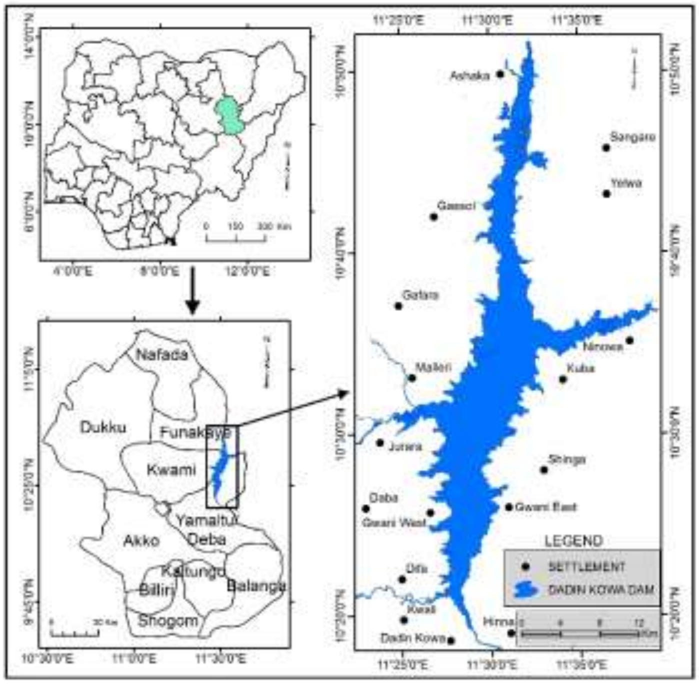

Figure 1: Location of the Study Area.

METHODOLOGY

The types of data used in this study include two Sentinel 2A satellite images of 22nd April and 9th September, 2017. The other data is soil data covering the study area. The methodology begins by selecting band 3 and 7 (visible and near infrared bands) of Sentinel 2A. These bands were selected because on them water has a specific reflectance that does not spectrally overlap with other cover classes. Using ILWIS 3.8, the images were smoothen and sharpened by filtering and stretching so as to enhance the images for better visual interpretation and easy delineating water and non-water class cover. Sub map tool was then used to clip the area of interest (study area). Band rationing technique such as Normalize Difference Water Index (NDWI) was used in driving normalized images by taking the quotient of the difference and sum between near infrared and short wave infrared bands. In order to classified the normalized images into two classes a threshold values were extracted from the generated histograms of the two normalized images. Then, the extracted values were applied in a slice operation for demarcating the normalize images into water and non-water class cover. The sliced data sets were then crossed so as to determine the total inundated areas.

The scanned soil map was imported in to ArcGIS 10.4.1 georeferenced, clipped and vectorized the respective soil types covering the study area. The vectorized soil types were reclassified to soil suitability data set for flood recessional farming according to clay content of each class. Soils of higher clay content were considered suitable because it have low permeability and high moisture holding capacity; therefore, it will withstand flood recessional farming (Naderveen, 2012). Overlay tool was used to aggregate the flood inundation data set and reclassified soil data set; both data sets were considered equally important. Suitable areas for flood recessional farming were identified from the result obtained by the overlay analysis.

RESULTS AND DISCUSSION

Successful result of NDWI was shown in figure 2 which was carried out to suppress the overlapping spectral values of landcover types so as to enhance the differences among the class cover.

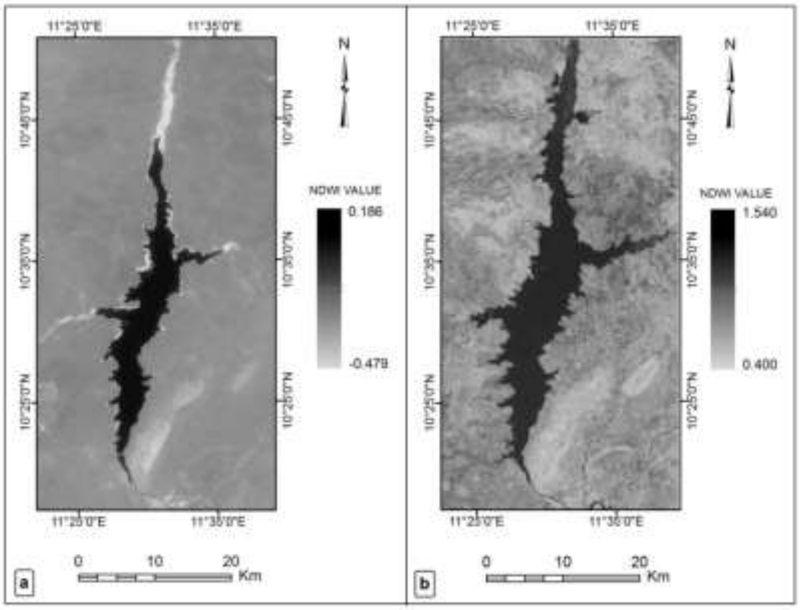

Fig. 2: NDWI Band Ratio: - (a) for dry season during total water recess (22/04/2017). (b) for rainy season when the dam is at full (09/09/2017).

Figure 2 shows the results of NDWI band rationing of band 4 and 6 (visible and NIR bands) of sentinel data of 22nd April and 9th September, 2017. The ratio index shows that waterbody have positives values, while values near zero and towards the negative index values relates to non-waterbody class cover.

Delineation of water and non-water boundary

The boundary between water and non-water class cover were delineated using thresholding values from the histogram of the ratio datasets as shown in figure 3 and Figure 4, on which green line represent the graph of the number of pixels (frequency) against the NDWI values. The red line on the graphs shows the cumulative percentage of pixels against NDWI values. The threshold values were extracted at point where the number of pixel is at minimum between the two peaks of the green graph line and also at a turning point between step one and two of the red graph line. The taller peaks (first peak from the origin with the lower index value) stand for non-water class while the shorter ones (second peak from the origin with the higher index value) represent water class. The extracted threshold values for NDWI datasets of the dry season when the water is totally draw-back (22/04/2017) and that of which the water is at full (09/09/2017) are 0.12 and 1.05 respectively.

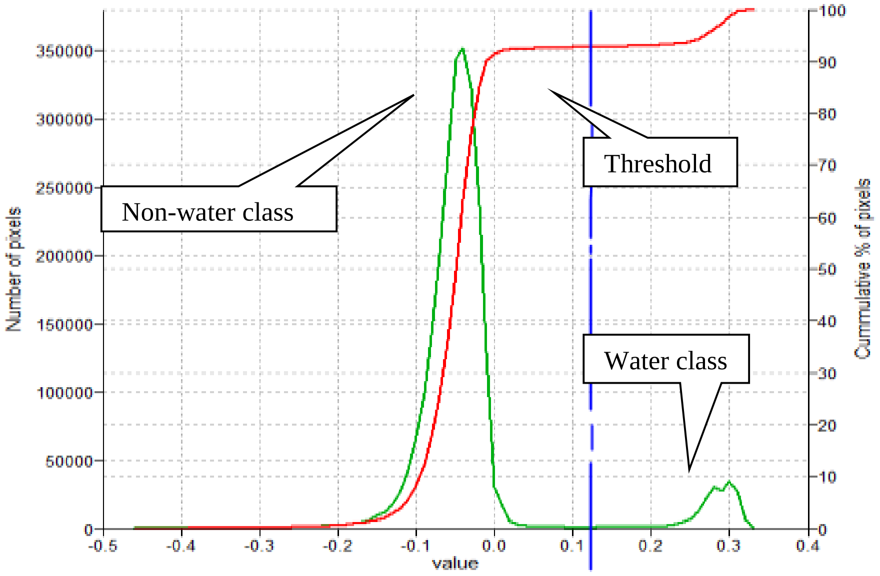

Fig. 3: NDWI Histogram of 22/04/2017

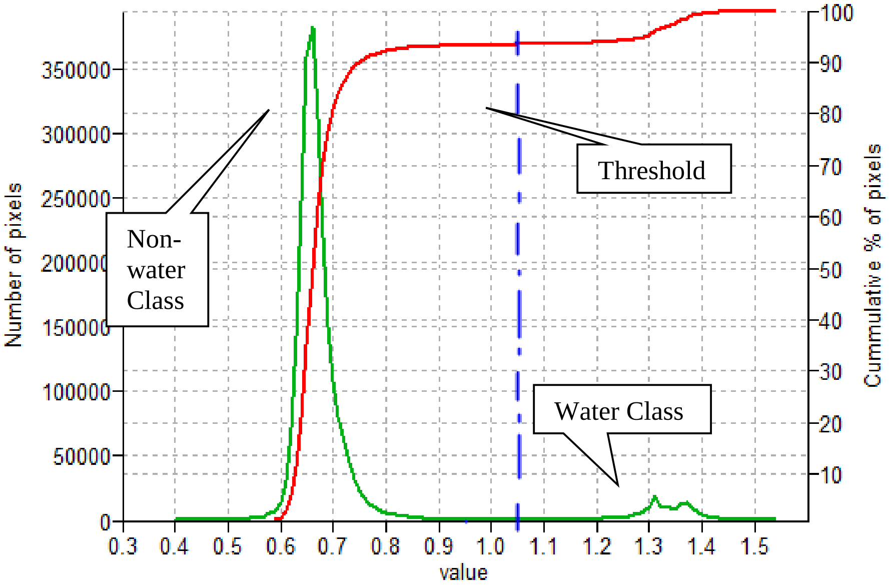

Fig. 4: NDWI Histogram of 22/04/2017

After determining the threshold values for delineating land surface and water, slicing operation was employed in converting the ratio images into classified maps (Figure 5).

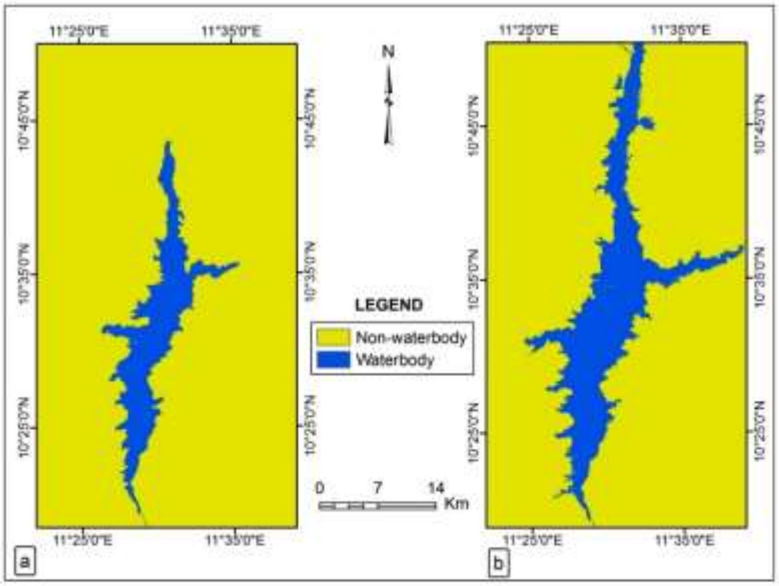

Fig. 5: Classified Ratio Maps:- (a) for dry season during total water recess (22/04/2017). (b) for rainy season when the dam is at full (09/09/2017).

Figure 5 portrayed the spatial pattern of waterbody and non-water class cover of Dadin Kowa dam in both dry (Figure 5a) and rainy (Figure 5b) seasons. Table 1 reveals the variation of waterbody size during total water recess and when the water is full.

Table 1: Variation of Waterbody size

Class	Water Draw-back (**km^2**)	Water at Full (**km^2**)
Non-water	1575.510	1468.473
Waterbody	140.843	247.880
Total	1716.353	1716.353

Table 1 display the variation of waterbody sizes in the two different seasons. In the rainy season when the dam is full the waterbody is determined as 247.880 km^2. During the dry season the waterbody covers only 140.843 km^2 that is when the dam is totally recessed back at the end of dry season. This indicates the variation of 107.037 km^2 which is equivalent to a decrease of 43.18% of its rainy season size.

Identification of Flood Recess Area

The two sliced maps were combined into one final map so as to segment the flood recess area, using the crossing operation as shown in Figure 6, while Table 2 displays the statistics of the segmented zones.

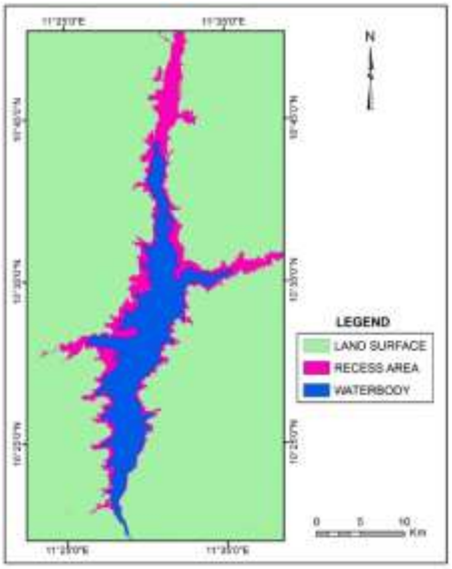

Fig. 6: Spatial Distribution of Recess Area around Dadin Kowa Dam.

Table 2: Statistics of the Crossing Operation.

Land Cover	Area (km^2)	%
Land surface	1468.473	85.56
Recess area	107.037	6.24
Waterbody	140.843	8.21
Total	1716.353	100

Table 2 reveals the statistics of the crossing operation. The results shows that land surface cover the area of 1468.473 km^2 which is equivalent to 85.56% of the total study area. Waterbody cover the area of 140.843 km^2 equivalent to 8.21% of the study area. The area coverage of 107.037 km^2 is classified as recessional area for the year 2017; this class is equivalent to 6.24% of the total study area.

Reclassification of Soil Type

Soils with medium and relatively low permeability are considered fairly suitable and optimal for dry season farming. Specifically, recessional farm site should be place on clay-rich soils (Naderveen, 2012). Figure 7a shows the spatial distribution of the identified three soil types covering the study area and these types were reclassified into three suitability regions for recessional agriculture (Figure 7b).

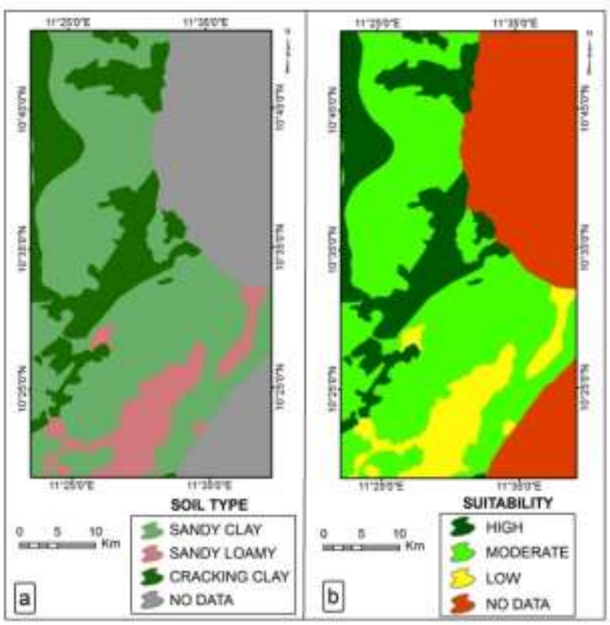

Fig. 7: (a) Soil type; (b) Reclassified Soil Type

Figure 7a and 7b shows the distribution of soil type and reclassified soil type respectively within the study area. The numerical representation of the reclassified soil types are given in Table 3.

Table 3: Reclassified Soil Types Suitability

Soil Type	Suitability	Area (km^2)	%
Cracking Clay	High	254.09	14.80
Sandy Clay	Moderate	745.09	43.41
Sandy-Loamy	Low	155.37	9.05
No Data	Nil	561.82	32.73

Table 3 reveals the statistics of the different soil types covering the study area. Cracking Clay being the richest clayish soil among the identified soil types has considered highly suitable for recessional farming. This class covers an area of 254.09 km^2 equivalent to 14.8% of the total study area. Sandy clay soil is considered moderate and it has covers 745.09 km^2 analogous to 43.41%. Sandy loamy soil is low suitable for flood recessional farming; this class covers 155.37 km^2 (9.05%). Area coverage of 561.82 km^2 (32.73%) isn't classified due to the inability in identifying it soil type.

Suitable Area for Recessional Farming

Flood recess area and soil type's suitability data sets were aggregated in ArcGIS environment with the aid of overlay analysis tool into a single suitability raster dataset (Figure 8).

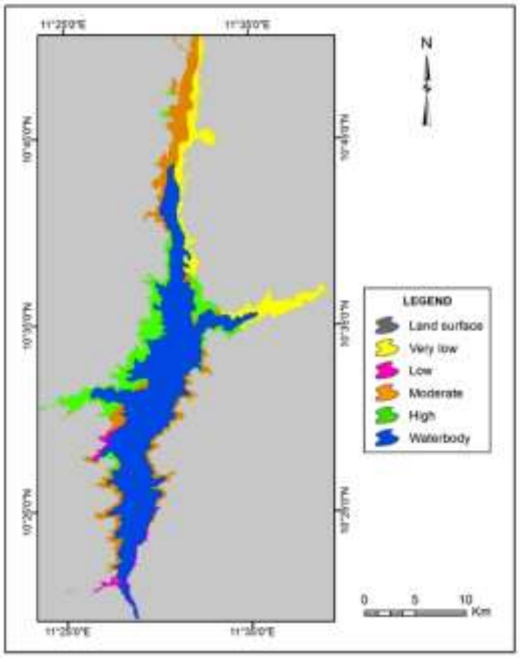

Fig. 8: Identified Suitable Sites for Recessional Farming.

Successful result of the overlay analysis was presented in Figure 8. The analysis was narrowed to the area of interest that is it only considered where flood recess area intersects with soil type's suitability dataset. Area cover of each suitability class as well as its proportion was shown in Table 4.

Table 4: Size and Proportion of Suitability Classes.

Suitability class	Area (km^2)	%
High	32.97	30.80
Moderate	42.55	39.75
Low	4.42	4.13
Very low	27.10	25.32

Table 4 shows the identified sites suitable for recessional farming around Dadin Kowa dam. The identified sites were classified according to how suitable a place is to recessional farming. Recess area with underlain clay soil considered highly suitable; this class covers an area of 32.97 km^2 which equal to 30.80% of the total recess area. The second class in the category with fairly clay content considered moderately suitable, this class amount to 42.55 km^2, the same as 39.75% of the recessional land. Low suitable sites occupied recess area of 4.42 km^2 analogous to 4.13% of the recessional land mass. Size and proportion of very low suitable sites were quantified as 27.10 km^2 and 25.53% respectively. This portion of the recess area was considered very low suitable due to the fact that soil type at the said locations is not available, this makes its suitability ambiguous.

CONCLUSION

Identification of suitable site(s) for recessional farming is a very vital geo-information for agricultural development and future planning. Based on that, a land suitability assessment has been carried out so as to aid decision makers on agricultural planning and management in the development of wetland and recessional agriculture. The output of this research has proven the competence and effectiveness of remote sensing and GIS tools in assessing remotely sensed data of sentinel 2A and existing soil map in the identification site for recessional farming. The methodology showed capabilities of extracting waterbody and segmenting different suitability grades of recessional areas for dry season farming, as well as producing useful database and presenting high quality maps in a short period of time. The result also, indicates that there are reasonable areas good for recessional farming around Dadin Kowa dam, which if fully utilize will boost agricultural production, curtail food shortage and in turn increases food security and nation's GDP.

The methodology provides a significant basis for application in other places by interested researcher who wants to do a similar work. For further work, a detail soil type data of the study area as well as clay content of each soil unit is required. Also, it is noted that for a more complete study, the framework of this research can be modified to include several parameters such as structure, nutrient and salt content, water holding properties, organic content and void ratio of different soil units.

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