CEREAL CROP IDENTIFICATION USING SENTINEL2 TIME SERIES, CASE OF SIDI BEL ABBES AREA

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ABSTRACT:

The department of Sidi Bel Abbes is considered among the primary region producing cereal at the national level in Algeria. The study that we conducted is based on time series analysis using Sentinel2 images to monitor the cultivated cereal crops, combined with the field data including cereal plots for the growing season of 2020-2021.The methodology adopted in this study focused mainly on the processing of a Normalized Difference Vegetation Index (NDVI) time series. The analysis of the NDVI time series from October to July 2021, allowed us to determine the typical profiles of cereal crops, based on thresholding obtained to extract the areas cultivated by cereal crops. The geographical distribution of cereal in terms of area represents a high density of green biomass in the highlands and a low density of vegetation towards the plain and the highlands of the northwest area. The analysis of the profile's growth for the cereal crops, allowed us to understand the behavior of the cereal crop during its development and to catch the relationship of these behaviors, the meteorological conditions and the agricultural practices followed.

1. INTRODUCTION

In Algeria, the plain are the main cereal areas, which depends in most of these regions on the cultivation of cereal. This practice is spread in the major part of agricultural land including cereal crops. The objective of this study is to identified the cereal areas in the department of Sidi bel Abbes during the growing season 2020-2021 using sentinel2A time series images(Guechi et al., 2021), then to catch the relationship of crop duration from different plots at local scale according to growing season of NDVI values (field observations, May 2021) (Maselli & Rembold, 2001; Chehat, 2007).

To meet an estimation close to the expectations at local scale for the decision-makers, it is important to take into account some factors that influence the crop growth and the predicted yield, data such as climatic conditions, cultivation practices that can be related with recent data from remote sensing for crop growth monitoring.

The cereal sector is one of the main parts of agricultural production in Algeria, occupying an important place in the food system and the national economy. Cereal production, including fallow land, represents about 80% of the available agricultural area (Useful Agricultural Area: UAA).

Entire the country, the annual area sown to cereals is between 3 and 3.5 million hectares. The area harvested each year represents 63% of the area sown. It thus appears to be a dominant crop (Bessaoud et al., 2019)

Mainly, the average annual consumption of cereals per Algerian is207 kg of wheat in various forms (bread, couscous, pasta, etc.) (Chehat, 2007). The importance of consumption makes cereal a strategic product from the point of view of food security(Djermoun, 2009).

2. STUDY AREA AND USED DATA

2.1 Study area

The study area is located northwest of the country, at 470 m altitude, in the center of a vast plain between the Jebel Tessala in the north and the mountains of Daya in the south. The wilaya occupies a strategic central position and covers about 15% of the territory of the northwest region of the country or 9 150.63 km ². It is considered as a relay because of its privileged location as it is crossed by the main roads of this part of the country(Safia et al., 2015) .

The wilaya of Sidi Bel Abbes is bounded as follows (Fig.1):

- North by the wilaya of Oran.
- Northwest by the wilaya of Ain Témouchent.
- Northeast by the wilaya of Mascara.
- West by the wilaya of Tlemcen.
- East by the wilayas of Mascara and Saida.
- South by the wilayas of Nâama and El-Bayad.
- Southeast by the wilaya of Saida.

The wilaya of Sidi Bel Abbes has an agro-sylvo-pastoral vocation and is characterized by three distinct natural regions.

- The steppe, located in the south of the wilaya, is very important from the point of view of surface, it is dominated by esparto grass. It occupies an area of 323 944 (ha) or 35% of the area of the wilaya.

- The mountainous area (north and center) covered mainly by forests, has an area of 366 080 (ha) or 40% of the total area.

- The plains (plain of Sidi-Bel-Abbes and Telagh) with a dominance of cereal crops cover an area of 225 035 (ha) or 25% of the total area.

The majority of the land in the wilaya of Sidi Bel Abbes is destined to agriculture through a diversity of crops in particular: cereals, orchards, fruit plantations and market gardening.

The diachronic study of cereal crop cover in the Sidi Bel Abbes region is based on the use of a series of sentinel 2A images of the current agricultural year. The flowchart below traces different stages of analysis, use and processing performed in this study. The field visit at local scale in order to identify and collect GPS points of some cereal plots managed by the technical institute of field crops.

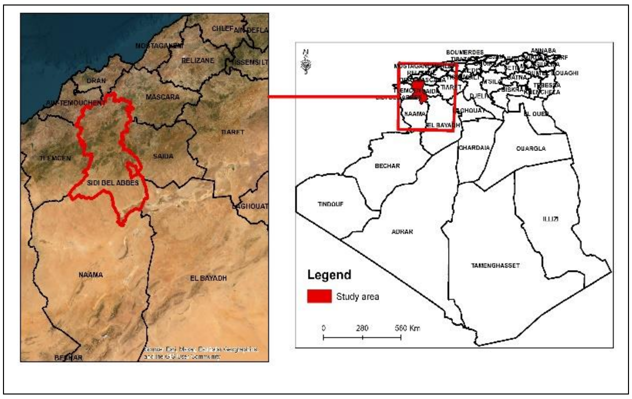

Figure 1. geographic extent of the study area.

2.2 Climate conditions

Agriculture is closely linked to climatic conditions, and cereal crops are no exception. In the case of Sidi Bel Abbes, Algeria, climatic conditions play an important role in the development of cereal crops.

It is important to note that Sidi Bel Abbes is located in a semi-arid region with a Mediterranean climate. Average temperatures range from 12°C in January to 26°C in August, with an average annual rainfall of about 350 mm (Fig.2).

The vegetative development of cereal crops in Sidi Bel Abbès depends on several factors, including temperature, humidity, soil quality, and the amount of sunlight. Although climatic conditions can be a challenge for growing cereals in this semi-arid region, farmers can adapt their farming practices to make the most of local conditions (Fig.2).

We notice average monthly variations in rainfall with a maximum in April and November (Fig.2). The minimum corresponds to the months of February, August and October. This confirms the characteristic of the semi-arid bioclimatic.

The comparison of the curve of variation of the average monthly precipitation, with the temperature, illustrates a significant decrease in the abundance of precipitation abundance of precipitation, which consequently has an influence on the distribution of the cereal crops.

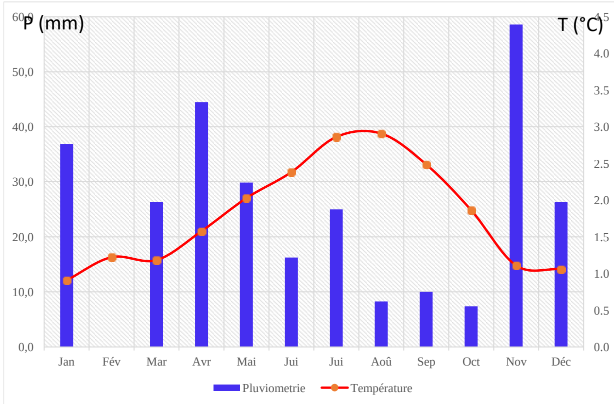

Figure 2. Rainfall across temperature variation in the season 2020-2021.

Moisture is also an important factor in the development of cereal crops. Cereals need an adequate amount of water to develop properly. In the case of Sidi Bel Abbes, the amount of annual precipitation is relatively low, which can have a negative impact on the growth of cereal crops. However, if cereals are grown in areas with good drainage, they can adapt to drier conditions.

Maximum of 70% of humidity is observed in October, winter season, and a and a minimum of 40% is observed in July, summer season (Fig.3).

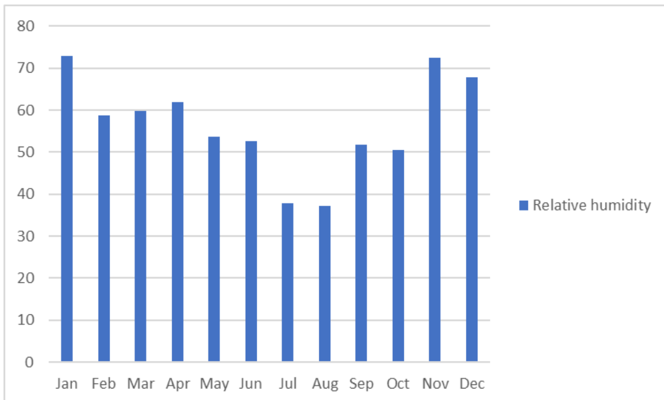

Figure 3. Relative humidity in the study area.

Assembling the vegetation indices (NDVI) of the current agricultural year. The determination of the NDVI values of the time series used relative to the collected GPS points, is done by superimposing these collected points in field on our satellite data to have the NDVI for each GPS point, and then we have the assemblies in a table, which represents the evolution of NDVI for each GPS point during the current agricultural year.

2.3 Used data

Sentinel-2 is a satellite imaging mission that is implemented by the European Commission (EC) and the European Space Agency (ESA) as a part of the Copernicus program (Fig.4). The two identical satellites (Sentinel-2A and Sentinel-2B) provide continually, multispectral, wide swath (290 km), high spatial resolution (four bands at 10 m, six bands at 20 m, and three bands at 60 m), and high revisit frequency (five days with combined satellites) image data.

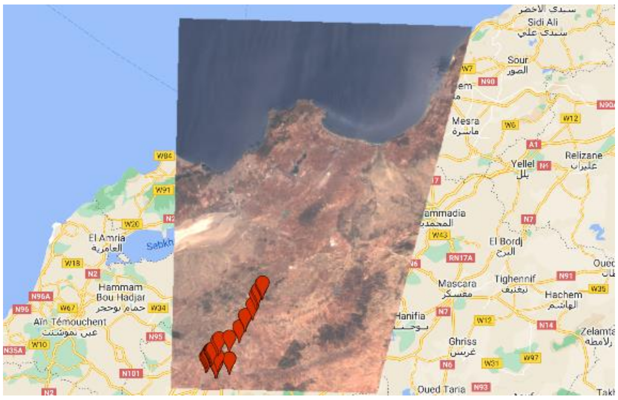

Figure 4. Sentinel 2 image of agricultural season 2020-2021 Data visualization of the field survey (GPS points collected from the field work in Sidi Bel Abbes 2021 (Red points).

The monitoring period of cereal crop cover in the Sidi Bel Abbes region is based on the use of 25 series of sentinel 2A images of the current agricultural year. The data were processed in Google Earth engine Platform (GEE)(Zhao et al., 2021).

The field visit at local scale in order to identify and collect GPS points of some cereal plots (Fig.4).

Assembling the vegetation indices (NDVI) of the current agricultural year. The determination of NDVI values of the time series used relative to the collected GPS points, is done by superimposing these collected points in field on our satellite data to have the NDVI for each GPS point, and then we have the assemblies in a table, which represents the evolution of NDVI for each GPS point during the current agricultural year.

3. METHODS

The methodology of this paper is detailed in two parts: monitoring crop phenology with Sentinel 2 time series and crop/ non crop mapping using thresholding algorithm.

The flowchart below traces the two parts of analysis, use and processing performed in this study (Fig.6).

First, Sentinel-2 time series are pre-processed on GEE by removing cloud and shadow to generate normalized difference vegetation index (NDVI) images. Then The monthly NDVI profiles are generated for the training GPS points for one-year 2021. On the other hand, The Otsu thresholding algorithm can obtain an optimal threshold automatically by maximizing the inter-class variance and minimizing the weighted within-class variance (Otsu, 1979).

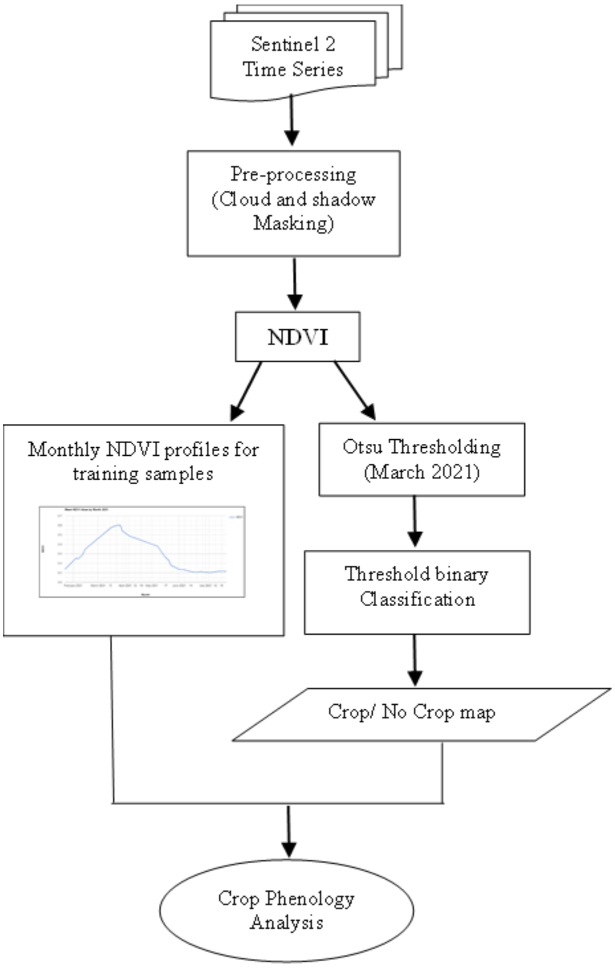

Figure 5. Flowchart of the proposed methodology.

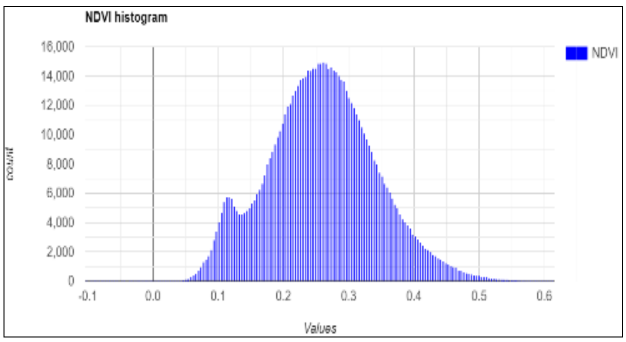

Figure 6. Thresholding NDVI values.

Binarization is the key step in extracting cereal crop land by using NDVI. During this process, it plays an important role. The (Otsu, 1979) as a common method of image segmentation is one of the most accurate and widely used methods (Sahoo et al., 1988). Otsu's method automatically obtains the optimal threshold through the histogram function of the grayscale image (Fig.6).

The basic principle of this method is to calculate the threshold, which maximizes the variance between classes (Mizushima & Lu, 2013). It can be expressed as follows Equation (1):

$$\sigma_B^2(t) = \frac{[M_G P(t) - M(t)]^2}{P(t)[1 - P(t)]} \quad \text{……….(1)}$$

Where M_G is the average intensity of the entire image(t) is the cumulative average up to level t (t ∈ [a, b], P(t) is the cumulative sum of probabilities assigned to object (background). The value t is the optimal value that maximizes $\sigma^2_B(t)$ (equation (2)):

$$t^* = \underset{a \le t \le b}{\operatorname{argmax}}\, \delta_B^2(t) \quad \text{……………………….(2)}$$

In our study, the Otsu thresholding algorithm was applied to on the derived NDVI image of March 2021 to identify an optimal threshold for NDVI Sentinel 2 to separate crop from non-crop pixels for producing a crop maps.

Finally, crop phenology analysis is performed and detailed in the sections below.

Numerous studies have suggested that Otsu's method is an effective solution for extracting built-up or other land use types from various indices derived from remote sensing data (Estoque & Murayama, 2015; Shi et al., 2014). In this paper, we are based on Otsu's method, we implemented an algorithm under GEE to obtain the optimal thresholds.

4. EXPREMENTAL RESULTS

In this section, this study based on time series of images for the current growing season, allow us to follow the cereal growth by stacking the NDVI values during the agricultural year 2020-2021 using Google Earth Engine (Fig.6).

Figure 8. Cereal crop mask.

The obtained results show the binary classifier provides the lowest accuracy (k=0,56) for the experiments and the obtained classification maps have the less visual quality (high commission error), that can be explained by the difficulty in change of its parameters and to get over correct effect (difficulty thresholding according to different crops).

4.1 Evolution of NDVI values during the growing period

The temporal profiles were established for the pixels corresponding to the sampling points that were carried out on the plain of Sidi Bel Abbes.

The NDVI calculated in this study is generated for each month separately. Generally, vegetation covers take positive NDVI values globally above 0.1 or the densest vegetation have higher values. Bare soils have NDVI values below 0.1 and sometimes above 0.1 when the soil is rich in organic matter.

4.2 Interpretation of cereal crop profile during growing period

The analysis of changes in NDVI values of cereal plots collected from the field has allowed us to identify a relationship between the evolution of NDVI values of the current agricultural season and the cereal development cycle and climatic conditions.

4.2.1 Vegetative period

This is due to the fact that the vegetation cover at the vegetative stage is light and thin, which leads to a decrease in the amount of reflectance, therefore, this has affected negatively on the value of NDVI. This period is characterized by a decrease in temperature that is varied between 10 ° C to 15 ° C with a significant rainfall that reaches up to 58 mm for the month of December (Fig.7).

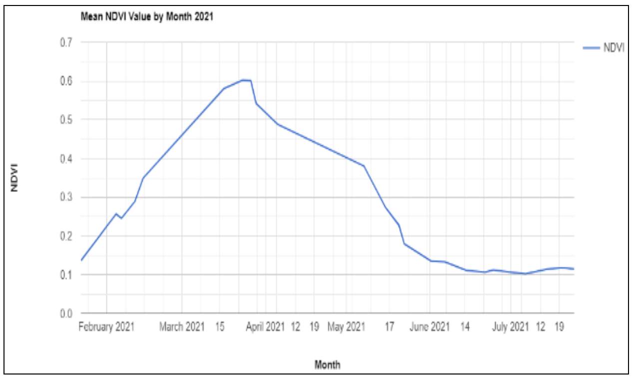

Figure 7. NDVI profile during the growing period (2020-2021).

4.2.2 Reproductive period

The high values of NDVI increase progressively from the end of December until the beginning of February, and from the end of February, we notice that there is a stop of increase and a stabilization of the values of NDVI until the middle of March where the NDVI restores their increase again, and arrives at its peak in the middle of April (Fig.7).

The intensity occurs due to the important chlorophyll activity during the reproductive phase which consequently an intensity of green pigment of plant cover which positively influenced by the amount of reflectance. The breakdown of the increase and stabilization of NDVI values in the curves between mid-February and mid-March is influenced by the climate condition (frost during January in the case of durum wheat), which causes damage to the vegetation cover according to the climate observation during 2020-2021 (January is the coldest month known for frost).

4.2.3 Maturation period

From the end of April until June, we observe the beginning of a decrease in the value of NDVI. These decreases occur because the level of intensity of green pigment that corresponds to this period is low due to the change of color and the fall of leaves that according climatic conditions that affect damage that cause a sharp decrease in grain production (Fig.7).

The minimum values of the NDVI are located in this period corresponding to the driest period in the year.

4.3 Spatial distribution of Cereal crop

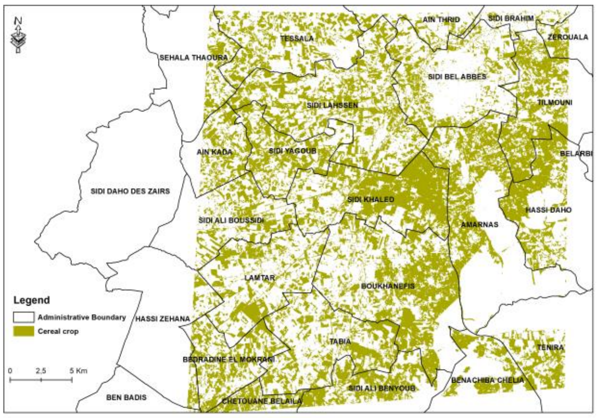

Figure 9. Geographical extent of cereal crop.

The first remark that can be extracted after reading the map of NDVI cover distribution in the department of Sidi bel Abbes (Fig.9). We can say that the vegetation cover is mainly and abundantly located in the plain area and they gradually decrease towards the north of the plain toward the tessala region. This difference in the distribution of vegetation cover is due to the nature of the soil and the climate condition in this region.

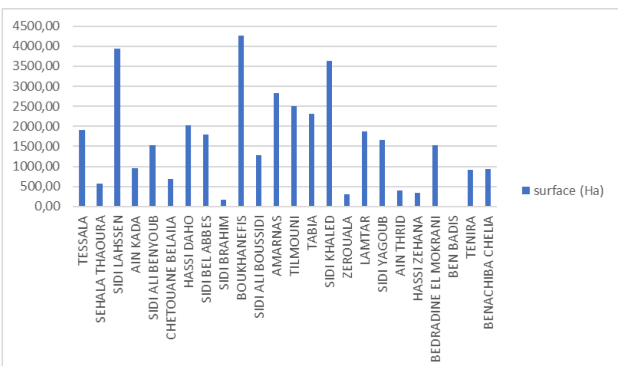

Figure 9. Graphical representation of the results obtained.

This graphical treatment brings out the geographical distribution of cereal growing in the 22-department covered by our results. The results obtained helped us to determine the geographical context of cereal growing and also to see the location of the potential in terms of surface. According to the graph, the potential communes in terms of surface area, we have recorded three communes in particular: Boukhanifis (4255 ha), Sidi lahssen (3943 ha) et Sidi Khaled (3634 ha) (Fig.10).

5. CONCLUSION

Analysis and determination of the periods of the cereal growth, made possible today using to the satellite imagery. The time series images during agricultural season (2020-2021), allows to determine the cereal zone of the region and to follow the growth for the different stage using thresholding NDVI values.

The results obtained from the processing of satellite images show that there is a disparity in the agricultural areas by municipality, and this is due to the geographical characteristics of the area, also the climate, which is one of the important factors.

Meteorological analysis, allowed us to determine the general characteristics of climate for the agricultural year (2020-2021), which is characterized by a continental climate in which the cold winter and hot summer and dry with some winds that can cause damage to agricultural production.

The NDVI values were successfully estimated to study the agricultural zone of the region. While the plain area has a high cereal cover.

The cereal phenology plays a necessary role in the analysis of vegetation cover, we must choose very carefully the date of extraction of the satellite image involved to assess this biological parameter in future research according to temporally data or satellite data rich in terms of spectral bands, spectral data or field measurements by spectrometer.

In terms of this work, this research requires field work in which the cereal-growing areas will be well identified to have a good characterization of this potential which is important for this country to preserve its food security.

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REFERENCES

Bessaoud, O., Pellissier, J.-P., Rolland, J.-P., & Khechimi, W. (2019). Rapport de synthèse sur l’agriculture en Algérie [PhD Thesis]. CIHEAM-IAMM.

Chehat, F. (2007). Analyse macroéconomique des filières, la filière blés en Algérie. Projet PAMLIM «Perspectives agricoles et agroalimentaires Maghrébines Libéralisation et Mondialisation» Alger, 7-9.

Djermoun, A. (2009). La production céréalière en Algérie : Les principales caractéristiques. Nature & Technology, 1, 45.

Estoque, R. C., & Murayama, Y. (2015). Classification and change detection of built-up lands from Landsat-7 ETM+ and Landsat-8 OLI/TIRS imageries : A comparative assessment of various spectral indices. Ecological indicators, 56, 205-217.

Guechi, I., Gherraz, H., & Alkama, D. (2021). Correlation analysis between biophysical indices and Land Surface Temperature using remote sensing and GIS in Guelma city (Algeria). Bulletin de la Société Royale des Sciences de Liège.

Maselli, F., & Rembold, F. (2001). Analysis of GAC NDVI data for cropland identification and yield forecasting in Mediterranean African countries. Photogrammetric Engineering and Remote Sensing, 67(5), 593-602.

Mizushima, A., & Lu, R. (2013). An image segmentation method for apple sorting and grading using support vector machine and Otsu's method. Computers and electronics in agriculture, 94, 29-37.

Otsu, N. (1979). A threshold selection method from gray-level histograms. IEEE transactions on systems, man, and cybernetics, 9(1), 62-66.

Safia, A., Mohamed, B., Lotfi, B. T., Farouk, M., & Samir, M. M. (2015). Contribution to the Characterization of Peri-urban Natural Areas of Sidi Bel Abbes Town (Northwestern Algeria).

Sahoo, P. K., Soltani, S., & Wong, A. K. (1988). A survey of thresholding techniques. Computer vision, graphics, and image processing, 41(2), 233-260.

Shi, K., Huang, C., Yu, B., Yin, B., Huang, Y., & Wu, J. (2014). Evaluation of NPP-VIIRS night-time light composite data for extracting built-up urban areas. Remote Sensing Letters, 5(4), 358-366.

Zhao, Q., Yu, L., Li, X., Peng, D., Zhang, Y., & Gong, P. (2021). Progress and trends in the application of Google Earth and Google Earth Engine. Remote Sensing, 13(18), 3778.