A Normalised Difference Vegetation Index Model for Maize Crop Performance Monitoring and Cropland Area Mappingin Sudan Ecological Zone of Nigeria.

Abstract:

The monitoring and mapping of crops remotely are critical for easy identification stressed crop,prompt response to part of the crop field that requires immediate attention and the potential harvest as well as for agricultural field management. Optical remote sensing offers one of the most attractive options for vegetation indices evaluation and some optical remote sensing data are readily available free for this application,especially, Sentinel-2A, which is equipped with a multispectral sensor (MSI), offers some vegetation indices calculated to assess vegetation status. However, serious attention has not been given to the potential of vegetation indices calculated from MSI data especially in the developing countries. Thus, the study therefore calculated the time series NDVI for the length of the growing season for the selected crops (Maize) and geometrically calculated area of the farm plot size. In this study, thisstatistics include the mean, standard deviation, range, minimum and maximum NDVI values for all the farm plots over the growing season from planting period to harvesting period for the selected crops. The average NDVI value in May which marks the onset of the growing season for maize in the study area ranges from 0.044 to 0.148. In july, which represent the period of the grain filing stage ranges from 0.136 to 0.348 and in August, which is the maturity stage for harvest ranges from 0.110 to 0.450.

Our results showed that vegetation indices had the greatest contributions in identifying specific crop types and crop condition during the growing season.

Keywords: Crop performance, NDVI, Sentinel-2, cropland area.

Comment [sz1]: For clarity, the abstract should be organized according to:
1. Brief background (one or two sentences)
2. Objectives of the study
3. Data and research methods
4. Analysis method
5 Results
6. Conclusion

1.0 Introduction

Comment [sz2]: There are no citations taken from articles or books in this introduction. Therefore, add citations taken from any source!

The monitoring and mapping of crops remotely are critical for easy identification stressed crop,prompt response to part of the crop field that requires immediate attention and the potential harvest as well as for agricultural field management. Optical remote sensing offers one of the most attractive options for vegetation indices evaluation and some optical remote sensing data are readily available free for this application,especially, Sentinel-2A, which is equipped with a multispectral sensor (MSI), offers some vegetation indices calculated to assess vegetation status

A Normalised Difference Vegetation Index (NDVI) of a crop or a plant estimated regularly over the growing season periods of a crop can reveal a lot about the changes in that crop conditions. In other words, we can use NDVI to evaluate plant health remotely. The Normalized Difference Vegetation Index (NDVI) measures the greenness and the density of the vegetation captured in a satellite image. Healthy vegetation is characterised by a spectral reflectance curve in which the value is positive andthis can be discovered by calculating the difference between two bands – visible red and near-infrared. NDVI is that difference expressed as a number ranging from

-1 to 1.A sudden drop in the NDVI values may be a symptom of crop health deterioration.

The value drop can also correspond to normal changes, such as the time of harvesting, which is why NDVI should be counter-checked against other available data. Correct NDVI values interpretation can help agronomists raise healthier yields, save money on fertilizers, and take

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a better care of the environment. The input data for NDVI are multispectral satellite Image containing Near Infrared band and Red band.

Satellite imagery, are Earth observation imagery. They are images of the Earth, collected by imaging satellites or Unmanned Ariel Vehicle (UAV) called drones, and these pictures form a wide or narrow areas for observation. In Nigeria, the agency responsible for taking a wide satellite imagery area is the National Space Research and Development Agency (NASRDA). However, small-area imagery can come from UAV. The images include crops, livestock, building, water bodies, and any object on Earth. The Convolutional Neural Network (CNN) algorithm model can filter and classify these images and estimate the Area covered by each object. Similarly, the CNN algorithm focuses on crops through their chlorophyll contents and data collected through ground truthing and those for crop output for the Area under consideration.

1.1 Statement of Research Problem

There has been loss of significant maize yield to pest, disease and climate as a result of lack of improper, timely and first-hand information about the crop condition on the farm. The manual survey is laborious and time consuming. Remote Sensing technology through Normalized Difference Vegetation Index model provides a better alternative to crop monitoring during the growing season especially when a large area is involved for crop optimum yield. Hence, this study.

1.2 The Aim of the Study

Comment [sz3]: What is the difference between research objectives 1.2 and 1.3 which one is used?

The aim of the study is to use satellite imagery to estimate Normalized Difference Vegetation index for maize crop monitoring in Sudan Ecological Zone of Nigeria.

1.3 The objectives of the study are to:

Comment [sz4]: What is the difference between research objectives 1.2 and 1.3 which one is used?

a. map the cropland area for the study area.

b. Generate the NDVI to monitor the performance of the maize crop from the Earth Observation Satellite Image in sudan ecological zone of Nigeria.

c. Document the technical details of the algorithm for future reference by other users and replications for other crops.

2.0 METHODOLOGY

2.1 Study Area

The study area lies between latitude 11° 8¹ 4.034¹¹ to 11° 53¹ 16.372¹¹ and longitude 7° 21¹ 51.831¹¹ to 8° 10¹ 48.902¹¹. This contains the three states; Kano, Kaduna and Kastina and the selected LGAs in these three States are the six LGAs that lie interface between these three States where they share boundary. These selected LGAs include; Kudan, Markafi, Danja, Rogo Kafur and Karaye. The study area has an area of approximately 3828.49 km^2.

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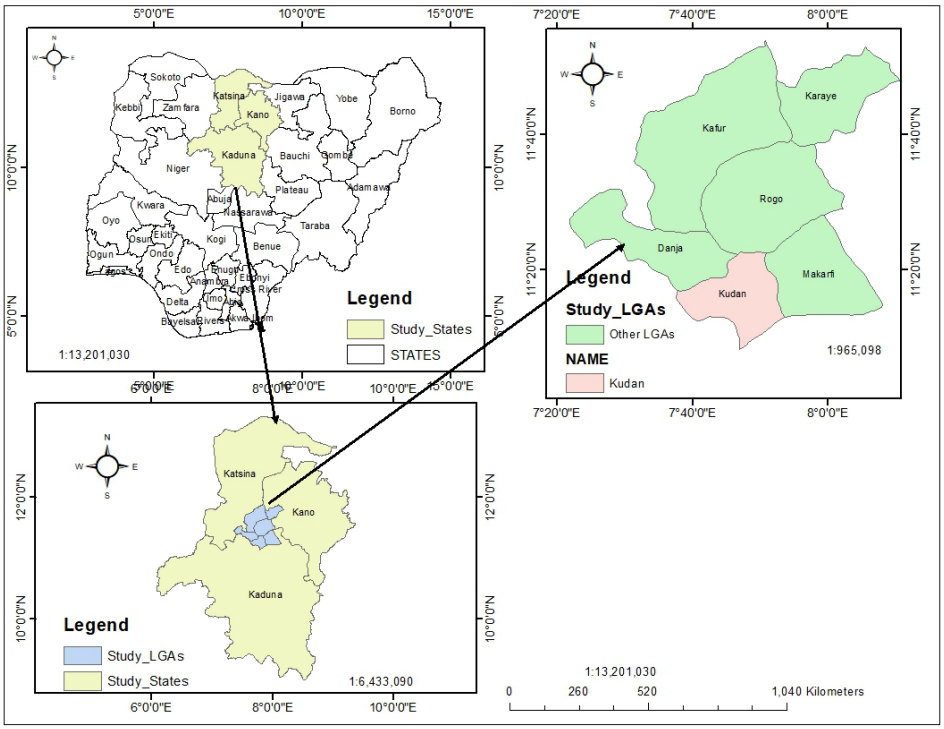

Fig. 1: Study Area Map

2.2 Data Types and Sources

Primary and secondary data were used for the study.

2.3 Primary Data:

These include the use of questionnaires loaded into ODK apps to seek information from the farmers about the conditions of their farm and their agronomic practices. The GPS coordinates of the perimeter of their farm's plots were also collected using Germine GPS receiver. The perimeter coordinates of 1080 farms were collected with the aid of handheld Globe Positioning System Receiver from six local governments (Rogo, kudan, markafi, Ranja) that lies interface between the three selected states,(Kano, Kaduna and Kastina) in Nigeria. The name of the farmer, the planted crop and phone number were documented for follow up and yield harvest weighing and documentation as one of the major input in the yield estimate model.

2.4 Secondary Data

Satellite Images were acquired for NDVI Analysis. These include Sentinel satellite and landsat satellite image acquired for the study area from the planting period, may 2022 to the period of harvesting, September, 2022.

1.Sentinel satellite image:**Sentinel-2** is an Earth observation mission from the **Copernicus Programme** that systematically acquires optical imagery at high spatial resolution (10 m to 60 m) over land and coastal waters. The mission is currently a constellation with two satellites, **Sentinel-2A** and **Sentinel-2B**.The mission supports a broad range of services and applications such as agricultural monitoring, emergencies management, land cover classification or water quality.

Sentinel-2 has been developed and is being operated by the European Space Agency, and the satellites were manufactured by a consortium led by **Airbus Defence and Space** in Friedrichshafen. The acquired image from the copernicus achive include sentinel 2A and 2B satellite image of 10m resolution with the two images having a revisit period of 10 days as a constellation which days. It is a multispectral data with 13 bands in the visible, near infrared, and short wave infrared part of the spectrum.

Comment [sz5]: I don't think the description of sentinel-2 needs to be reviewed here, what is important is what path is used. So more details

Table 1: Properties of the Acquired Sentinel Data for the Project

Spectral bands for the Sentinel-2 sensors

Sentinel-2 bands	**Sentinel-2A**		**Sentinel-2B**		
	Central wavelenghth (nm)	**Bandwidth (nm)**	**Central wavelength (nm)**	**Bandwidth (nm)**	**Spatial resolution (m)**
Band 1 – Coastal aerosol	442.7	21	442.2	21	60
Band 2 – Blue	492.4	66	492.1	66	10
Band 3 – Green	559.8	36	559.0	36	10
Band 4 – Red	664.6	31	664.9	31	10
Band 5 – Vegetation red edge	704.1	15	703.8	16	20

Band 6 – Vegetation red edge	740.5	15	739.1	15	20
Band 7 – Vegetation red edge	782.8	20	779.7	20	20
Band 8 – NIR	832.8	106	832.9	106	10
Band 8A – Narrow NIR	864.7	21	864.0	22	20
Band 9 – Water vapour	945.1	20	943.2	21	60
Band 10 – SWIR – Cirrus	1373.5	31	1376.9	30	60
Band 11 – SWIR	1613.7	91	1610.4	94	20
Band 12 – SWIR	2202.4	175	2185.7	185	20

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2. Landsat Satellite Image

Comment [sz6]: A description of the lansat image is also not necessary. Instead, what is important is the image of Landsat 8 and what path, taken in what month in what year.

Since one of the major limitations of optical remote sensor is cloud cover, we decided to acquire landsat satellite image with 30m spatial resolution that are closer to the needed date of sentinel data and are relatively free from cloud cover as a replacement for date of sentinel data that are affected by cloud. The table 1 below shows the acquired Sentinel and Landsat Satellite Image that were used for the study. The table2 shows the sentinel image band characteristics while the table 3 shows landsat image band characteristics.

Landsat 8 (formerly the Landsat Data Continuity Mission, or LDCM) was launched on an Atlas-V rocket from Vandenberg Air Force Base, California on February 11, 2013. The satellite carries the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) instruments. The OLI measures in the visible, near infrared, and shortwave infrared portions

(VNIR, NIR, and SWIR) of the spectrum. The TIRS measures land surface temperature in two thermal bands with a new technology that applies quantum physics to detect heat. Landsat 8 images have 15-meter panchromatic and 30-meter multi-spectral spatial resolutions along a 185 km (115 mi) swath.

Properties of Acquired Landsat Image for the Project

Operational Land Imager (OLI)

- Nine spectral bands, including a pan band:
- Band 1 Coastal Aerosol (0.43 - 0.45 µm) 30 m
- Band 2 Blue (0.450 - 0.51 µm) 30 m
- Band 3 Green (0.53 - 0.59 µm) 30 m
- Band 4 Red (0.64 - 0.67 µm) 30 m
- Band 5 Near Infrared (0.85 - 0.88 µm) 30 m
- Band 6 SWIR 1 (1.57 - 1.65 µm) 30 m
- Band 7 SWIR 2 (2.11 - 2.29 µm) 30 m
- Band 8 Panchromatic (PAN) (0.50 - 0.68 µm) 15 m
- Band 9 Cirrus (1.36 - 1.38 µm) 30 m

Thermal Infrared Sensor (TIRS)

- Two spectral bands:
- Band 10 TIRS 1 (10.6 - 11.19 µm) 100 m
- Band 11 TIRS 2 (11.5 - 12.51 µm) 100 m

Table 2: Satellite Data Acquistion with dates

S/N	Satellite Image Date	Satellite Image Type	Revisit Period
1	02/05/2022	Sentinel 2A	5 days with 2B
2	07/05/2022	Sentinel 2B	5 days with 2A
3	22/05/2022	Sentinel 2A	5 days with 2B
4	27/05/2022	sentinel 2B	5 days with 2A
5	03/05/2022	Landsat 8 (OLI)	8 days with landsat 9
6	11/05/2022	Landsat 9 (OLI)	8 days with landsat 8

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7	19/05/2022	Landsat 8 (OLI)	8 days with landsat 9
8	27/05/2022	Landsat 9 (OLI)	8 days with landsat 8
9	01/06/2022	Sentinel 2A	5 days with 2B
10	04/06/2022	Landsat 8 (OLI)	8 days with landsat 9
11	12/06/2022	Landsat 9 (OLI)	8 days with landsat 8
12	20/06/2022	Landsat 8 (OLI)	8 days with landsat 9
13	28/06/2022	Landsat 9 (OLI)	8 days with landsat 8
14	06/07/2022	Landsat 8 (OLI)	8 days with landsat 9
15	14/07/2022	Landsat 9 (OLI)	8 days with landsat 8
16	22/07/2022	Landsat 8 (OLI)	8 days with landsat 9
17	07/08/2022	Landsat 8 (OLI)	8 days with landsat 9
18	05/08/2022	sentinel 2A	5 days with 2B
19	10/08/2022	Sentinel 2B	5 days with 2A
20	30/08/2022	sentinel 2A	5 days with 2B
21	08/09/2022	Landsat 8 (OLI)	8 days with landsat 9
22	24/09/2022	Landsat 8 (OLI)	8 days with landsat 9

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3.0 DATA ANALYSIS

The perimeter coordinates of all the farm plots were plotted as points and these were used to digitise all the farm plots as polygon using geographic information system platform. For accuracy purpose,the GPS coordinates of the perimeters of each plot taken on the field were labelled in excel as A1, B1,C1,D1 to An, Bn, Cn, Dn. This means plot one was labelled as A1,B1,C1,D1 to plot 1080 which was labelled as A1080, B1080, C1080, D1080.

3.1 Normalized Difference Vegetation Index(NDVI)Analysis

Since one of the objective of the study is to generate the indices that simplify Ag-statistics estimation, we therefore analysed time series Normalised Difference Vegetation Index (NDVI) value per farm plot from planting period to harvest period.

The Normalized Difference Vegetation Index(NDVI) for the entire study area were calculated using the NDVI algorithm.

The following equation was used.

$$NDVI = \frac{\text{NIR} - \text{RED}}{NIR + RED}$$

NIR = Near infrared band of the satellite image

RED = RED band of the satellite image

In sentinel satellite image, band 8 represents Near Inrared (NIR) while band 4 represents RED.Therefore, NDVI calculation for sentinel data = band 8 - band 4/ band 8 - band 4 and for landsat data, NDVI = (band 5 - band 4)/(band 5 - band 4). This implies that NIR for landsat correspond to band 5 while RED corresponds to band 4. For the generation of average NDVI for farm plots, all the digitized farm plots polygon were overlaid on the NDVI layer for the selected LGAs and the average NDVI was generated for each plot for maize, using the zonal statistics tool within Geographic Information System Platform.

4.0 RESULTS AND DISCURSION

Comment [sz7]: In the discussion, there is not a single reference that corroborates the results of this study. Please add at least a few references to create a proper discussion.

The results and discussion are very confusing. The results obtained should be described in accordance with the objectives to be achieved.

One of the most widely used vegetation index is the Normalized Difference Vegetation Index (NDVI) for crop monitoring. Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); however, no green leaves gives a value close to zero. A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves for the best crop performance in terms of crop health and greeness.

The study therefore showed the time series NDVI for the length of the growing season for the selected crops (Maize) andthe geometrically calculated areaof the farm plot size. The tables show the NDVI statistics for maize from may, 2022 (day of planting period) to September 2022 (Day of harvesting period). Thisstatistics include the mean, standard deviation, range, minimum and maximum NDVI values for all the farm plots over the growing season from planting period to harvesting period for the selected crops. The average NDVI value in May which marks the onset of the growing season for maize in the study area ranges from 0.044 to 0.148. In july, which represent the period of the grain filing stage ranges from 0.136 to 0.348 and in August, which is the maturity stage for harvest ranges from 0.110 to 0.450.

5.1 Limitation to the generation of the NDVI Statistical values for all the farm plots

Thetotal number of farm plots selected for the study and whose coordinates were collected are 1080 plots for the three selected crops. The zonal statistics tool within Geographic Information System platform were able to generate the NDVI statistical values for plots whose sizes are greater than the pixel size of each of the two satellite images used for the study. Landsat image has 30m by 30m spatial resolution while sentinel image has 10m by 10m spatial resolution. This means that a single pixel of Landsat satellite image measures 30m x30m as a square pixel and sentinel measures 10m x 10m as a square pixel. NDVI values were not generated for many farm plot that is not big enough to accommodate minimum of a single pixel within it. The area of some farm plots are less than 30 meter by 30 meter in size. For that reason, the Zonal statistics tool could not generate NDVI statistics for those plots. This account for variations in the number of plots whose NDVI were generated. For, Sentinel image, between 250 to 327 plots were generated for the selected crop. This number becomes lesser for Landsat image because of its lower spatial resolution (30m X30m) which does not allow NDVI statistical values generation from zonal statistics for many farm plots smaller than the image pixel size of 30m by 30m as some of the farm plots sizes are lesser than 30m by 30m in area. It should be noted that for the successful generation of average NDVI for a polygon using zonal statistics, minimum of a pixel or more must fall

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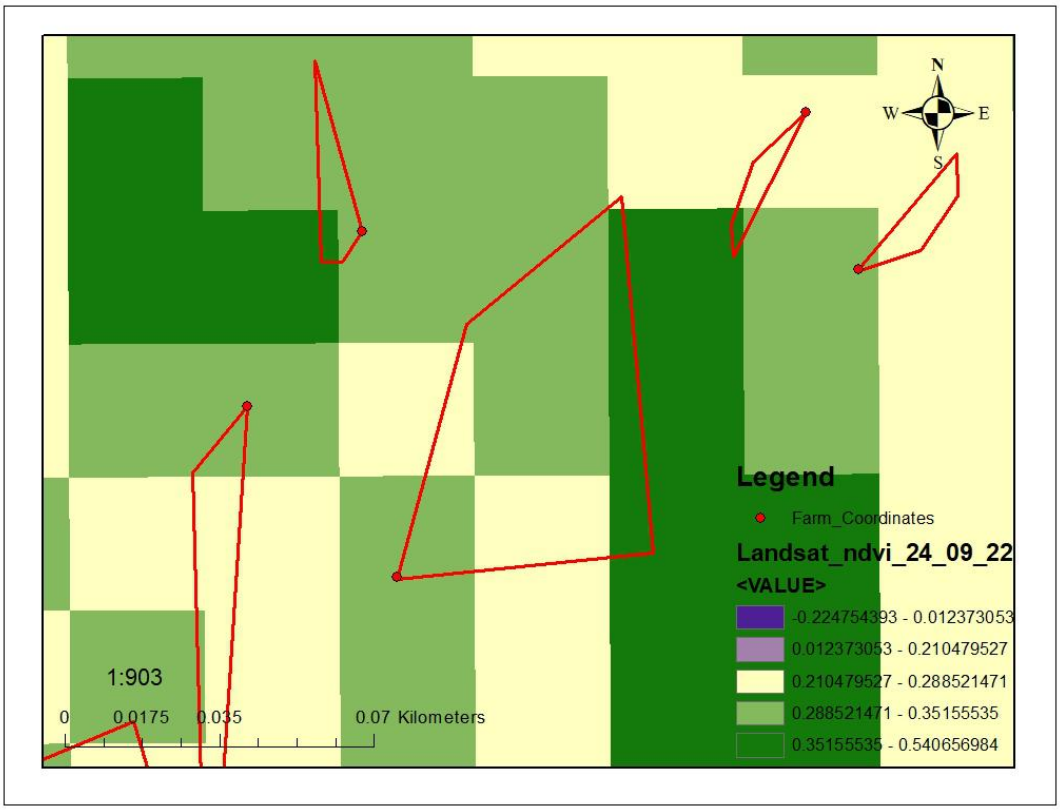
within the polygon that represents farm plots. This is not the case for some plots in some of our plots. see picture 1 below



Picture 1 : Farm plots overlay on the landsat Pixel of 30m by 30m resolution

The bigger farm plot at the centre contain more than one pixel and average NDVI value can be calculated for it using zonal statistics, other surrounding pixels were omitted from the calculation automatically by the GIS platform tool used.

5.2. CROPLAND AREA MAPPING

The supervised classification of the satellite image for land use landcover reveals that the cropland area for the cultivation of arable crops in the selected six LGAs is 75.2796 Square Miles. This area are found mostly along rivers network and near the dam area ; the area with sufficient water for farming. This cropland area and other landcover classes are documented in the table3 and figure 2 below is the map showing the area for arable crop farming otherwise known as cropland area in the study area.

Table3: Landuse Landcover for Mapping for Cropland Area and other land cover Estimation

Landuse Landcover classes	Area in Square Mile
Cropland Area	75.2796
Vegetation Area	348.172
Grassland Area	77.5633
waterbody coverage	18.5738
Bareland Area	933.3746
Settlement Area	25.0366
Total	1477.9999

Comment [sz8]: Area is generally used in Ha or Km square, so change the unit.

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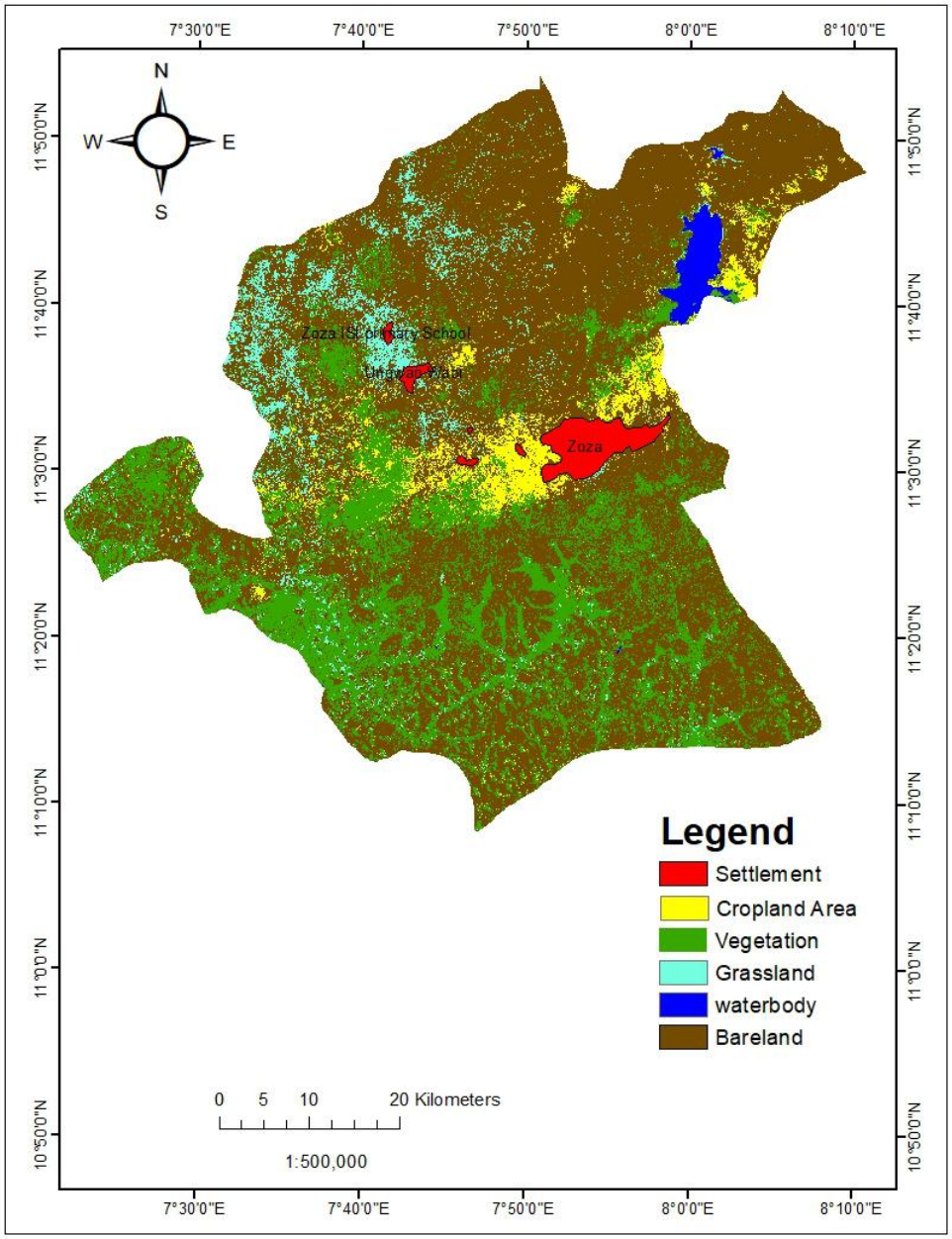

Fig2: Landcover Area Showing Cropland Area for July 2022

5.3. CONCLUSION

The study has successfully demonstrated the capability of NDVI model for crop monitoringand has given a guide into the calculation of cropland area quantification and yield value estimation from the field. The results of our NDVI analysis and cropland area mapping are good insight into solving national agricultural planning problems and agricultural resources allocation for effective agricultural practices for national food security.

5.4. REFERENCE:

Comment [sz9]: There were only 7 references used. Of the 7 existing references, all are old years. For the article to have better quality, the author is expected to add citations to the latest and up-to-date articles.

C. J. Tucker, "Monitoring corn and soybean crop development with hand-held radiometer spectral data," Remote Sensing of Environment 8, 237-248 (1979) [doi:10.1016/0034-4257(79)90004-X].

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R. E. Crippen, "Calculating the vegetation index faster," Remote Sensing of Environment 34, 71-73 (1990) [doi:10.1016/0034-4257(90)90085-Z].

Wang, X.; Mochizuki, K.; Yamaya, Y.; Tani, H.; Kobayashi, N.; Sonobe, R. Crop classification from Sentinel-2-derived vegetation indices using ensemble learning. J. Appl. Remote Sens. 2018,12, 026019

5.5APENDIX: NDVI FOR 7th AUGUST 2022 of the GROWING SEASON FOR MAIZE PLOTS

PLOT_ID	MEAN	PLOT AREA	MIN	MAX	STD
A1	0.13926321268	899.45436458600	0.13926321268	0.13926321268	0.00000000000
A10	0.14174300432	899.45436458600	0.14174300432	0.14174300432	0.00000000000
A100	0.14147070795	1798.90872917000	0.14143371582	0.14150770009	0.00003699213
A1004	0.15140222013	1798.90872917000	0.15069462359	0.15210981667	0.00070759654
A101	0.15392306447	899.45436458600	0.15392306447	0.15392306447	0.00000000000
A1015	0.15600873530	2698.36309376000	0.15571418405	0.15635313094	0.00026321934

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A1016	0.15649241209	899.454364586000	0.15649241209	0.15649241209	0.00000000000
A1018	0.14662317187	1798.908729170000	0.14513364434	0.14811269939	0.00148952752
A102	0.14855803549	899.454364586000	0.14855803549	0.14855803549	0.00000000000
A104	0.17707353830	899.454364586000	0.17707353830	0.17707353830	0.00000000000
A105	0.14678984880	899.454364586000	0.14678984880	0.14678984880	0.00000000000
A1054	0.16403548420	1798.908729170000	0.16340593994	0.16466502845	0.00062954426
A106	0.17948380609	2698.363093760000	0.17912340164	0.17987716198	0.00030860224
A108	0.20109967887	899.454364586000	0.20109967887	0.20109967887	0.00000000000
A110	0.17892807722	899.454364586000	0.17892807722	0.17892807722	0.00000000000
A113	0.18790673465	1798.908729170000	0.18659539521	0.18921807408	0.00131133944
A116	0.18698866665	899.454364586000	0.18698866665	0.18698866665	0.00000000000
A118	0.17366736382	1798.908729170000	0.17335635424	0.17397837341	0.00031100959
A119	0.17950771749	899.454364586000	0.17950771749	0.17950771749	0.00000000000
A12	0.16886410117	1798.908729170000	0.16823667288	0.16949152947	0.00062742829
A121	0.10782401264	1798.908729170000	0.10758144409	0.10806658119	0.00024256855
A132	0.10544826835	899.454364586000	0.10544826835	0.10544826835	0.00000000000
A140	0.11193363369	899.454364586000	0.11193363369	0.11193363369	0.00000000000
A144	0.11425574124	899.454364586000	0.11425574124	0.11425574124	0.00000000000
A146	0.11532562971	899.454364586000	0.11532562971	0.11532562971	0.00000000000
A148	0.11176078767	899.454364586000	0.11176078767	0.11176078767	0.00000000000
A151	0.10083807260	899.454364586000	0.10083807260	0.10083807260	0.00000000000
A152	0.10238801688	899.454364586000	0.10238801688	0.10238801688	0.00000000000
A154	0.09897122532	899.454364586000	0.09897122532	0.09897122532	0.00000000000
A157	0.10220589489	899.454364586000	0.10220589489	0.10220589489	0.00000000000
A162	0.10598595440	899.454364586000	0.10598595440	0.10598595440	0.00000000000
A164	0.11186741290	899.454364586000	0.11186741290	0.11186741290	0.00000000000

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	3		3	3	0
	0.2676727473		0.2676727473	0.2676727473	0.0000000000
A176	7	899.45436458600	7	7	0
	0.2944973707		0.2944973707	0.2944973707	0.0000000000
A18	2	899.45436458600	2	2	0
	0.2578923404		0.2578923404	0.2578923404	0.0000000000
A181	2	899.45436458600	2	2	0
	0.2564497292		0.2564497292	0.2564497292	0.0000000000
A184	0	899.45436458600	0	0	0
	0.2944599241	1798.9087291700	0.2879537642	0.3009660840	0.0065061599
A185	0	0	0	0	0
	0.2639781832	1798.9087291700	0.2464423477	0.2815140187	0.0175358355
A188	7	0	7	7	0
	0.3481092453	1798.9087291700	0.3390598297	0.3571586608	0.0090494155
A190	0	0	1	9	9
	0.2432977408		0.2432977408	0.2432977408	0.0000000000
A2	2	899.45436458600	2	2	0
	0.2468256652		0.2468256652	0.2468256652	0.0000000000
A20	4	899.45436458600	4	4	0
	0.2940159142		0.2940159142	0.2940159142	0.0000000000
A209	0	899.45436458600	0	0	0
	0.2435687929		0.2435687929	0.2435687929	0.0000000000
A215	4	899.45436458600	4	4	0
	0.1786318570	1798.9087291700	0.1779849678	0.1792787462	0.0006468892
A217	4	0	3	5	1
	0.1907712072		0.1907712072	0.1907712072	0.0000000000
A218	1	899.45436458600	1	1	0
	0.1065455675		0.1065455675	0.1065455675	0.0000000000
A219	1	899.45436458600	1	1	0
	0.1060377955		0.1060377955	0.1060377955	0.0000000000
A220	4	899.45436458600	4	4	0
	0.1083665341		0.1083665341	0.1083665341	0.0000000000
A221	1	899.45436458600	1	1	0
	0.1119507104		0.1119507104	0.1119507104	0.0000000000
A225	2	899.45436458600	2	2	0
	0.2239962071	1798.9087291700	0.2218573689	0.2261350452	0.0021388381
A228	2	0	5	9	7
	0.2362202704		0.2362202704	0.2362202704	0.0000000000
A23	0	899.45436458600	0	0	0
	0.2351121902		0.2351121902	0.2351121902	0.0000000000
A231	5	899.45436458600	5	5	0
	0.1933149918	1798.9087291700	0.1931660175	0.1934639662	0.0001489743
A245	9	0	3	5	6
	0.1772187799		0.1772187799	0.1772187799	0.0000000000
A248	2	899.45436458600	2	2	0
	0.1582608670		0.1582608670	0.1582608670	0.0000000000
A251	0	899.45436458600	0	0	0
	0.1663357913	1798.9087291700	0.1650159359	0.1676556468	0.0013198554
A256	5	0	0	0	5
	0.1544700264		0.1544700264	0.1544700264	0.0000000000
A258	9	899.45436458600	9	9	0

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	0.1603875607		0.1603875607	0.1603875607	0.0000000000
A26	3	899.45436458600	3	3	0
	0.0900994986		0.0900994986	0.0900994986	0.0000000000
A269	3	899.45436458600	3	3	0
	0.0923493355		0.0923493355	0.0923493355	0.0000000000
A27	5	899.45436458600	5	5	0
	0.0941597037	1798.9087291700	0.0931758806	0.0951435267	0.0009838230
A271	0	0	1	9	9
	0.1024291589		0.1024291589	0.1024291589	0.0000000000
A276	9	899.45436458600	9	9	0
	0.0819646790		0.0819646790	0.0819646790	0.0000000000
A29	6	899.45436458600	6	6	0
	0.0900202542	2698.3630937600	0.0878444984	0.0920351892	0.0017146175
A292	5	0	6	7	2
	0.0862409509	1798.9087291700	0.0859771221	0.0865047797	0.0002638287
A294	7	0	9	6	8
	0.0896488875		0.0896488875	0.0896488875	0.0000000000
A295	2	899.45436458600	2	2	0
	0.0888814479		0.0888814479	0.0888814479	0.0000000000
A30	1	899.45436458600	1	1	0
	0.0850185155		0.0850185155	0.0850185155	0.0000000000
A300	9	899.45436458600	9	9	0
	0.2763887643	1798.9087291700	0.2680267989	0.2847507298	0.0083619654
A32	8	0	6	0	2
	0.3019443750		0.3019443750	0.3019443750	0.0000000000
A327	4	899.45436458600	4	4	0
	0.3133049905		0.3133049905	0.3133049905	0.0000000000
A331	3	899.45436458600	3	3	0
	0.2940585215	2698.3630937600	0.2826457321	0.3007005751	0.0081061408
A34	9	0	6	1	5
	0.3607175052		0.3607175052	0.3607175052	0.0000000000
A340	2	899.45436458600	2	2	0
	0.0781956724	1798.9087291700	0.0780147239	0.0783766210	0.0001809485
A381	8	0	6	1	3
	0.3311539143	1798.9087291700	0.3276252746	0.3346825540	0.0035286396
A382	3	0	6	1	7
	0.3810048699		0.3810048699	0.3810048699	0.0000000000
A385	4	899.45436458600	4	4	0
	0.4048418700	1798.9087291700	0.3963063359	0.4133774042	0.0085355341
A386	7	0	3	1	4
	0.3711358904	1798.9087291700	0.3587380051	0.3835337758	0.0123978853
A387	8	0	6	1	2
	0.2969544430	2698.3630937600	0.2902759611	0.3007013797	0.0047341177
A39	6	0	6	8	4
	0.3525764346		0.3525764346	0.3525764346	0.0000000000
A391	1	899.45436458600	1	1	0
	0.3849338889		0.3849338889	0.3849338889	0.0000000000
A394	1	899.45436458600	1	1	0
	0.1832554489		0.1832554489	0.1832554489	0.0000000000
A4	4	899.45436458600	4	4	0
A42	0.2487865090	899.45436458600	0.2487865090	0.2487865090	0.0000000000

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	4		4	4	0
	0.2050148844		0.2050148844	0.2050148844	0.0000000000
A421	7	899.45436458600	7	7	0
	0.3005682826		0.3005682826	0.3005682826	0.0000000000
A436	0	899.45436458600	0	0	0
	0.3143346011		0.3143346011	0.3143346011	0.0000000000
A441	6	899.45436458600	6	6	0
	0.2723106741		0.2723106741	0.2723106741	0.0000000000
A445	9	899.45436458600	9	9	0
	0.2368475049		0.2368475049	0.2368475049	0.0000000000
A448	7	899.45436458600	7	7	0
	0.2230758816		0.2230758816	0.2230758816	0.0000000000
A452	0	899.45436458600	0	0	0
	0.2262417972		0.2262417972	0.2262417972	0.0000000000
A453	1	899.45436458600	1	1	0
	0.2515502125	1798.9087291700	0.2501673102	0.2529331147	0.0013829022
A454	0	0	4	7	6
	0.2666009962		0.2666009962	0.2666009962	0.0000000000
A458	6	899.45436458600	6	6	0
	0.2461911737		0.2461911737	0.2461911737	0.0000000000
A465	9	899.45436458600	9	9	0
	0.2629489600		0.2629489600	0.2629489600	0.0000000000
A476	7	899.45436458600	7	7	0
	0.2552485466		0.2552485466	0.2552485466	0.0000000000
A478	0	899.45436458600	0	0	0
	0.2644546330		0.2644546330	0.2644546330	0.0000000000
A487	0	899.45436458600	0	0	0
	0.2653537690	1798.9087291700	0.2564605474	0.2742469906	0.0088932216
A49	6	0	5	8	2
	0.3056749403	1798.9087291700	0.2983071804	0.3130427002	0.0073677599
A490	5	0	1	9	4
	0.2710623741		0.2710623741	0.2710623741	0.0000000000
A491	2	899.45436458600	2	2	0
	0.1675620302	1798.9087291700	0.1667699664	0.1683540940	0.0007920637
A494	6	0	8	3	7
	0.1779323667	1798.9087291700	0.1771523207	0.1787124127	0.0007800459
A503	3	0	4	2	9
	0.3604594171		0.3604594171	0.3604594171	0.0000000000
A509	1	899.45436458600	1	1	0
	0.3294100612	1798.9087291700	0.3234610855	0.3353590369	0.0059489756
A510	4	0	6	2	8
	0.2677836418		0.2677836418	0.2677836418	0.0000000000
A52	2	899.45436458600	2	2	0
	0.1921641379		0.1921641379	0.1921641379	0.0000000000
A520	6	899.45436458600	6	6	0
	0.1932516992		0.1932516992	0.1932516992	0.0000000000
A522	1	899.45436458600	1	1	0
	0.1934270113		0.1934270113	0.1934270113	0.0000000000
A523	7	899.45436458600	7	7	0
	0.1519773602	1798.9087291700	0.1515604257	0.1523942947	0.0004169344
A531	5	0	6	4	9

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	0.1727667003		0.1727667003	0.1727667003	0.0000000000
A535	9	899.45436458600	9	9	0
	0.1891041472	1798.9087291700	0.1890005916	0.1892077028	0.0001035556
A537	6	0	4	8	2
	0.0747897401		0.0747897401	0.0747897401	0.0000000000
A557	5	899.45436458600	5	5	0
	0.0978068038		0.0978068038	0.0978068038	0.0000000000
A56	8	899.45436458600	8	8	0
	0.0954830646		0.0954830646	0.0954830646	0.0000000000
A560	5	899.45436458600	5	5	0
	0.0972578674		0.0972578674	0.0972578674	0.0000000000
A562	6	899.45436458600	6	6	0
	0.0974495659	2698.3630937600	0.0969653278	0.0978561416	0.0003677960
A565	3	0	6	3	3
	0.0812341123		0.0812341123	0.0812341123	0.0000000000
A57	8	899.45436458600	8	8	0
	0.0780402720	1798.9087291700	0.0778965801	0.0781839638	0.0001436919
A572	0	0	0	9	0
	0.0775295645		0.0775295645	0.0775295645	0.0000000000
A574	0	899.45436458600	0	0	0
	0.2648599147		0.2648599147	0.2648599147	0.0000000000
A580	8	899.45436458600	8	8	0
	0.2627624869		0.2627624869	0.2627624869	0.0000000000
A586	4	899.45436458600	4	4	0
	0.3283474445		0.3283474445	0.3283474445	0.0000000000
A596	3	899.45436458600	3	3	0
	0.2475049942	1798.9087291700	0.2439044714	0.2511055171	0.0036005228
A598	7	0	0	5	8
	0.3010495007		0.3010495007	0.3010495007	0.0000000000
A612	0	899.45436458600	0	0	0
	0.2795512676		0.2795512676	0.2795512676	0.0000000000
A619	2	899.45436458600	2	2	0
	0.2820754647		0.2820754647	0.2820754647	0.0000000000
A627	3	899.45436458600	3	3	0
	0.2473604381		0.2473604381	0.2473604381	0.0000000000
A631	1	899.45436458600	1	1	0
	0.2106220126		0.2106220126	0.2106220126	0.0000000000
A645	2	899.45436458600	2	2	0
	0.2458127379	4497.2718229300	0.2118355184	0.2680807411	0.0205846824
A65	4	0	8	7	6
	0.2925016880		0.2925016880	0.2925016880	0.0000000000
A653	0	899.45436458600	0	0	0
	0.3618157282	3597.8174583500	0.3156016469	0.3822605013	0.0268824738
A655	5	0	0	9	9
	0.2521100640		0.2521100640	0.2521100640	0.0000000000
A664	3	899.45436458600	3	3	0
	0.2967952191	1798.9087291700	0.2912307381	0.3023597002	0.0055644810
A669	8	0	6	0	2
	0.3822846710		0.3822846710	0.3822846710	0.0000000000
A670	7	899.45436458600	7	7	0
A671	0.4115418195	899.45436458600	0.4115418195	0.4115418195	0.0000000000

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	7		7	7	0
	0.3747045695		0.3747045695	0.3747045695	0.0000000000
A679	8	899.45436458600	8	8	0
	0.3482075631		0.3482075631	0.3482075631	0.0000000000
A695	6	899.45436458600	6	6	0
	0.3626184761		0.3626184761	0.3626184761	0.0000000000
A702	5	899.45436458600	5	5	0
	0.3240834176	1798.9087291700	0.3198593556	0.3283074796	0.0042240619
A703	5	0	9	2	7
	0.3675680756		0.3675680756	0.3675680756	0.0000000000
A704	6	899.45436458600	6	6	0
	0.3483874797		0.3483874797	0.3483874797	0.0000000000
A708	8	899.45436458600	8	8	0
	0.3468554914		0.3468554914	0.3468554914	0.0000000000
A716	0	899.45436458600	0	0	0
	0.3318323195		0.3318323195	0.3318323195	0.0000000000
A718	0	899.45436458600	0	0	0
	0.3213692307	2698.3630937600	0.2770399749	0.3576250672	0.0333903613
A723	5	0	3	3	9
	0.3304028809		0.3304028809	0.3304028809	0.0000000000
A736	1	899.45436458600	1	1	0
	0.2657377719	1798.9087291700	0.2620220482	0.2694534957	0.0037157237
A752	9	0	4	4	5
	0.2905255854		0.2905255854	0.2905255854	0.0000000000
A764	1	899.45436458600	1	1	0
	0.2852194160	1798.9087291700	0.2844699919	0.2859688401	0.0007494241
A767	2	0	2	2	0
	0.2740775346		0.2740775346	0.2740775346	0.0000000000
A770	8	899.45436458600	8	8	0
	0.2446091473		0.2446091473	0.2446091473	0.0000000000
A771	1	899.45436458600	1	1	0
	0.3586227297		0.3586227297	0.3586227297	0.0000000000
A775	8	899.45436458600	8	8	0
	0.2960911095	1798.9087291700	0.2874626219	0.3047195971	0.0086284875
A777	1	0	3	0	9
	0.2555826902		0.2555826902	0.2555826902	0.0000000000
A778	4	899.45436458600	4	4	0
	0.2663235068		0.2663235068	0.2663235068	0.0000000000
A783	3	899.45436458600	3	3	0
	0.3097887784	1798.9087291700	0.3084734976	0.3111040592	0.0013152808
A800	2	0	3	2	0
	0.3380616605	1798.9087291700	0.3073784411	0.3687448799	0.0306832194
A801	3	0	0	6	3
	0.3530162274		0.3530162274	0.3530162274	0.0000000000
A81	8	899.45436458600	8	8	0
	0.3437301814		0.3437301814	0.3437301814	0.0000000000
A811	6	899.45436458600	6	6	0
	0.3010810613		0.3010810613	0.3010810613	0.0000000000
A812	6	899.45436458600	6	6	0
	0.3283136785		0.3283136785	0.3283136785	0.0000000000
A817	0	899.45436458600	0	0	0

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A818	0.3169731795 8	899.45436458600	0.3169731795 8	0.3169731795 8	0.0000000000 0
A830	0.3204720020 3	899.45436458600	0.3204720020 3	0.3204720020 3	0.0000000000 0
A832	0.2739541381 6	1798.9087291700 0	0.2729491889 5	0.2749590873 7	0.0010049492 1
A835	0.2685847878 5	899.45436458600	0.2685847878 5	0.2685847878 5	0.0000000000 0
A836	0.3853896856 3	1798.9087291700 0	0.3785966634 8	0.3921827077 9	0.0067930221 6
A840	0.2523885667 3	899.45436458600	0.2523885667 3	0.2523885667 3	0.0000000000 0
A841	0.2637764066 5	1798.9087291700 0	0.2634875774 4	0.2640652358 5	0.0002888292 1
A843	0.3231395483 0	899.45436458600	0.3231395483 0	0.3231395483 0	0.0000000000 0
A844	0.2965815067 3	899.45436458600	0.2965815067 3	0.2965815067 3	0.0000000000 0
A848	0.3260810077 2	899.45436458600	0.3260810077 2	0.3260810077 2	0.0000000000 0
A859	0.2603861987 6	899.45436458600	0.2603861987 6	0.2603861987 6	0.0000000000 0
A88	0.2207778692 3	899.45436458600	0.2207778692 3	0.2207778692 3	0.0000000000 0
A885	0.2404508888 7	899.45436458600	0.2404508888 7	0.2404508888 7	0.0000000000 0
A888	0.2532237172 1	899.45436458600	0.2532237172 1	0.2532237172 1	0.0000000000 0
A89	0.2650983929 6	899.45436458600	0.2650983929 6	0.2650983929 6	0.0000000000 0
A906	0.2359290272 0	899.45436458600	0.2359290272 0	0.2359290272 0	0.0000000000 0
A914	0.3683323860 2	899.45436458600	0.3683323860 2	0.3683323860 2	0.0000000000 0
A921	0.3973098397 3	899.45436458600	0.3973098397 3	0.3973098397 3	0.0000000000 0
A963	0.2309571355 6	899.45436458600	0.2309571355 6	0.2309571355 6	0.0000000000 0
A966	0.2126801759 0	899.45436458600	0.2126801759 0	0.2126801759 0	0.0000000000 0
A975	0.1891135722 4	899.45436458600	0.1891135722 4	0.1891135722 4	0.0000000000 0
A978	0.1855442598 5	1798.9087291700 0	0.1808422356 8	0.1902462840 1	0.0047020241 6
A991	0.1752572357 7	899.45436458600	0.1752572357 7	0.1752572357 7	0.0000000000 0
A675	0.1692145392 3	1798.9087291700 0	0.1680239737 0	0.1704051047 6	0.0011905655 3

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