Journal of Engineering and Sustainable Development

Vol. 23, No.04, July 2019
ISSN 2520-0917
https://doi.org/10.31272/jeasd.23.4.6

EVALUATION OF THE EFFICIENCY OF AGRICULTURAL PRODUCTION IN THE PIVOTAL FARMS UTILIZING REMOTE SENSING TECHNIQUES

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Received 22/8/2016 Accepted 23/4/2018 Published 1/7/2019

Abstract: Evaluation of the efficiency and estimating crop yield and forecasting are very important, because relation to food security of the country and to reach the stage of self-sufficiency. Research is trying to estimate the crops, and solves the problem of monitoring of farms inaccessible by field visits; monitor the implementation of the agricultural plan in addition, to monitoring the health status of crops. Utilizing application of remote sensing RS, geographical information system (GIS) added satellites imageries with multi temporal and spatial analysis of vegetation cover. The research includes the collection of (12 image) Landsat8 and (3 image) Sentinel-2. In addition the meteorological data from agricultural meteorological stations of the Iraqi Ministry of Agriculture. Moreover the field data. Covered the winter planting season from 01/10/2015 to 01/05/2016.The research includes using Cropwat program to calculation Calendar germination of crops, and using ERDAS IMAGINE 2014 to create process and calculation NDVI, Change Detection, and spectral profile analysis from imageries. Moreover using ArcGIS 10.3 for building Geodatabase, building spatial database, analysis data, and product maps. The results of the evaluation showed that most of the Ain al-Tamur pivotal farms are highly efficient and the results of change detection for the NDVI and NIR are very effective.

Keywords: *Wheat Crop, Sentinel-2, Cropwat, NDVI, Pivot Irrigation.*

تقييم كفاءة الإنتاج الزراعي للمزارع المحورية باستخدام تقنيات التحسس النائي

الخلاصة: تقييم كفاءة وتقدير غلة المحاصيل الزراعية مهمة جدا بسبب ارتباطها بالأمن الغذائي للبلد والوصول الى مرحلة الاكتفاء الذاتي. البحث يحاول تخمين المحاصيل، وإيجاد حل لمشكلة مراقبة المزارع التي يتعذر الوصول إليها بالزيارات الميدانية، ومراقبة تنفيذ الخطة الزراعية بالإضافة إلى ذلك، مراقبة الحالة الصحية للمحاصيل. باستخدام تطبيق الاستشعار عن بعد ونظام المعلومات الجغرافية وبمساعدة مرئيات الأقمار الاصطناعية مع التحليل المتعدد الأزمنة للغطاء النباتي. تضمن البحث جمع (12صورة Landsat8) (3 صور Sentinel-2). بالإضافة إلى ذلك بيانات الأرصاد الجوية من محطات الأرصاد الجوية الزراعية لوزارة الزراعة العراقية. بالإضافة الى بيانات ميدانية غطت الموسم الزراعي الشتوي من 01/10/2015 إلى 01/05/2016، واستخدم CROPWAT لحساب تقويم الإنبات للمحاصيل. واستخدام لإنشاء عملية كشف التغيير، وحساب مخطط الانعكاسية والمعالجة برنامج ERDAS IMAGINE 2014. كذلك استخدام ArcGIS 10.3 نظم المعلومات لبناء قاعدة البيانات الجغرافية، وبناء قاعدة بيانات المكانية، تحليل البيانات، وإنتاج الخرائط.

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أظهرت نتائج التقييم أن معظم المزارع المحورية عين التمر ذات كفاءة عالية ونتائج(change detection NDVI or IR) كانت فعالة جدا.

1. Introduction

The agricultural production in Iraq plays a significant role in environmental, social and economic aspects and in particular the strategic crops and its relation to food security. Today importance of measuring and monitoring of our environment has become increasingly crucial to the expansion of our population.

Land values appreciate, of our natural resources dwindle, human activities and continue to emphasize the quality of our land, water and air. Land use, and the technology of modern satellite and computers for data processing contemporary of Surveyors are now able to measure and monitor the Earth and its natural resources are literally on a global basis. [1].

The mapping and monitoring of vegetation conditions has been one of the most important objectives of remote sensing since the advent of remote sensing technology. Satellite remote sensing and multispectral imaging systems have revolutionized the mapping and monitoring of vegetation properties, which became commercially available during the 1970s. [2].

Remote sensing by satellites offers several options for reducing crop-forecasting errors, particularly in data-sparse regions [3].The Landsat 8 (L8). Four decades of imagery provides a unique resource for those who work in monitoring agriculture, and monitoring the health status of crops.

The Landsat 8 satellite (launched on February 11, 2013) became available [4]. The spatial resolution for eight bands 30 m and one Pan Band 15 m, and two band thermal 100m.Sentinel-2A was launched on 23 June 2015 on a Vega rocket from Europe's Spaceport near Kourou in French Guiana, an overseas department of France.[5].

Imageries satellite sentinel-2 consists of 13 bands distributed into three types according to the spatial resolution, 3 band in visible range and one near infrared with band 10m, six bands at near infrared with 20m, and three atmospheric bands with 60m.

2. Study Area

The study area located in west the holy Karbala' province as shown by red color in figure (1).study area include Ain al-Tamur Nahia border at Ain al-Tamur Agriculture of Division. Locally study area extends between latitude (32˚08'-32˚47') north and longitude (43˚09'- 44˚49') east, an area of (1968.378893) km. The study area selected for this research, because of the availability of best way for evaluation of the efficiency of agricultural production in the pivotal farm utilize remote sensing techniques. The study area selected due it famous for the agriculture of strategic wheat crop, which is considered a major source of food security and irrigation by the pivotal fixed (sprinklers irrigation).

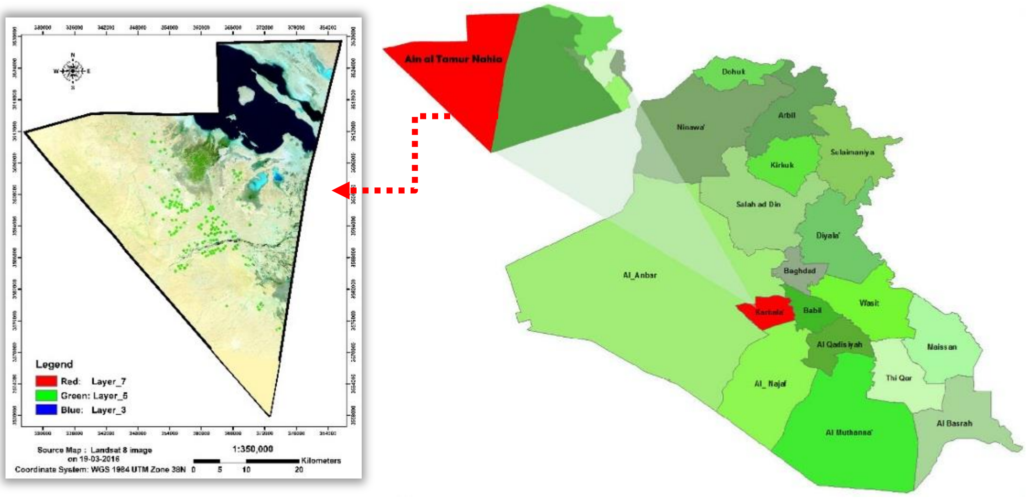

Fig. (1) Illustrate location the study area (source by researcher)

3. Problem Statement

1. Continuous monitoring of the health status of each pivotal farm during the winter planting season.
2. Comparison and evaluation the production results between the farm and another depending on the standard pivotal areas (68, 80,120 dunam).

4. Theoretical Background

4.1. Growth Stage Scales Feekes

Growth Stage Scales Feekes Using to describe the stages of crop growth (Fig. 2). It is important to understand the growth and development of the wheat plant for the use of fertilizers and plant growth regulators and pesticides properly for crop production. Many pesticide marks constrain the application until the crop in certain growth stages (Table 1) indicated Feekes growth tables [6]. Growth is the increase in the size and number of leaves and stems, therefore depending on farm management in the Ain al-Tamur need to experience and connect with guiding teams in the Division of Agriculture. In order to choose the right time for fertilization and pest control and irrigation in time and quantity required to meet the needs of the crop.

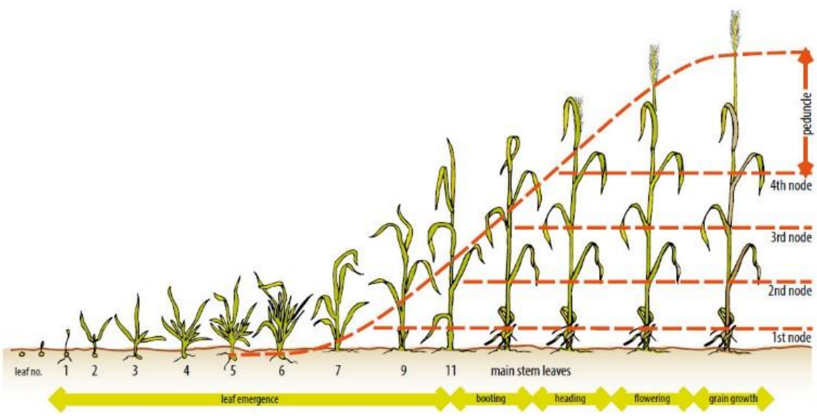

Fig. (2)Growth Stage Scales Feekes for wheat crop. (Source:[7])

Table 1: Major steps for the management of wheat crop depending on the stages of the growth scale Feekes. (Source: [11])

Feekes Growth Stage	Management Considerations
1.0	Check stands for emergence and uniformity. Check for weeds and apply herbicides if necessary. Begin monitoring for various aphid species (continue through season). Check seedlings for Hessian fly feeding damage.
2.0 3.0	Make early nitrogen applications to enhance tillering in thin stands. Avoid excess nitrogen.
4.0	Scout for insect and disease problems. Check stands for heaving caused by freezing/thawing cycles. Decide whether post-emergence weed control is warranted.
5.0	Make spring top dress nitrogen applications. Apply herbicides as needed for weed control.
6.0	Cutoff for nitrogen applications to avoid leaf injury. Cutoff for some growth regulator herbicides.
7.0	Scout for insect and disease problems.
8.0 9.0	Apply fungicides to protect flag leaf from foliar diseases if necessary. Cutoff for any further herbicide applications unless harvest aid treatments are needed.
10.0	Determine if fungicide applications for glume blotch management are needed. Check for armyworm feeding. Consider control measures if armyworm feeding is clipping heads.
10.5.1	Apply fungicides to suppress Fusarium head blight if necessary

4.2. Temperature Limits to the Wheat Crop.

Agricultural production is significantly affected by several factors, from the stage of seeding until the harvesting stage, the main effects of soil and weather. Where they are treatment the weakness of the health status of the soil through fertilizer and fertility is increased by diversifying agriculture each year. As a result, yield forecasting represents an important tool for optimizing crop yield and to evaluate the crop-area insurance contracts [8].The temperature from the more specific climatic elements for planting, and production of agricultural crops, during direct impact on the crop and indirect. Among other climate elements in turn are the determinants of agricultural production, as the success of planting these crops primarily. The fundamental nature of the thermal situation in the planting area, it affects through the stages growth on various physiological processes that take place within the crop, as well as its role in locating their concentration and spread [9].Three degrees thermal is the maximum thermal class upper limit thermal and micro-class or lower limit minimum and their thermal class optimum, which is the most efficient temperature, which grow staple crops. Table (2) illustrate temperature limits to the wheat crop. In paragraph irrigation explain how it was to control the temperature and make it within the temperature limits.

Table 2: Temperature Limits to the wheat crop. (Source: [7] [9])

Wheat Growth Stages	Month	Maximum Temperature C°	Optimum Temperature C°	Minimum Temperature C°
Planting – Emergence	November	30-25	18	12
Emergence-Start Tillering	December	20	14-12	5-3
Vegetative Tillering Growth	January - February	22-20	18-16	10
Heading	March	30-25	22	15
Ripening	April - May	40-32	26-24	22-17

4.3. Crop Diseases And Integrated Management of Weeds In Crop

Plant diseases can severely affect wheat yields. There are three types of diseases leaf, head, & virus diseases. Several diseases can cause significant yield reduction in wheat, stunting, and delayed maturity; Symptoms include lack of nutrients or stunting growth uneven, yellowing, and the weakness of vitality, low agriculture, low yield and seed quality. The symptoms include yellow streaks of white. These viruses are transmittal through many ways, and lost productivity depends on the type of the virus, a strain of the virus, wheat variety, time of infection, and environmental conditions [6].

4.4. Pivot Irrigation

Irrigation is the synthetic application of water on the ground for agricultural production. Efficient irrigation will influence the all of growth process from seed preparation, the germination, root growth and nutrient use in the growth of plants and re-growth, yield and quality. Centre Pivot system is self-propelled irrigation systems, which apply water to pasture or crop, generally from above the canopy. Centre Pivot systems are anchored at one end and rotate on a fixed central point. Center-pivot sprinkler systems suspended one pipeline with support from an array of mobile towers is suspended 2 to 4 meters above ground level. Water is pumped into central pipe and when the towers revolve slowly around pivot point, a large circular area is irrigated. Spray nozzles mounted on or suspended from the water distribution pipeline under pressure as revolve pipeline. And graduated from the small to large nozzles so as to receive the outer circle faster moving the same amount of water as the slower moving inside. Pivotal System Center requires an energy source to move the water from the source addition the energy to move the machine on a farm station [10].Center pivot irrigation usually uses less water compared with multiple surface irrigation and furrow irrigation technology, which reduces costs and maintains water. It also helps to reduce labor costs compared with some ground of irrigation techniques, which are often more labor-intensive. The benefits of sprinklers pivotal to have the ability to control temperatures, through spraying deodorants in the case of temperature rise from the limit.

4.5. NDVI (Normalized Difference Vegetation Index)

Transform a simplest vegetation index is (NIR–RED) because that difference has a positive and large value much more so than would be obtained for the other land covers. Since the NIR domain is invisible to the human eye, the higher reflectance in the green band. Chlorophyll does not absorb all wavelengths of sunlight; it absorbs the blue and red wavelengths, while green light is reflected. The reflection of visible radiation is mainly function of leaf pigments, whereas the Near-Infrared (NIR) reflected by the internal mesophyll structure of leaves. NIR radiation passes through the first layer of the leaf (the palisade tissue); when it reaches the mesophyll and the internal leaf cavities it is scattered both upwards (which is referred as reflected radiation) and downwards (transmitted radiation). The behavior of the NIR reflectance is also a function of leaf area index (LAI), cell turgor, leaf thickness, leaf internal air and water content [8].In general, NDVI values equation (1) from +1 to -1 range from open fields have a value of about 0.2 NDVI and vegetation health of about 0.8. NDVI values give an indication of stress on crops. This could be the reason for the lack of water, lack of fertilizers and pesticides, or an abundance of weeds. At present, it can be a low-cost sensor in the infrared spectrum revealed stress crop about two weeks before the human eye can see this. Based on the information, farmers make decisions about where to do what in terms of irrigation and use of fertilizers and pesticides [12].In addition, remote sensing imagery can be a better and quicker method compared to traditional method for managing nitrogen efficiently [8].Abundance and deficiency nitrogen affects chlorophyll and therefore can measure nitrogen from the index NDVI (Fig. 3).

Where:
NIR (Near-Infrared band)
Red (band visible)

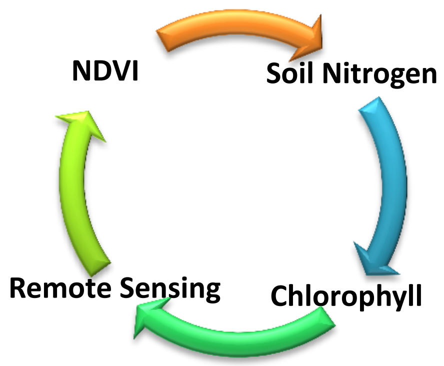

Fig. (3) Using NDVI to determine crop nutrient requirements.

4.6. Change Detection

Extraction of Intake dual "change / no change" information using two dates images is one of the most widely used manner change detecting. The analog logic visualization on a computer screen using two or three dates for the remote sensing data recorded and placed in the RGB memory banks. Can be used a) original gangster individual and / or b) multiple data transformations of the original data, such as NDVI [13].

5. Material &Methods

5.1. Material

1. **Landsat 8 Satellite Data** download from the website USGS every 16 days, with spatial resolution 30m. Starting download from 11 October 2015 to 06 May 2016. Some Landsat 8 images so cloudy there are remove from monitoring. Stop download Landsat 8 images depend on harvest date calculated in the program Cropwhat.
2. **Sentinel-2 Satellite Data** download also from the website USGS with different periods, in addition, the spatial resolution 10m, and irregular depend on USGS site

policy. Starting download from 19 December 2015 to 08 March 2016. Sentinel-2 image download depend on website USGS

3. **Meteorological Data** from the Iraqi ministry of agriculture\network for agricultural meteorology Iraqi. The data covered daily temporal limits for study regions.
4. **Field Survey Data** (Fig.4) include coordinates crop positions, crop growth data, and verification of field sampling data.

Fig. (4) Field photo on 09-03-2016 at stage vegetative tillering growth

5.2 Methods

research methodology followed, as shown in fig. (5).

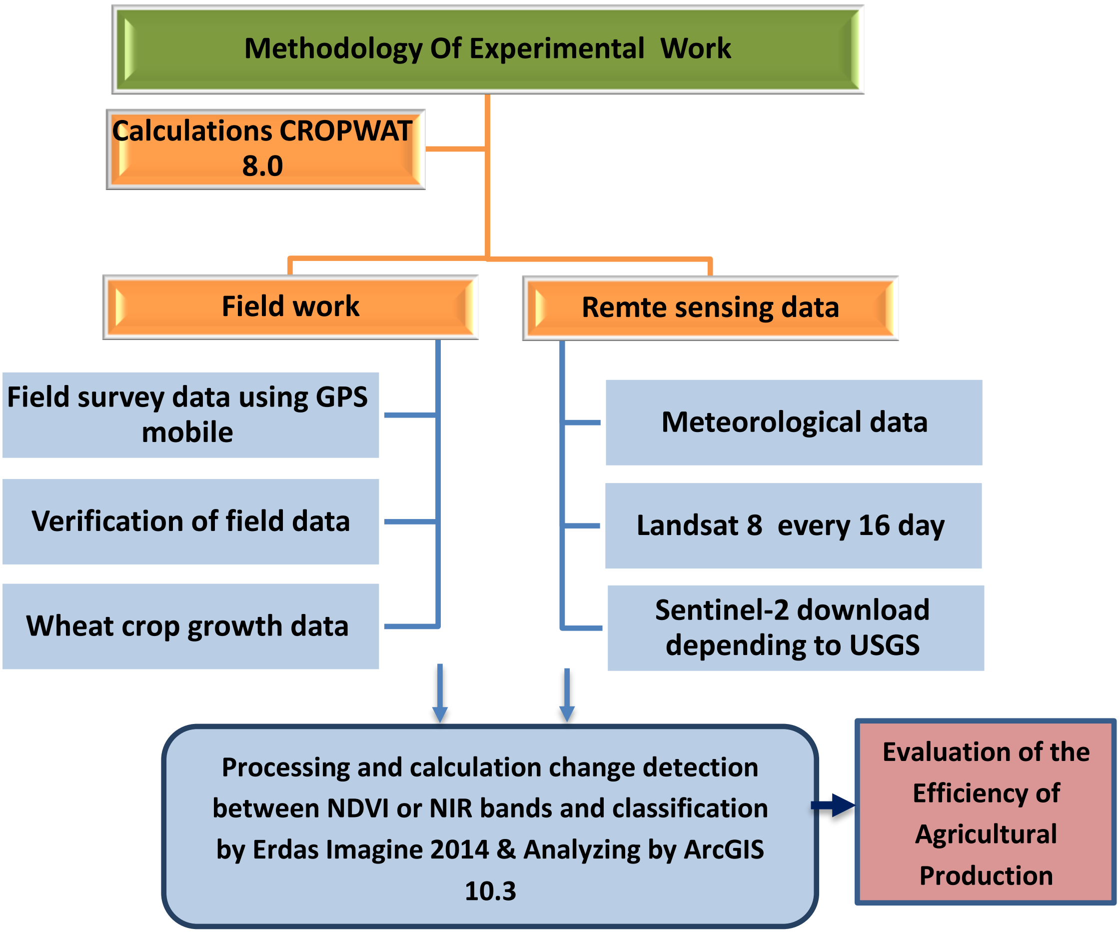

Fig. (5)Workflow summarized of the research.

5.2.1. Calculation Calendar Germination

Methodology of work began with the program Cropwat 0.8 to determine the calendar germination of wheat crop, and know when to harvest according to planting date, in addition to know the number of images required. The calculation crops harvest date after the program provide the date to seed and growth stages and Kc value of each crop (Fig. 6). In addition, some farmers are doing a delay and provide in seed for a few days for various reasons. Such as having a summer crop was not harvested or after their early agriculture for an early harvest. Hence if planting wheat on (15/11/2015) supposed to harvests on (23/04/2016).

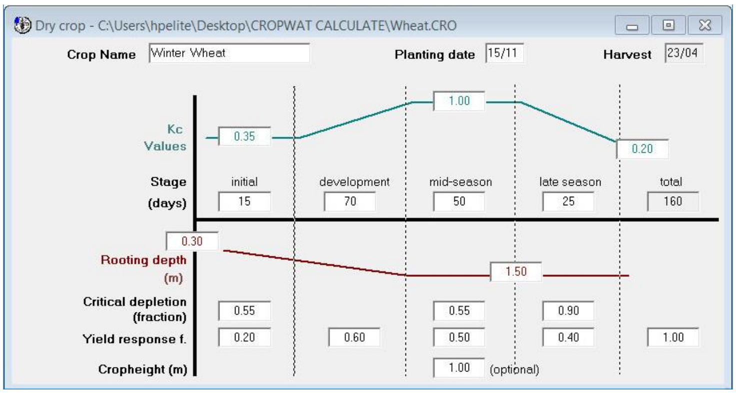

Fig. (6)Calculation of harvest date wheat crop

5.2.2. Monitoring Health Status of the Crop

Using Erdas Imagine 2014 calculation NDVI. NDVI image derived from Landsat 8 imageries (Fig. 7) in red region (0.64–0.67 µm) and near-infrared region (0.85–0.88 µm).While NDVI image Sentinel-2 imageries (Fig. 8) derived from red region (0.665–0.690 µm) and near-infrared region (0.842–0.957 µm).

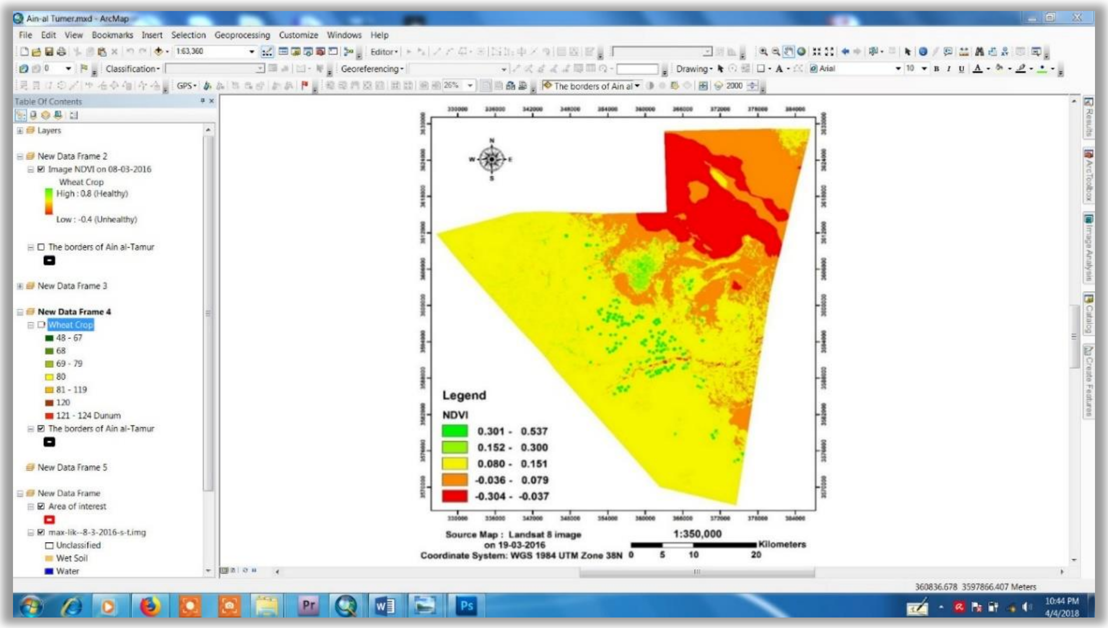

Fig. (7) NDVI scene Landsat 8 on 19-03-2016, rise in the NDVI/chlorophyll index to value0.537.

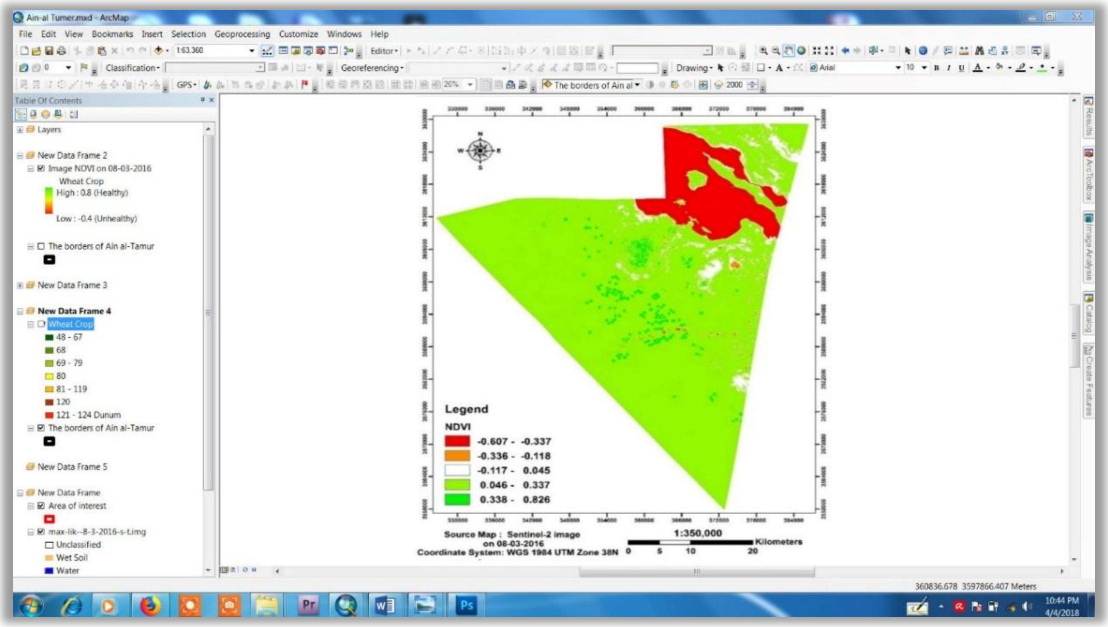

Fig. (8) NDVI sceneSentinel-2 on 08-03-2016, rise in the NDVI/chlorophyll index to value from 0.807 to 0.826.

5.2.3. Monitoring The Change In Crop

Using Erdas Imagine 2014 calculation change detection by equations (2) & (3) illustrated below for original bands and NDVI. Change detection, between NDVI imageries derived from Landsat 8 scene (Fig. 9)Change detection, between Landsat 8 imageries at near-infrared region (0.85–0.88 μm) shown in (Fig. 10).

$$\Delta \text{ NDVI i, j} = \text{NDVI i, j (1) - NDVI i, j (2)} + \text{(c)} \qquad (2)$$

Where: Δ NDVI i, j = change in pixel value at NDVI
NDVI i, j (1) = NDVI value on date 1
NDVI i, j (2) = NDVI value on date 2
c = a constant (e.g. 127)
i = line No.
j = column No.
k = a single band (e.g. Landsat 8 band 11)

$$\Delta \text{ BV i, j, k} = \text{BV i, j, k (1) - BV i, j, k (2)} + \text{(c)} \qquad (3)$$

Where**:** Δ BV i, j, k = change in pixel value
BV i, j, k (1) = brightness value on date 1
BV i, j, k (2) = brightness value on date 2

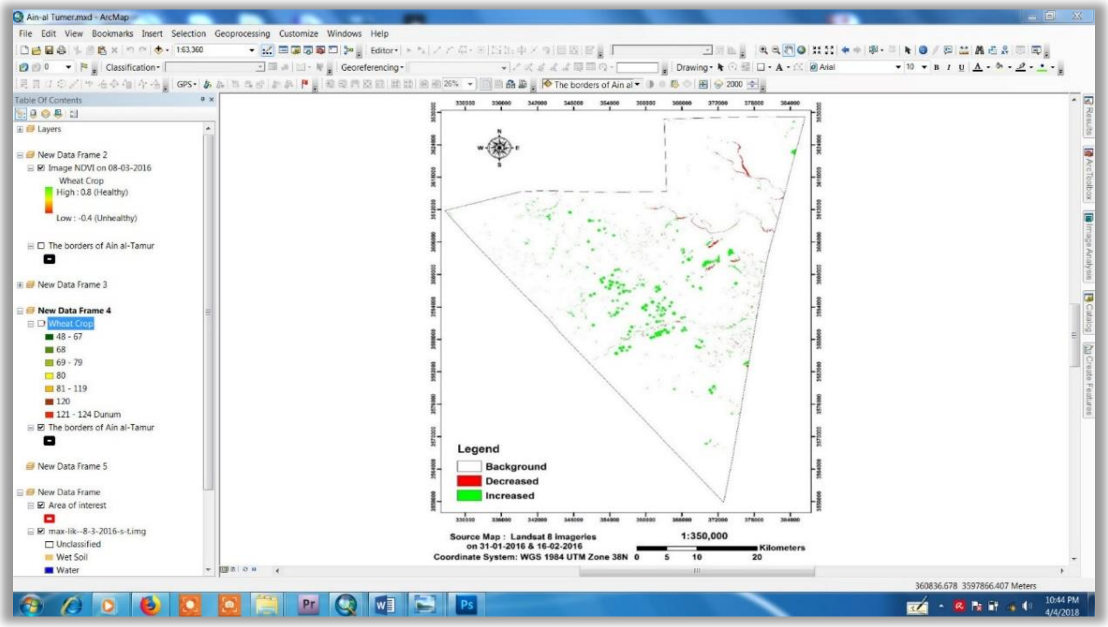

Fig. (9) Change detection, between NDVI imageries Landsat 8 on31-01-2016 & 16-02-2016.A gradual increase in wheat crop at most farm.

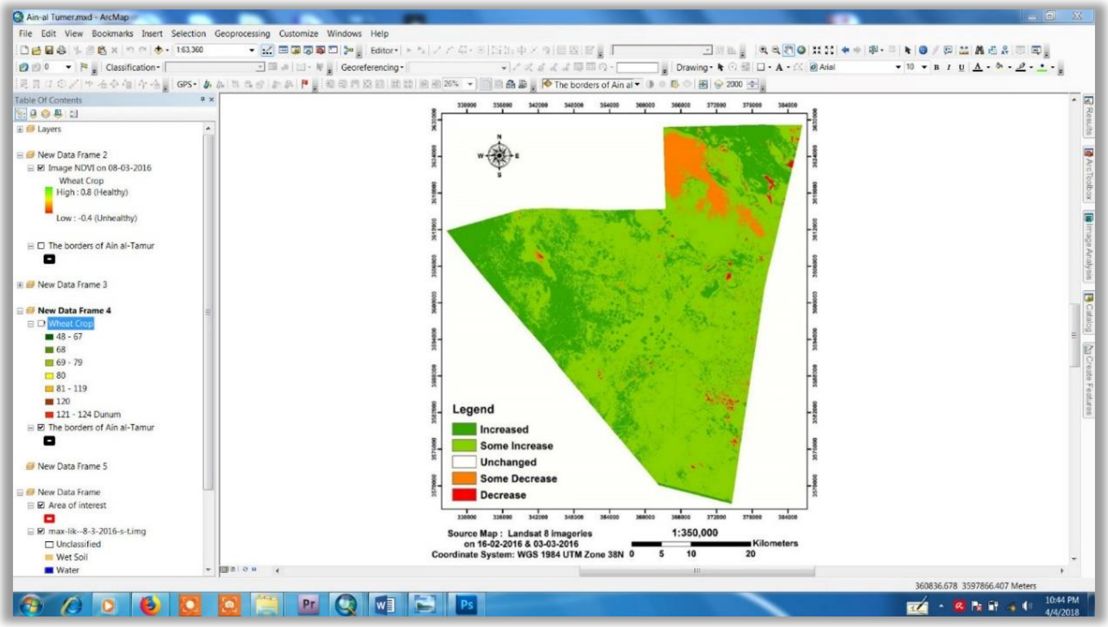

Fig. (10) Change detection, between Landsat 8 imageries on16-02-2016 & 03-03-2016 for band 5 NIR. Increase and Some increase at stem extension and heading stage.

5.2.4. Linking the Different Remote Sensing Data

Ain al-Tamur Agriculture Division farms monitor by using Landsat 8 imageries (Fig. 11) at true color (4, 3, 2), and the sentinel-2 imageries (Fig. 12) at true color (4, 3, 2), and linked with change detection NDVI, change detection NIR band, and NDVI.

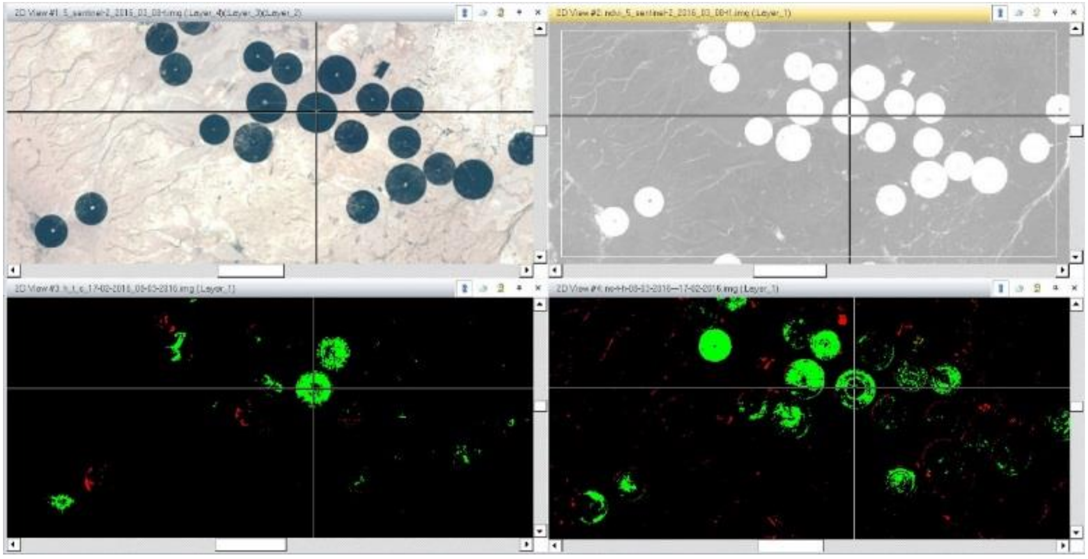

Fig. (11) Monitoring stage farm Majid Aashk, view1Sentinel-2 image at band (8, 4, & 3) on 08-03-2016, view2 NDVI on 08-03-2016, view3 change detection band NIR on 17-02-2016 & 08-03-2016, &view4 change detection between NDVI on 17-02-2016 & 08-03-2016.(Note: The color red represents a decrease; the green color represents an increase in the change detection).

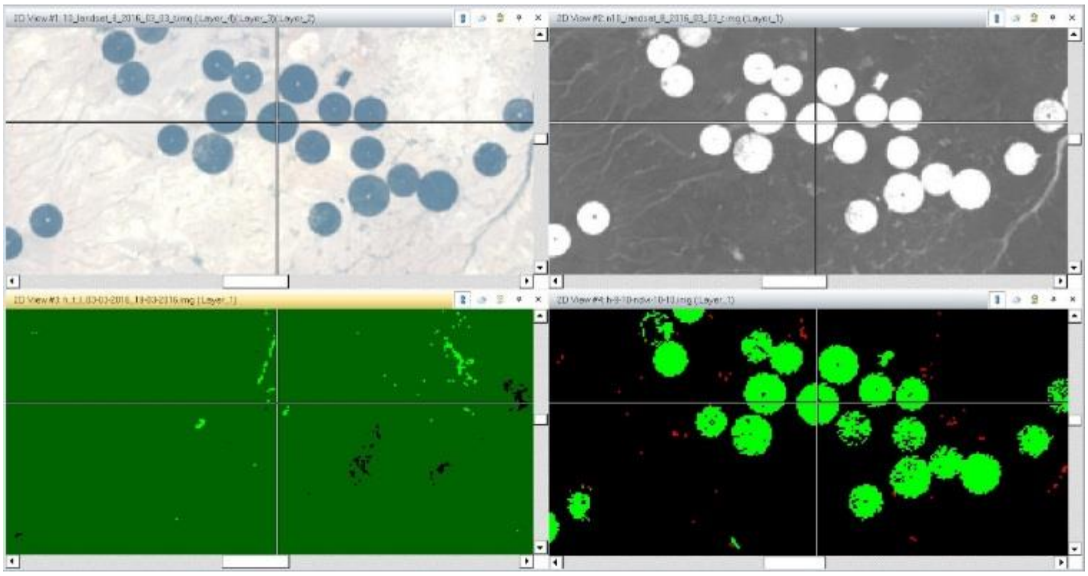

Fig. (12) Monitoring stage farm Majid Aashk, view1 Landsat 8 image at band (5, 4, & 3) on 19-03-2016, view2 NDVI on 03-03-2016, view3 change detection band NIR on 03-03-2016 & 19-03-2016, &view4 change detection between NDVI on 16-02-2016 & 03-03-2016.

5.2.5. Pivotal Farms Evaluation

Using Arc Catalog 10.3 in preparing spatial database (Fig. 13) for work inquiring on statistics data, and create histogram for farm area (Fig. 14) for work, evaluate the efficiency. In addition, maps production of the outputs of the final classification, after the conversion format of imageries from raster to vector (polygon), finally export feature wheat crops (Fig. 15)It has been classified into seven classes depending on three standard areas (68, 80,120 dunam) and the highest and lowest of them.

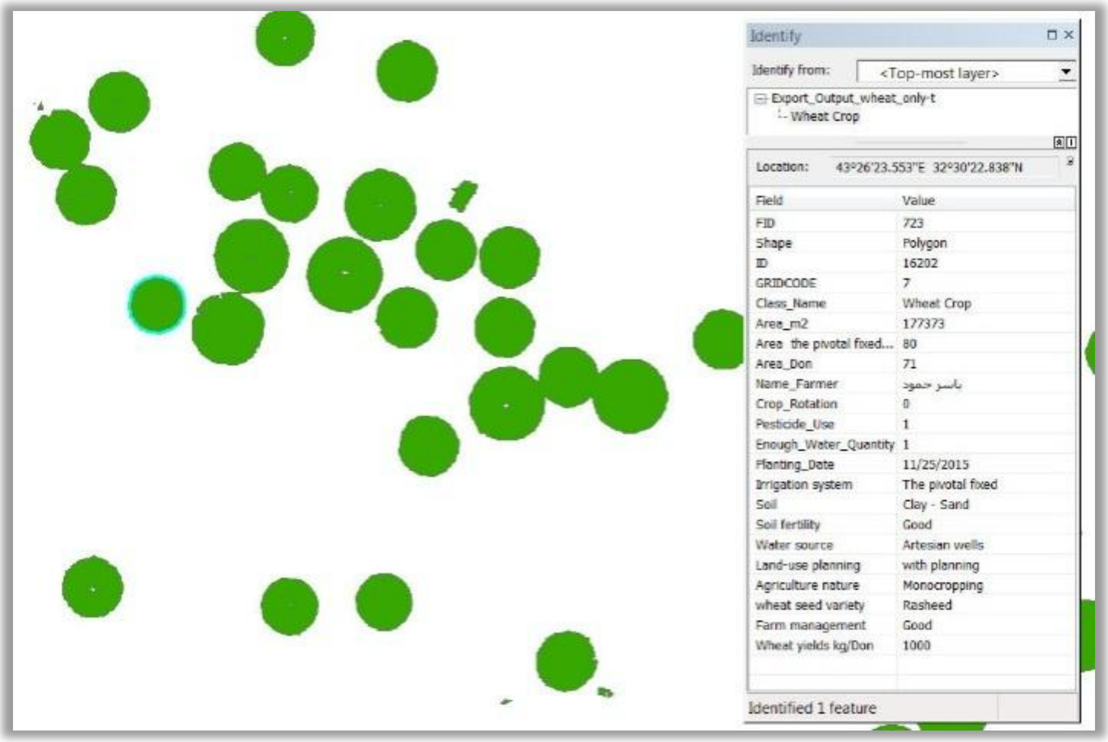

Fig. (13) Illustrate the identify farm by select and shown spatial database for farm.

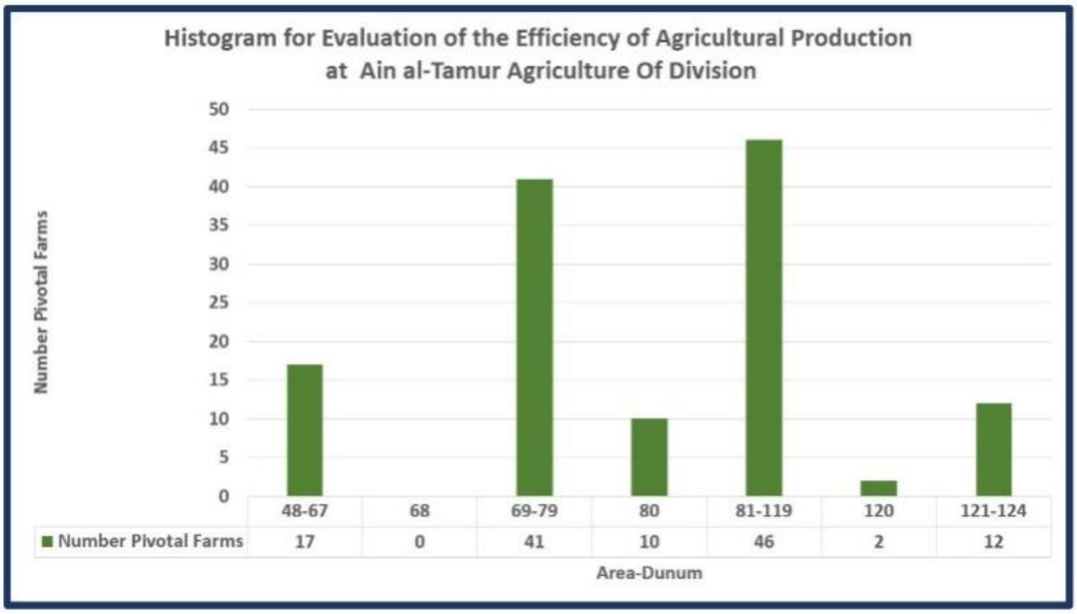

Fig. (14) Histogram Evaluation of the Efficiency of Agricultural Production at Ain al-Tamur Agriculture of Division. Of the total 128 farm pivotal, Firstly (46 farm) limited area between (81-119 dunam) produced very high. Secondly (41 farm) limited area between (69-79 dunam) produced very high too. Thirdly, (17 farm) limited area between (48-67 dunam) production is weak.

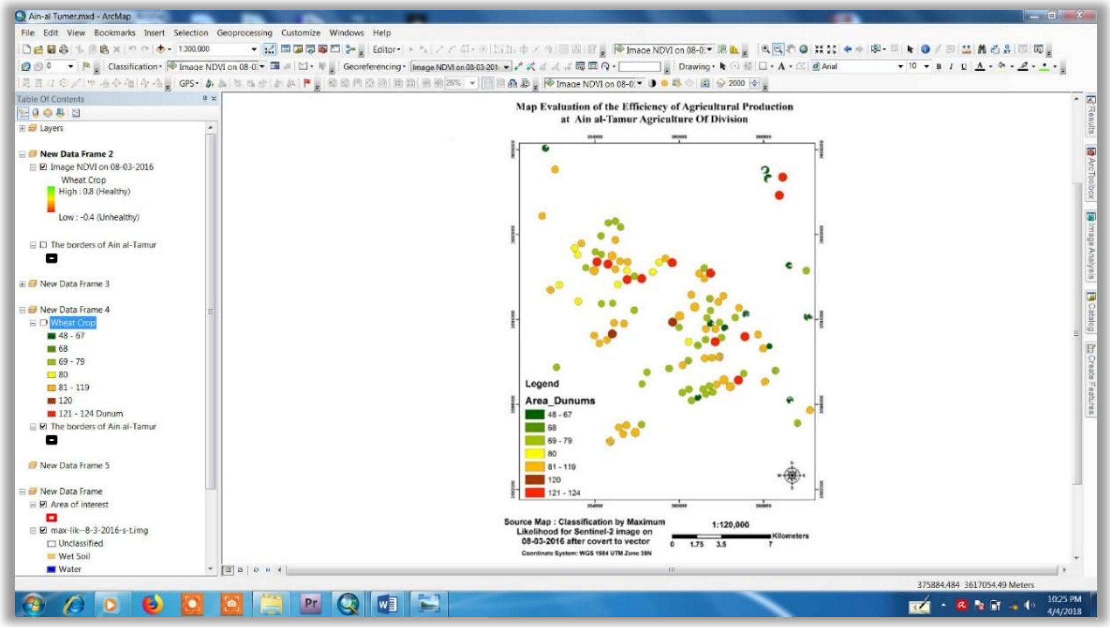

Fig. (15) Evaluation of the Efficiency of Agricultural Production at Ain al-Tamur Agriculture of Division for wheat crop depending on the area.

6. Conclusions

1. The results of the evaluation showed that most of the Ain al-Tamur pivotal farms are highly efficient.
2. The results of change detection for the NDVI and NIR are more effective techniques for distinguishing the crop status of health and need for fertilizer, irrigation and control of diseases of agricultural crops to reach the high efficiency of production during the season (from seeding stage to harvesting stage).
3. Linking remote sensing data (raw image, NDVI, change detection NIR, and change detection NDVI) with meteorological data theoretically. Results showed an entirely Variation in productivity according to farm management and weather situation.
4. The crop density in Ain al-Tamur is higher, because of the superiority of the agricultural condition (non- sparse vegetative cover, good irrigation, and high contrast between soil and crop in true color bands).
5. The meteorological data (that belong to the same study region) have been utilized to give more precise interpretation for the satellite images.
6. The spatial resolution for Landsat 8 (30m) is not very active to distinguish crop states in the cultivated area, so that higher spatial resolution (Sentinel-2) with its 10-meter resolution was sufficient for this task.
7. The results of change detection for the NDVI and NIR are more effective techniques for distinguishing the crop status during the season (from seeding stage to harvesting stage).
8. The early stages of crop stress has been investigated using IR bands of the satellite images, this could give a change to treatment the crop and increase its productivity.
9. The detail information related to the crop regions and yields are very important to enhancement the spatial database for the crop monitoring process.

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