Determination the Best Vegetation Spectral Indices for Estimating Rice Crop Area in the Kefal Shinafiya Project in Iraq

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Abstract

In this study nine vegetation indicators and Landsat 8 satellite images for the OLI sensor were used to monitoring the rice yield and adopt two scenes with two different dates, the first at the beginning of cultivation and the second at the growth stage vegetative. The results showed that the best indicator for estimating the rice crop area is Rice Growth Vegetation Index (RGVI), where the lowest error rate was recorded 4.3% for the estimated rice crop area of 4503.5 Hectares compared to the reference data of the Iraqi Ministry of Planning for 2018, which amounted to 4316 Hectare. As for the Ratio Vegetation Index (RVI) and Normalized Difference Vegetation Index (NDVI) indicators, in terms of percentage of error, they were 6.9% and 9.4%, respectively, and the values were close to the reference data. While the Infrared Percentage Vegetation Index (IPVI) and Triangular Vegetation Index (TVI) indices recorded the highest error rates against the reference data, which were 30.3% and 26%, respectively.

Keywords: Rice, Spectral Vegetation Indices and GIS.

تحديد أفضل المؤشرات الطيفية للغطاء النباتي لتقدير مساحة محصول الرز في مشروع كفل شنافية في العراق

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الخلاصة

استخدمت في هذه الدراسة تسعة عوامل من مؤشرات الغطاء النباتي ومرئيات القمر الصناعي لاندسات 8 للمتحسس OLI لمراقبة محصول الرز واعتماد مشهدين بتاريخين مختلفين الاول في بداية الزراعة والثاني في مرحلة النمو الخضري. أظهرت النتائج أن أفضل مؤشر لتقدير مساحة محصول الرز هو (RGVI) حيث سجل اقل معدل للخطأ بلغ4.3 % للمساحة المقدرة من محصول الرز التي بلغت 4503,5 هكتار مقارنة بالبيانات المرجعية التي بلغت 4316 هكتار المقاسة من قبل وزارة التخطيط العراقية لسنة 2018. أما مؤشري (RVI) و(NDVI) من حيث نسبة الخطأ فبلغت 6.9% و9.4% على التوالي وكانت القيم قريبة من البيانات المرجعية. في حين كان مؤشري (IPVI) و(TVI) قد سجلا أعلى نسبة خطا مقابل البيانات المرجعية والتي هي بنسبة 30.3% و26% على التوالي.

الكلمات المفتاحية: الرز ومؤشرات النباتات الطيفية ونظم المعلومات الجغرافية

Introduction

It is essential to anticipate the yield of rice before the hour of reaps. to know the leaders and organizers to anticipate the measure of rice that must be imported or exported. What's more, to empower governments to create vital emergency courses of action to reallocate food during seasons of starvation (Nuarsa, *et al*., 2012). Exact estimation of rice yield will be significant to those appraisals for sustenance security and national advancement (Shiu and Chuang 2019). Consistency of the yield before collect utilizing satellite far off detecting is significant in numerous parts of farming dynamic (Noureldin, *et al*., 2013).
Billions of individuals around the globe depend on rice as a staple food and a pay creating crop. Asia is the pioneer in rice development and it is important to keep up an advanced rice information base to guarantee food security just as a financial turn of events. (Wijesingha, *et a*l., 2015). The utilization of the Normalized Diference Vegetation Index (NDVI) with the Leaf Area Index (LAI) created the model with the most elevated precision and security during the two rice seasons. Models produced 90 days in the wake of planting apply to any comparable natural conditions and farming practices (Noureldin, *et al*., 2013). The outcomes show an immediate connection between the stature of the rice plant and MODIS Vegetation Index (VI). Smooth NDVI crop schedule and timing arrangement data with Whittaker Smoother gave incredible gratefulness to the region planted with rice (86% accuracy and 75% rating accuracy) (Wijesingha, et al., 2015). Landsat ETM + has great potential for applying rice yield assessment. (Nuarsa, *et al*., 2012).

Point level yield investigation demonstrated that MODIS Enhanced Vegetation Index (EVI) is exceptionally related with rice yield and yield conjecture utilizing the greatest EVI in the normal rice cycle with a normal expectation blunder of 4.2%. this examination exhibits the tremendous capability of the MODIS network item to keep up a cutting−edge geographic data framework for rice development (Wijesingha, *et al*., 2015). Used phenological algorithm based on Landsat Operational Land Imager (OLI) images and choice vegetation indices extracting stranger in basin River Bansloi, Eastern India. Option advance indices (NDVI, EVI, Land Surface Water Index (LSWI) and Rice Growth Vegetation Index (RGVI)) were used to identify paddy cultivating areas, and everywhere the validating methods are similarly gratifying preciseness of resemble paddy cultivated areas and predicted yield. So, the Rice yield estimation before harvest to give know of export, import Rice crop for the future. (Paul, *et al*., 2020).

The aims of this study are to know the best indices for estimating rice crop area and volume of water per season.

Materials and Methods

The study area is located in the three governorates Babylon, AL-Najaf, and AL-Qadisiya of Iraq, and is intersected by the Euphrates River up to 180 km southern Baghdad. It is located within scenes (path168/raw38) as shown in Figure (1).

Selecting the satellite images that cover the study area of the Landsat 8 satellite for the sensor (OLI) Resolution 30 meters and adopting two scenes, the first of which was at the beginning of agriculture time capture 6 June 2018, where the rice fields are submerged in water, and using the LSWI indicator to identify the rice fields. As for the second scene, at a time of good vegetative growth of rice time capture 25 August 2018, and the use of the eight indicators (EVI, Infrared Percentage Vegetation

Index IPVI, NDVI, Soil-Adjusted Vegetation Index (SAVI), Triangular Vegetation Index (TVI), Difference Vegetation Index (DVI), Ratio Vegetation Index (RVI) and RGVI) to determine the Rice Crop (Table1).

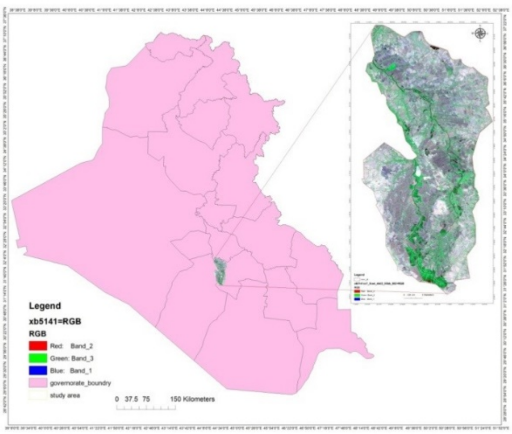

Figure (1) Iraq Map with Selected of the Study Area

Extracting the area planted with the rice crop using the Arc GIS program, extracting the area from the nine spectral indices from the satellite image and comparing it with the actual area calculated by the Iraqi Ministry of Planning, the Central Statistics Organization, Directorate of Agricultural Statistics for the year 2018 (Table 2).

Calculate the water consumption to be added to the rice crop throughout the season based on the extracted area from the spectral evidence and the irrigation water depth calculated by (Salim, et al., 2016) was 1035 mm throughout the growing season.

Calculate the Percentage of Error

The error percentage is the difference between the measured value and the correct value and is determined by comparing these two values and converting them into a percentage; so that you can see how close the estimate or estimate is to the true value. To calculate the error rate is to know the approximate value of the rice area extracted from the spectral plant indicators and the real value measured by the Iraqi Ministry of Planning, IRAQ, Central Statistical Organization, Directorate of Agricultural Statistics. (2018), and by using them you will be able to find the error rate (Bennett, et al., 2005).

Table (1) List of Common Vegetation Indicators, and Their Mathematical Equation, Used for Mapping and Crop/ Production Forecasting. (Mosleh, *et al.*, 2015)

No.	Indices	Formula	Reference
1	Enhanced Vegetation Index (EVI).	EVI= 2.5 × [(NIR - Red)/ (NIR+ 6Red – 7.5Blue) +1]	Jiang, *et al.*, 2008
2	Infrared Percentage Vegetation Index (IPVI)	IPVI=[(NIR-Red)/ (NIR +Red)] +1/ 2	Crippen, 1990
3	Normalized Difference Vegetation Index (NDVI)	NDVI =NIR– Red/ NIR +Red	Rouse, *et al.*, 1973
4	Ratio Vegetation Index (RVI)	RVI =NIR/ Red	Jordan, 1969
5	Soil-Adjusted Vegetation Index (SAVI)	SAVI = NIR– Red (1 +L)/ NIR +Red+L L=0.5	Huete, 1988
6	Land Surface Water Index (LSWI)	LSWI =NIR– SWIR1/ NIR +SWIR1	Xiao, *et al.*, 2005
7	Triangular Vegetation Index (TVI)	TVI =(NDVI)½ +0.5	Deering, *et al.*, 1975
8	Difference Vegetation Index (DVI)	DVI =NIR - Red	Clevers, 1986
9	Rice Growth Vegetation Index (RGVI)	RGVI=1- Blue –Red / (NIR +SWIR1+SWIR2)	Nuarsa, *et al.*, 2011

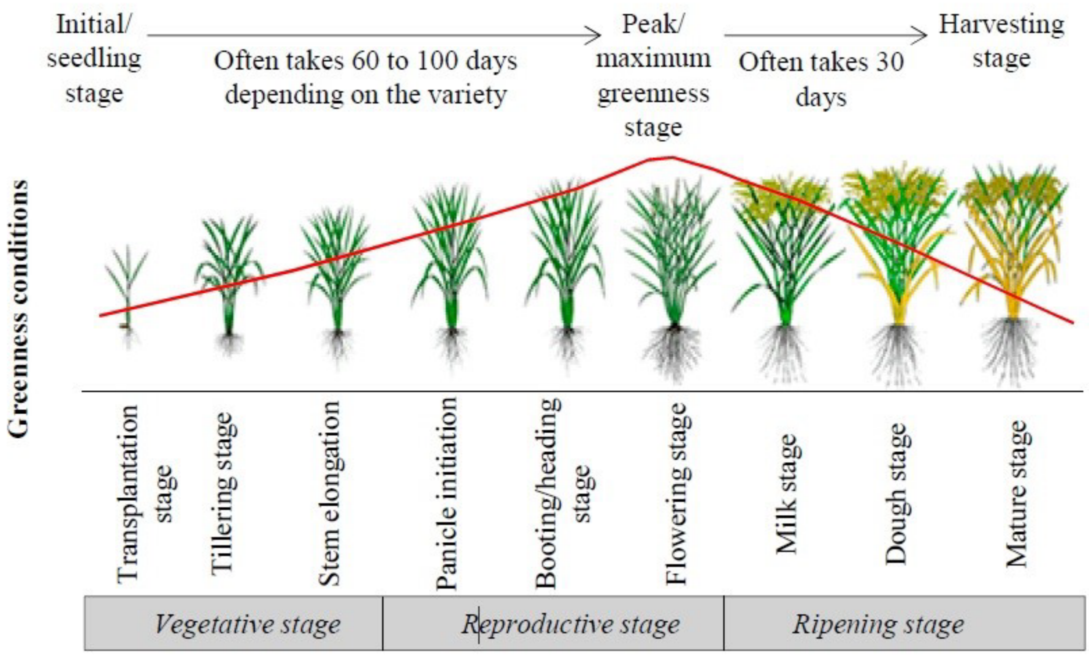

Figure (2) Growing Stages of a Typical Rice Crop and the Red Curve Shows a Typical Temporal Dynamic of Very Commonly Used Remote Sensing-based Vegetation Greenness Index (International Rice Research Institute (IRRI, 2014), (Mosleh, *et al*., 2015)

Vegetation Indices Data

In this research using Landsat 8 Data and Vegetation indices. The vegetation spectrum typically absorbs in the red and blue wavelengths, reflects in the green wavelength, strongly reflects in the near infrared (NIR) wavelength, and displays strong absorption features in wavelengths where atmospheric water is present. Different plant materials, water content, pigment, carbon content, nitrogen content, and other properties cause further variation across the spectrum. Measuring these variations and studying their relationship to one another can provide meaningful information about plant health, water content, environmental stress, and other important characteristics. These relationships are often described as vegetation indices (VIs). The importance of knowing the stages of the growth of Vegetation Indices Data to identify and monitoring the rice plant (Figure 2).

Results and Discussion

Raster calculator tools from map algebra in Arc GIS program are applied to detect an invasive Rice area, using nine indices equations as (Table1), four indices were chosen as best discrimination based on their capabilities of improving vegetation spectral responses as the results bellow. For rice crop area class executed from vegetation indices rasters which derived from Landsat 8 OLI satellite data (Figure 3). Based on (Table 2), the results of estimating the rice crop area planted in the Kefal Shinafieh Project for the year 2018 using spectral indices showed that all the spectral indices gave a different estimated area where the IPVI and TVI indices gave the highest estimation of the area of 5632.5 and 5445.5 Hectare.

Table (2) Vegetation Indices and Estimated Area of Rice Crop for the Year 2018 to Kefal Shinafiyeh Project

Data of the Ministry of Planning	Vegetation Indices	Estimated Rice Area in Hectare	Percentage Difference in Area per Indicator In Hectare	Error Rate per Indicator%	Volume of Water per Season m³/ Season
4316	IPVI	5632.5	1316.5	30.5	58296375
	TVI	5445.5	1129.5	26.2	56360925
	LSWI	3399.5	916.5	21.2	35184825
	DVI	3445.5	870.5	20.2	35660925
	SAVI	3539.5	776.5	17.9	36633825
	EVI	3865	451	10.4	40002750
	NDVI	3908	408	9.4	40447800
	RVI	4618	302	6.9	47796300
	RGVI	4503.5	187.5	4.3	46611225

While the RGVI index gave an estimate of the area of 4503.5 Hectare, the index RVI gave 4618 Hectare, while the rest of the indices gave an area of (NDVI, 3908, EVI, 3865, SAVI, 3539.5, DVI, 3445.5, and LSWI, 3399.5) Hectare (Table 2) compared to the reference Data of the Ministry of Planning/ Agricultural Statistics for Rice Area in Hectare for the Year 2018 (Reference data, which amounted to be 4316 Hectare. When calculated the percentage of error based on the area of rice crop extracted from the spectral indices and the area of rice crop from the reference data, the report of the Iraqi Ministry of Planning for the region of Kefal Shinafiyeh for the year 2018, Vegetation indices for RGVI, RVI, NDVI, EVI, SAVI, DVI, LSWI, TVI, and IPVI were recorded to characterize the rice plant with error rates of 4.3%, 6.9%, 9.4%, 10.4%, 17.9%, 20%, 21.2%, 26%, and 30.3% respectively (Table 2). The results showed a difference in the estimated areas, vegetation indices, to distinguish the rice plant, and this is due to several reasons, including the differences in planting time, as farmers vary in planting times, and thus the field is not irrigated with water before the time of taking the satellite image, or the field is irrigated after taking the satellite image, and this is the reason for a difference in the area measured by the Land Surface Water Index (LSWI). As for the rest of the vegetation cover indices, the differences were in the areas estimated to distinguish the rice plant due to the difference in the growth of the rice plant and the height of the plant that occurs as a result of the difference in the addition of fertilizer between one field and another, but we note that some indices prevail over these reasons, including two indices RGVI and RVI (Table 2).

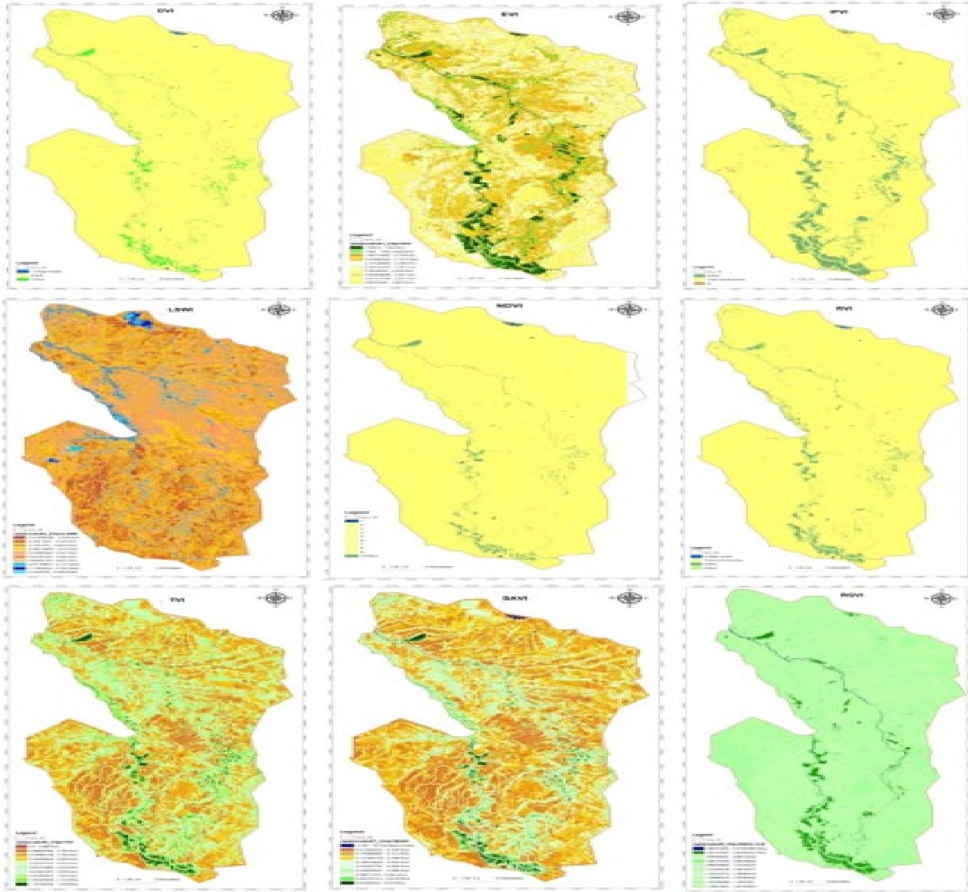

Figure (3) Vegetation Indices

Conclusions

Through practical applications of the Landsat 8 satellite images using the raster calculator tools from map algebra in ARC GIS, nine botanical indices were used and evaluated to detect and identify the rice plant. Vegetation indices for RGVI, RVI, NDVI, EVI, SAVI, DVI, and LSWI were among the best indices to distinguish the rice plant with error rates of 4.3%, 6.9%, 9.4%, 10.4%, 17.9%, 20%, and 21.2% respectively. The botanical indices for TVI and IPVI were considered to be one of the worst indices to distinguish the rice plant with error rates of 26%, and 30%, respectively (Table 2). The results yielded that the Rice Growth Vegetation Index (RGVI) recorded the lowest percentage of the error which indicated that the highest reflectance of the rice plant compared to other indices.

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