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Monitoring the Growth of Agricultural Crops Phenology using Google Earth Engine in Wasit Governorate / Central Iraq.

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Abstract

The estimation of a crop's phenological growth stage is very important in remote monitoring and advisory of crops using satellite imaging. However, it has not been thoroughly researched and recorded in the context of crop identification and crop health, scheduling of irrigation. The study area is located in the Kut Governorate in (Dujaili) district, with an area estimated at (1,583,000) dunums, in which various crops are grown, including (wheat, barley, alfalfa, vegetables of all kinds, and corn of both types (yellow, white). The aim of the study is to monitoring the growth stages of agricultural crops and irrigation of crops using the Google Earth Engine GEE platform, the research comes within the framework of bridging the knowledge deficit by using GEE in monitoring plants, since few studies discussed the use of the platform in detecting vegetation. The study conclude the utilization of the GEE platform and the creation of a code through which crops and irrigation were monitored in the study area with different date that included the stage of tillage, initial germination, peak time of the plant to the weaning irrigation and then harvesting to be effective in explaining the growth of agricultural crops phonologically, and this technique leads to short time and accuracy in results as well as new method produces monthly high-resolution (10m resolution) maps of the cropping areas as the growth stages of the crops, the method is a temporal gradient of Sentinel-1 data and crop Phenology information based on the GEE as a model environment that can support such a context and that the NDVI index is a good indicator to monitor of all vegetation areas, Whereas, the Modified Chlorophyll Absorption Ratio Index (MCAR2) is more sensitive to changes in chlorophyll content, Leaf Area Index (LAI) variation and lessening of the soil effect.

Keywords: Phenology; Sentinel-1; Google Earth Engine; MCAR2; NDVI

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مراقبة نمو المحاصيل الزراعية فينولوجياً باستخدام منصة محرك كوكل السحابية في محافظة واسط / وسط العراق

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المستخلص

يعد تقدير مرحلة النمو الفينولوجية للمحصول أمرًا مهمًا للغاية في المراقبة عن بعد وتقديم المشورة فيما يخص المحاصيل باستخدام التصوير عبر الأقمار الصناعية والتي لم يتم بحثها وتسجيلها بدقة في سياق تحديد المحاصيل وصحة المحاصيل وجدولة الري . تقع منطقة الدراسة في محافظة الكوت في قضاء (الدجيلي)، وتقدر مساحتها بـ (1,583,000) دونم، تزرع فيها المحاصيل المتنوعة منها (القمح، الشعير، البرسيم، الخضار بأنواعها، والذرة بنوعيها (أصفر، أبيض)(. تهدف الدراسة الحالية الى رصد مراحل نمو المحاصيل الزراعية وري المحاصيل باستخدام منصة Google Earth Engine GEE، ويأتي البحث في إطار سد النقص المعرفي باستخدام GEE في مراقبة النباتات، حيث أن الدراسات القليلة ناقشت استخدام المنصة في الكشف عن الغطاء النباتي، وخلصت الدراسة إلى الاستفادة من منصة GEE وإنشاء كود يتم من خلاله مراقبة المحاصيل والري في منطقة الدراسة بتواريخ مختلفة شملت مرحلة الحراثة الأولية, مرحلة الانبات , رية الفطام , ثم مرحلة الحصاد لتكون فعالة في تفسير نمو المحاصيل الزراعية وتؤدي هذه التقنية إلى الاستفادة من الوقت والدقة في النتائج وممكن الحصول من الطريقة الجديدة شهرياً على دقة عالية (دقة 10م). الطريقة عبارة عن تدرج زمني لبيانات Sentinel-1 ومعلومات فينولوجيا للمحاصيل استنادًا إلى GEE كبيئة نموذجية يمكنها دعم مثل هذا السياق وأن مؤشر NDVI هو مؤشر جيد لرصد جميع مناطق الغطاء النباتي، الى أن مؤشر نسبة امتصاص الكلوروفيل المعدل modified chlorophyll absorption ratio index 2 (MCARI2) أكثر حساسية للتغيرات في محتوى الكلوروفيل وتغير مؤشر مساحة الأوراق Leaf Area Index (LAI) وتقليل تأثير التربة.

الكلمات المفتاحية : فينولوجياً، سينتيل1، منصة محرك كوكل السحابية، معامل امتصاص نسبة الكلوروفيل المعدل 2، مؤشر الغطاء النباتي.

1. Introduction

Climate change occurs naturally, but during the last century global warming has been so rapid that it cannot be attributed to natural causes alone. Many studies indicate that global warming is highly likely to cause climate shifts (Wu & Johnston 2007). Based on observed and modeled data, it has been established that elevated CO2 concentration and climate shifts would impact considerably hydrological cycles mainly through the alteration of evapotranspiration and precipitation.

When monitoring and advising crops remotely via satellite photography, the estimation of a crop's phenological growth stage is crucial. However, it has not been well studied and documented in the context of its application to crop identification, crop health, scheduling of irrigation, decisions regarding purchase and application of agricultural inputs such as soil nutrients, alerting of possible diseases, harvest prediction or detection, and yield estimation. It is now known that the application of soil nutrients in the panicle stage of a paddy can increase the Chlorophyll and Nitrogen (N) content in the high photosynthetic-rate leaves, and as a result increase the yield. (Wang,2003).

The Google Earth Engine (GEE) is a cloud-based geospatial analysis platform that enables users to visualize and analyze satellite images of our planet data sets (at petabyte-scale) for analysis and ultimate decision making. Following the free availability of Landsat series in 2008, Google archived all the data sets and linked them to the cloud computing engine for open source use.(Mutange & Kumar,2019). The GEE is a service provided by Google that let users programmatically utilize Google servers to do heavy remote sensing (RS) related computations on the cloud and to download the final product “if needed". The GEE is also preloaded with almost every known RS sensors to the most recent dates, which makes it convenient in terms of data availability. (Al-Mamalachy & Al-Saedi,2022). It is common practice to tie remote sensing data to a particular biophysical property.

Utilizing a combination of several spectral bands, also referred to as vegetation indices (VIs), is a typical strategy. Two VIs introduced by Haboudane, et al., 2004) for the estimation of the biophysical characteristic green leaf area index, the photosynthetically active leaf area, were the modified chlorophyll absorption ratio index 2 (MCARI2) and modified triangular vegetation

index 2 (MTVI2). In the Haboudane *et al*. (2004) study, to improve the sensitivity of two established VIs (MCARI and MTVI) to green leaf area index, a soil adjustment factor was developed. Barry ,et al. ,2008 indicated there was no difference in the results between MCARI2 and MTVI2. He indicates that the results from MTVI2 and MCARI2 had identical results due to similar equations; however, the mathematical similarity was not described in detail and he founded how the MCARI2 and MTVI2 are related theoretically. VIs as introduced in the Haboudane ,*et al.,* 2004. Specifically, this study seeks to determine why the results from MCARI2 and MTVI2 did not differ in previous studies.

The aim of the study is to monitoring the growth stages of agricultural crops and irrigation of crops using the GEE computer platform. The research comes within the framework of bridging the knowledge deficit in the use of GEE in monitoring plants, since few studies discussed the use of the cloud platform in detecting vegetation.

2. Location of study area

The importance of the Dujaili project stands out as being one of the most important projects in Iraq in the past and up to the present time. The scholars will try to shed light on the importance of the project by knowing some historical facts about it:

The idea of establishing an agricultural-industrial complex in Iraq were in 1974, similar to the Belgrade agricultural-industrial complex. The lands of the Dujaili project were chosen for the main reason that the front of the project is located before the Kut barrage, and thus the water share of the project lands is secured throughout the year. In 1974, the project was transformed by a state decision into major development projects, and the Dujaili Agricultural Authority was formed to supervise it to give the project greater independence and wide freedom of movement, and a board of directors was formed for it according to Republican Decree No. 450 on 8/31/1974.

In 1974, the interest turned into a public establishment (the Agricultural Public Establishment in Dujaili), and on May 16, 1976, a contract was signed for the establishment of the Dujaila Agricultural/Industrial Complex with the Belgrade Agricultural and Industrial Complex (PKB) for the purpose of reclaiming the lands located within the boundaries of the complex and

investing them for the purpose of agricultural production (Plant-animal) and industrial (manufacture of plant and animal products) from a total area of the project estimated at 262000 dunums, and the reclamation will be in the form of three stages, one of the stages was 76000 dunums that have already been reclaimed. The project aimed at the following:

1. Reclamation of an area of 196000 dunums.
2. Establishment of five stations for cows with a capacity of 4830 cows for each station.
3. Production of 60000 tons of milk annually.
4. Production of 8500 tons of meat annually.
5. Production of 97000 tons of organic fertilizer.
6. Establishment of a feed plant with a capacity of 50000 tons annually.
7. Establishing a seed purification plant with a capacity of 48 tons / day.
8. Establishing a dairy factory with a capacity of 165 tons / day.

The study area is located in the Kut Governorate in (Dujaili) district, with an area estimated at (1,583,000) dunums, in which various crops are grown, including (wheat, barley, alfalfa, vegetables of all kinds, and corn of both types (yellow, white), as shown in Figure (1).

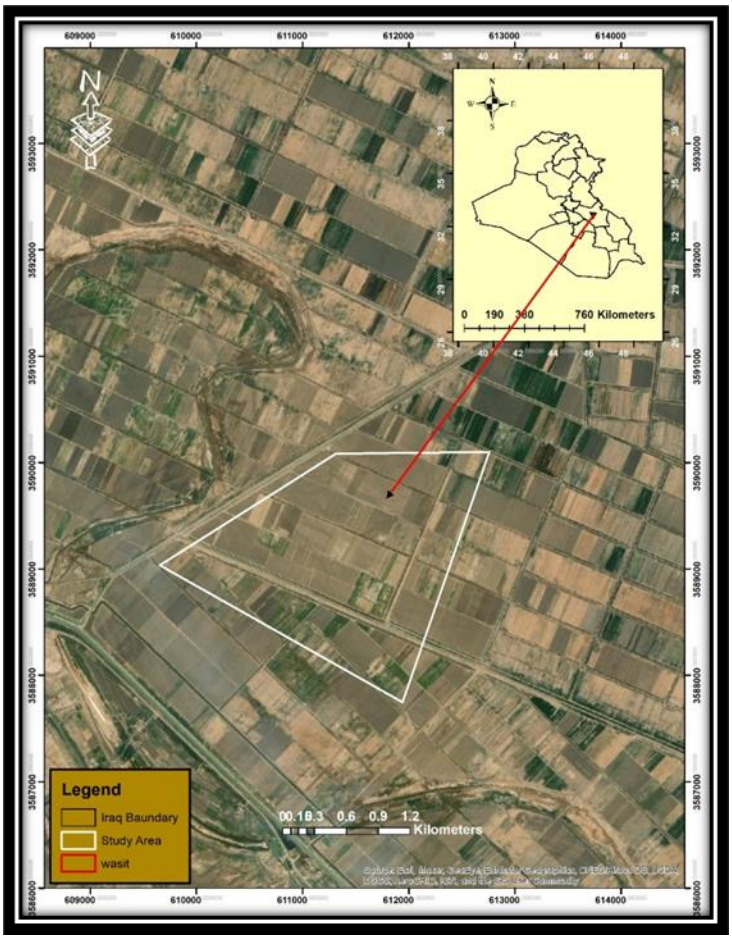


Figure (1): location of study area

3. Materials and Methods

3.1. The Methodology

The current study was carried out in two phases:

1. Stage one included the use of GEE to monitor the growth of agricultural crops and the irrigation times for those crops.

2. Stage Two Using the modified MCARI2 indicator within the study area and calibrating the data in the field. As shown in the chart below in Figure (2).

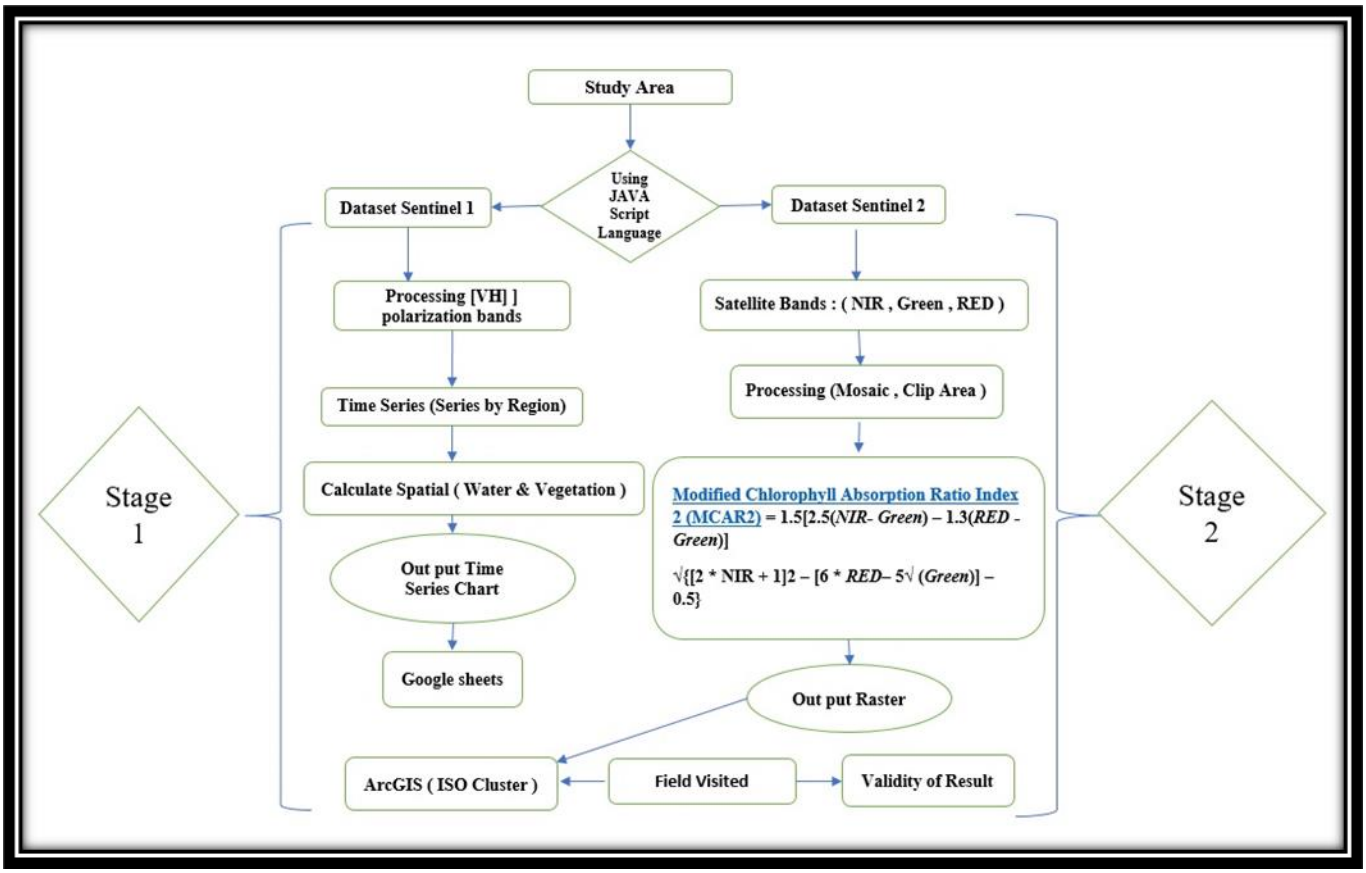


Figure (2): Methodology of the study

3.2. Data and software's used in the research

Multi-Data were used in present study:

A- Radar images: Radar images show points of different degrees, and those points are called (Specrles), the radar images resemble grains of salt and pepper scattered on the image. (Al Shafei & Najeeb, 2016). As shown in Figure (3).

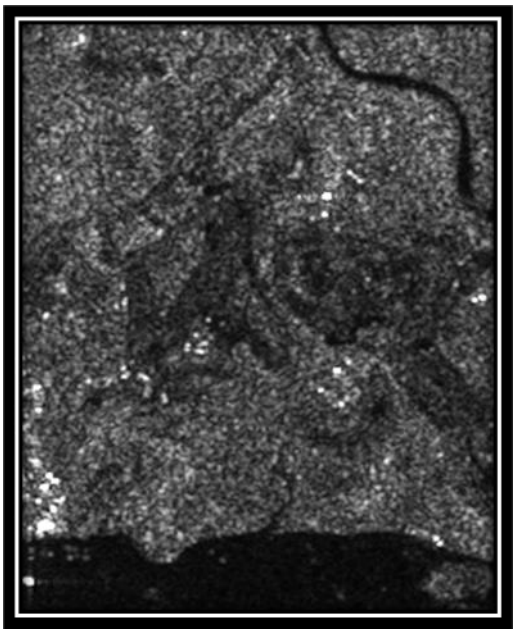


Figure (3): shows radar image

The Sentinel-1 satellite data the C-band sensor was used during the study from November 2021 to May 2022 to monitor the growth stages of agricultural crops as well as the irrigation times of the crops using the (vertical transmit / horizontal receive) VH band and a vertical transmit / horizontal receiver called Cross - Polarization in the selected agricultural crops fields.

Table (1) characteristics of data used in research

Satellite	Bands	Description	Wavelength	Resolution
Sentinel-1 / C-band	VH	vertical transmit/horizontal receive	(5.6 cm)	10 meters
Sentinel-2	B3	Green	560nm (S2A) / 559nm (S2B)	10 meters
Sentinel-2	B4	Red	664.5nm (S2A) / 665nm (S2B)	10 meters
Sentinel-2	B8	NIR	835.1nm (S2A) / 833nm (S2B)	10 meters

B- Software's used in the study

A number of software's were used in current study:

1- GEE is used to source, generate, and analyses surface water maps that were derived from imagery. GEE is an online coding environment enabling relatively rapid, server-based analysis of large spatial datasets. (Gorelick, et al., 2017). As in Figure. 4.

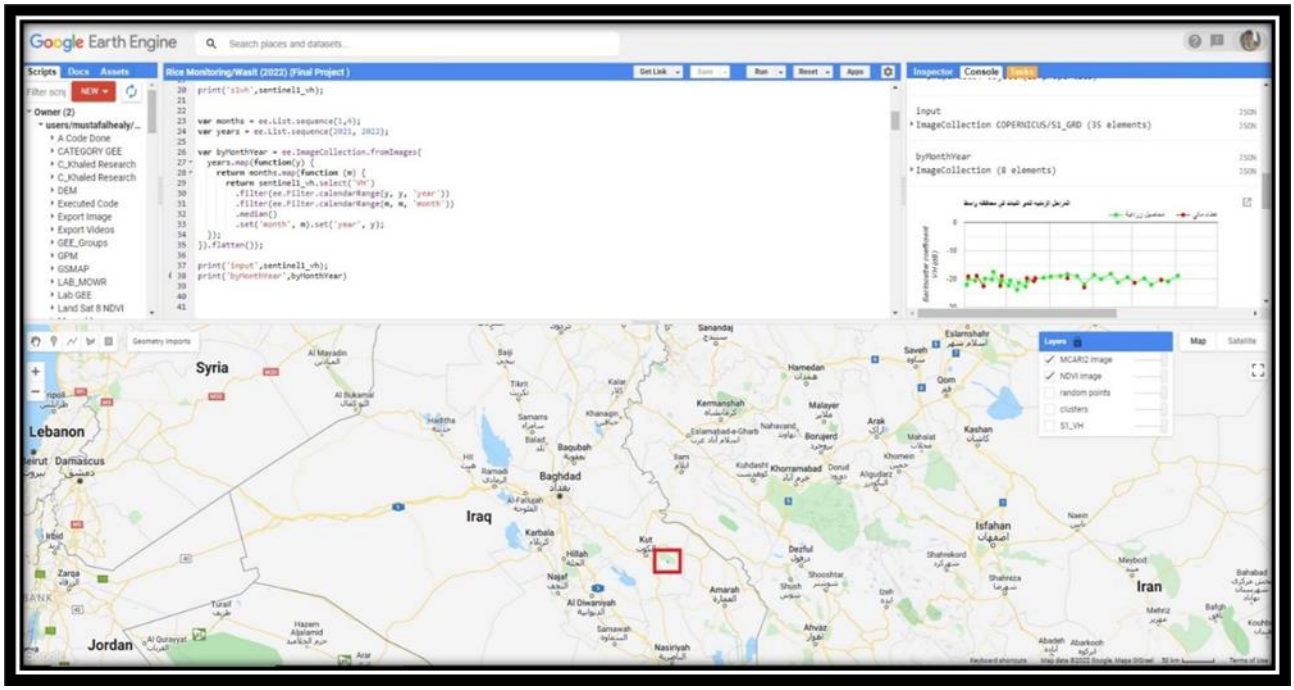
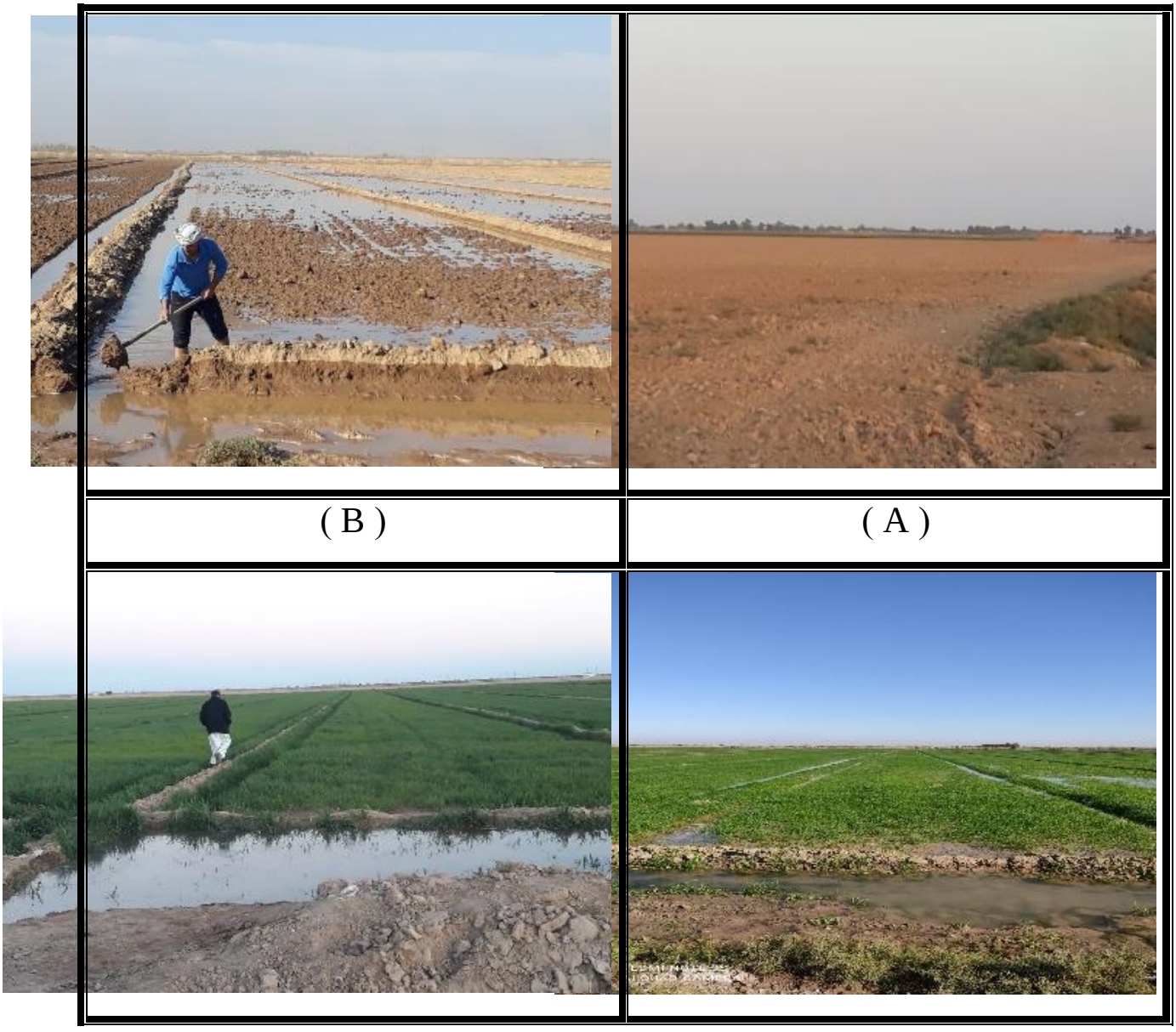


Figure (4): Google Earth Engine Environments

1- Arc GIS 10.8: (GIS) is a tool to work with georeferenced information. In particular a GIS is a system that allows the following operations: Reading, editing storing, and, generally speaking, managing spatial data. Analyzing those data. This includes everything from simple queries to complex models, which can be performed using the spatial component of the data (the location of each value or element), the thematic component of the data (the value or element itself), or both. Generating documents such as maps, reports, plots, etc. (Olaya,2018).
2- Google Sheets is a free online spreadsheet program that enables us to make and format spread sheets as well as collaborate with others.

3.3. Field Works:

The field work is considered important for the purpose of comparing the results obtained in the office with the ground truth. There was a periodic and continuous follow-up of the staff of the National Center representative office in Wasit Governorate, and the region was also visited from the period (15 to 17/2/ 2022) to see the irrigation reality of the study area, as shown in the pictures and the time periods for watering.



(B) (A)

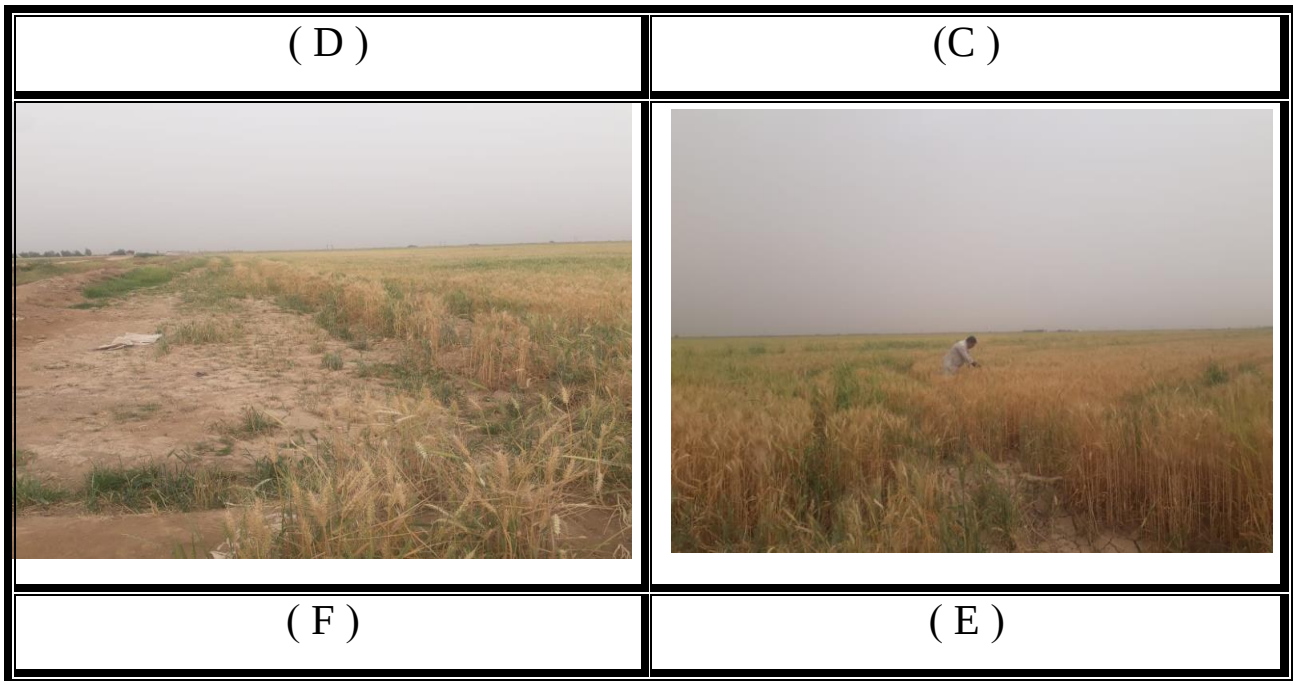


Figure (5): The time sequence of irrigation in the study area respectively

Figure (5-A) demonstrate shows the tillage stage ended on 10/11/2021, Fig. (5-B) represent the first irrigation stage, which was on 14/11/2021, Fig. (5-C) shows the second irrigation stage on 20/12/2021, Fig.(5-D) the third irrigation stage on 25/1/2022. Fig.(5-E) shows the stages of germination on 2/3/2022. And the Fig.(5-F) It shows the weaning irrigation on 21/3/2022.

4. Modified Chlorophyll Absorption Ratio Index (MCAR2) Vs NDVI

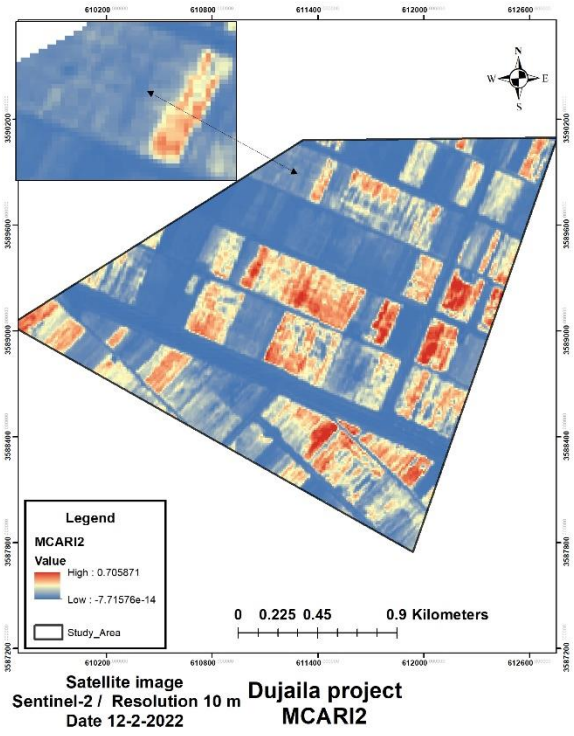
Remote sensing techniques considered the perfect way to monitor the vegetation density cover, especially in the areas cannot be reached. The vegetation indices were used widely as a vital analytic way to enhanced the multi-spectral images, aerosol and biomass. (Chopping, et al.2008).

The vegetation significantly affects the spectral reflection of two or more plants Spectral bands, usually the two red bands and NIR, where the difference between them is a strong indicator amount of green biomass, and active photosynthesis. (Teillet, et al.,1997). As in equations (1) and (2).

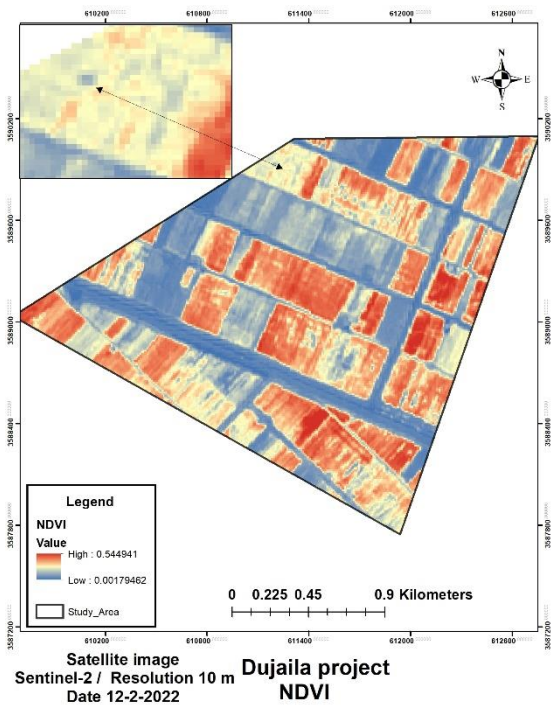
$$NDVI = \frac{(NIR - Red)}{(NIR + Red)} \quad (1)$$

$$MCARI2 = \frac{1.5[2.5(NIR - RED) - 1.3(NIR - GREEN)]}{(2NIR + 1)^2 - \left(6NIR - 5\sqrt{RED}\right) - 0.5|}, \quad (2)$$

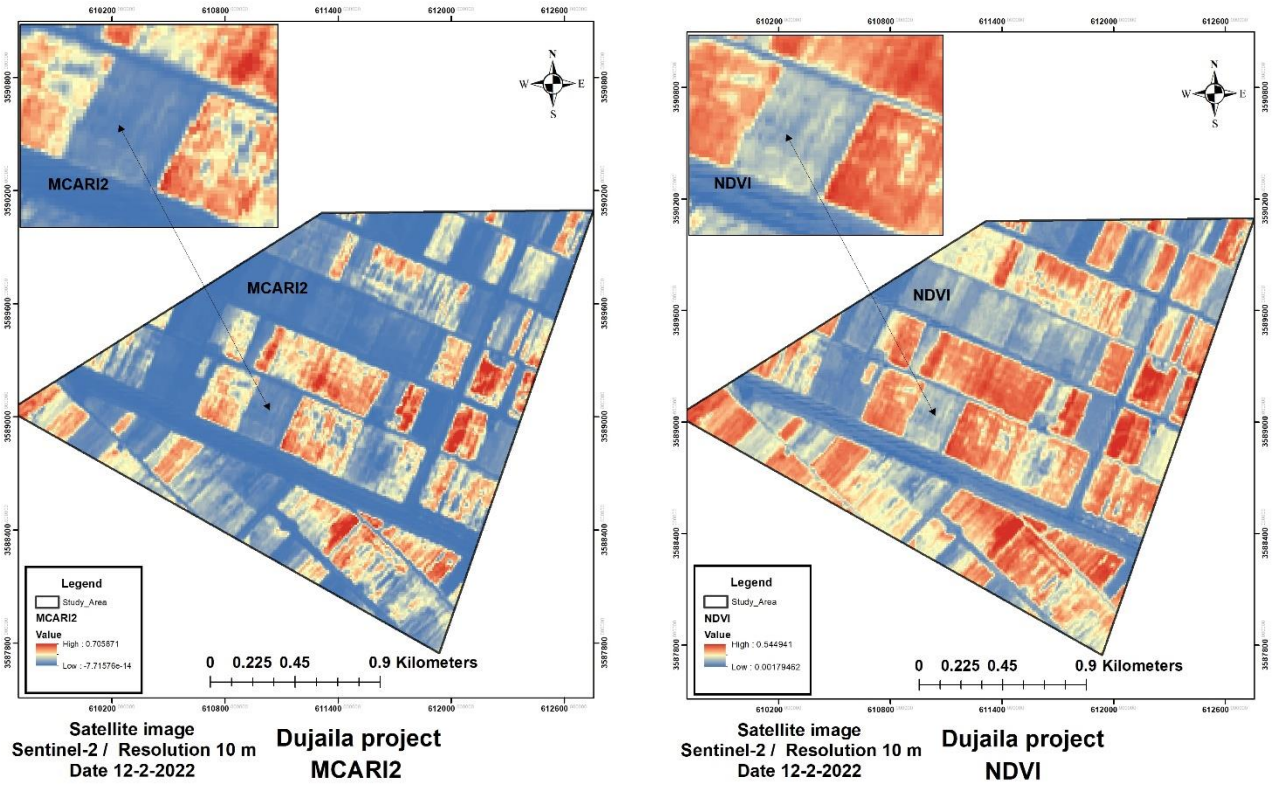
As a result of the varying degree of efficiency of plant indicators in overcoming external influences, an urgent need arose to test them and identify their efficiency in estimating and monitoring the characteristics of agricultural crops in many regions of the world, and in environments with different climates, topography and crops, in an attempt to normalize all these differences in an ideal plant indicator with A wider dynamic range, high sensitivity to agricultural crops, low sensitivity to soil, is not affected by the ability of spatial and spectral discrimination of satellites, and has little influence on the atmosphere and the effects of the environment. It is noted from Figure (6) that the MCARI2 indicator hides small weeds and shows good-growing crops due to the sensitivity of the indicator to chlorophyll, while the NDVI indicator is sensitive to all plants, whether weeds or crops.



(A)



(B)



(C) (D)

Figure (6): Shows the different between NDVI (D, B) and MCARI2(C, A) in study area

5. Data Analysis

According to the methodology shown in Figure (2), the study included two phases:

1. Monitoring the growth of agricultural crops and irrigation in the study area.

In the GEE environment, specify two values (crops and irrigation). The crops are shown with green dots and irrigation are red in the study area, at a monthly for the period from November to May of 2021, Date 11/14/2021, the scholars noticed that the crops and the irrigation process follow the same behavior, meaning that there is a withdrawal of water, the second irrigation date of 20/12/2021. the scholars note that the crops and the irrigation process follow the same behavior, meaning that there is a withdrawal of water, and also indicates the scheduling irrigating

system the fields, while the third irrigation stage dated 25/1/2021, the scholars note the same behavior of plants and water whereas the germination period, there was rain that was verified in march 2022 and the fourth irrigation stage (weaning irrigation), dated 21/3/2022 we note from the irrigation plan on the date 13/5/2022 that the crop was harvested completely and the land was prepared for the next agricultural season. As shown in Figure (7).

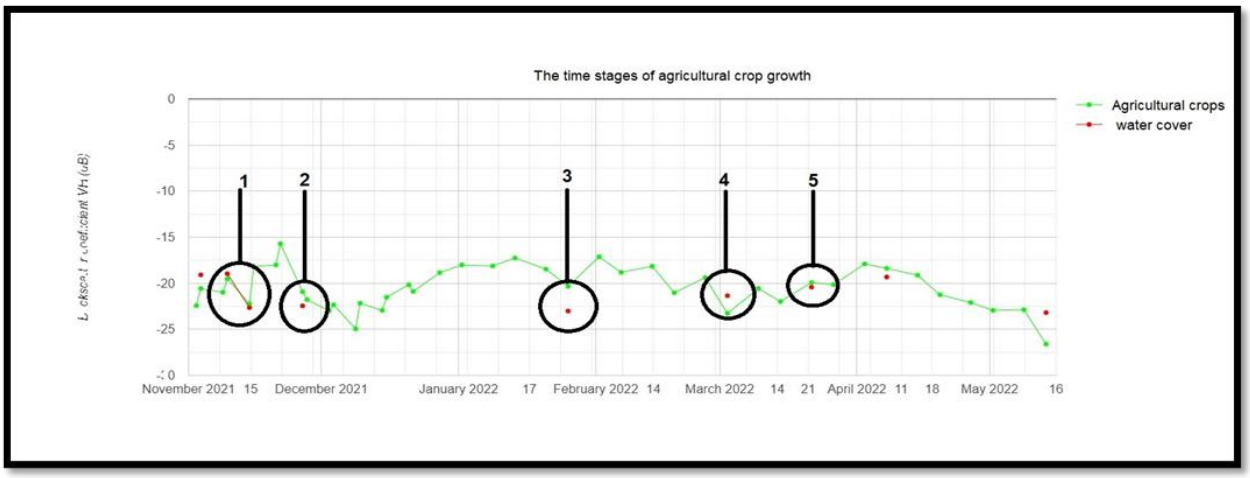


Figure (7): shows the multi-temporal stages of agricultural in the study area

2. By making use of the equation (2) in the GEE and the usage of the statistics of Sentinel 2 satellite, in which the desired bands (B3, B4, B8) had been determined, then the procedure of extracting them with the aid of Export process, as proven in in earlier Figure (6).

6. Conclusions

The present study concluded the following:

1.Due to Wasit Governorate is considered one of the most agricultural areas in Iraq territory with vegetation density cover which may be difficult to monitor; therefore, the remote sensing techniques including vegetation indices will be the suitable approach in the study, but because of the different effectiveness of estimating coverage, and limited capacity to investigate small agricultural areas, it was necessary to used indices such as MCARI2 in monitoring agricultural crops and demonstrate the small vegetation areas.

2. This new method produces monthly high-resolution (10m resolution) maps of the cropping areas as well as the growth stages of the crops. The method is a temporal gradient of Sentinel-1 data and crop Phenology information based on the Google Earth Engine (GEE) as a model environment that can support such a context.

3. The study concluded that the NDVI index is a good indicator to monitor all vegetation areas, Whereas, the modified MCARI2 index is more sensitive to changes in chlorophyll content, Leaf Area Index (LAI) variation and lessening of the soil effect.

4.The use of the GEE platform and the creation of a code through which crops and irrigation were monitored in the study area with different dates that included the stage of tillage, initial germination, peak time of the plant to the weaning irrigation and then harvesting to be effective in explaining the growth of agricultural crops phonologically, and this technique leads to short time and accuracy results.

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