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Crop Yield Estimation Based on Landsat-NDVI A Case Study of Sitapur District, Uttar Pradesh, India

Chandrakalla [1] & Manisha [2]

[1] Remote Sensing Applications Centre, Uttar Pradesh, Lucknow-226021, India, Email: chandralalla.@gmail.com
[2] Remote Sensing Applications Centre, Uttar Pradesh, Lucknow-226021, In dia, Email:manisha @gmail.com

Abstract

Using satellite imagery, this research estimates how much rice may be grown in the Sitapur area of Uttar Pradesh.The AGB and HI were determined using raster-based Geographic Information Technology, Landsat-8 satellite data, and the CASA Model. The available NDVI was used to estimate the AGB, and the total NDVI before and after the rice heading phase was used to determine the final HI, all of which indicate that NDVI during grain filling is an important yield-related characteristic. We have verified the 93% accuracy of our anticipated rice yield by comparing it to the yields obtained from the government department's Crop Cutting Experiments (CCE). Therefore, excellent connections may be shown between satellite data and agricultural data in the end product.

Keywords: *Harvest Index; NDVI; FAPAR; LUE; LUE; AGB; Landsat.*

Introduction

1. It is a more normal practice in India to estimate agricultural output at the gram panchayat (GP) and block levels. In particular, estimates of agricultural yields may have a significant impact on regional economic statistics and the development of agricultural policy.

2. Changes in plant growth, whether in chlorophyll content or the structure of the crop, may be captured by remote sensing throughout the crop calendar season.

3. Canopy-level spectral data gathered

4. by remote sensing may be used as an

5. early indicator of qualitative and quantitative changes in plant biophysical characteristics [1].

6. This technique is very helpful since it can provide spatial-temporal dispersed data, which is essential for "real-time" model driving.

7. Prediction of Harvest Outcome Using...

8. data map with varying levels of detail, as is often called for when modeling factors in agricultural yield forecasting[2]. Many stages of agricultural production may benefit from the data gleaned through remote sensing analyses, including expansion planning, stress management, and policy formulation [3, 4, 5, 6, 7]. Statistics and semi-empirical correlations between Above Ground Biomass (AGB) and vegetation index (VI) are used in conventional remote sensing-based agricultural yield estimate methodologies. Currently, NDVI is the most widely used technique, and it can be calculated from a wide variety of satellite data[8].

9. Many vegetation indices (VIs) are employed as proxies for biomass because they are based on the spectrum reflectance of healthy green vegetation [9, 10]. These indices have been shown to be reliable indicators of the relative abundance of a wide range of

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biophysical features of vegetation.

10. The normalized difference vegetation index (NDVI), which may be easily derived from satellite data, is a measure of plant photosynthetic efficiency that varies with the weather and other environmental factors. When used in conjunction with NDVI/vegetation maps, NDVI curves, and figures, agricultural managers may predict substantial differences in productivity and potential harvest using NDVI pictures [1].

11. Nutrient balance, weed and insect control, and water management are all factors that have been linked to production variation[11]. Tillering and leaf expansion are two factors that contribute to a higher LAI for rice plants. It peaks just before departure and declines with advancing age [12, 13, 14, 15]. [16]pointed

12. determined that total biomass and leaf area index (LAI) close to heading were positively connected with rice output, and that maintaining a higher leaf area duration (LAD) prior to heading till harvest increased grain yield.

13. Wheat yield estimate coupled with the NPP model[17] made use of a harvest index (HI) that was devised and used in the simulation of HI dynamic change under different climatic circumstances. Methods for estimating yields have become tougher and more readily exportable as a result of the integration of remote sensing data with crop simulation models. The temporal precision of remote sensing data often does not meet the need of crop models, making direct use of a driving variable challenging. The other approaches may be used to regional level yield estimates based on the availability of crop canopy features. The purpose of this research is to provide a workable approach to promoting regional-level mapping in order to estimate agricultural yields. The approach relies on the correlation between the AGB and the NDVI, both of which may be retrieved from satellite images.

14. Data & Methods

Material Used Satellite Image : Landsat - 8 Data ground resolution : 30m

Software's Packages : QGIS, Microsoft Excel

2.2 Methodology:

In accordance with the objectives of the study satellite image of Landsat - 8 has been collected for 2015. For digital data processing, analysis and integration of spatial and non-spatial data PC based rasterGIS package QGIS has been used in this study. Then, using NDVI algorithm NDVI image has been generated and the study area extracted from the NDVI image. Accumulated NDVI from emergence to Heading date(average NDVI Pre) and

Accumulated NDVI from Heading date to Maturity (average NDVI Post) have been calculated. Detailed flow chart ofmethodology is given below in Fig. 1:

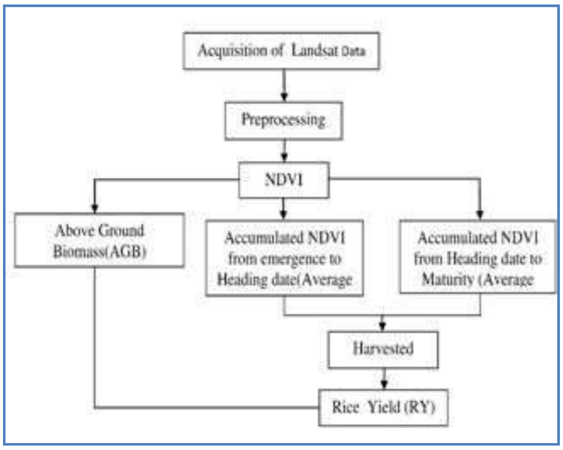

Fig. 1 Flow chart of methodology for Riceyield estimation.

15. Results and Discussion

The NDVI was retrieved in Study area with QGIS, and Above Ground Biomass was calculating with the help of NDVI. As we know, the rice growth rate is faster and faster after the stage of emergence, so both of the AGB and NDVI showing faster growth rate before the stage of Heading-date. After then, the NDVI is decreased gradually, but the Biomass is continue increased. So, The method of accumulation of NDVI data has been adopted in research, and the relationship is significant between AGB & NDVI. Above ground biomass has been calculated from Remote sensing data using CASA Model.

15.1. Calculation of biomass fromvegetation index:

15.1.1. PAR (Photo synthetically ActiveRadiation)

PAR is calculated as 1/2 the total solarsurface irradiance.

(PAR)= ½ Total solar Radiation ($MJm^{-2}yr^{-1}$)(1)

From calculation PAR(PhotosyntheticallyActive Radiation) = 3053.39 $MJm^{-2}yr^{-1}$

15.1.2. Calculation of FAPAR (Fraction ofAbsorb Photo synthetically Active Radiation)

$FAPAR=(NDVI-NDVI_{MIN})/(NDVI_{MAX}-NDVI_{MIN})$ (2)

or

$FAPAR=(SR-SR_{MIN})/(SR_{MAX}-SR_{MIN})$ (3)

$SR=(1+NDVI)/(1-NDVI)$ (4)

where, SR is simple ratio

FAPAR the fraction of absorbed PAR, which could be estimated form the simple ratio (SR) or NDVI by linear functions. Here FAPAR wascalculated as a linear function of SR(Table. 1). Table 1. Fraction of Photosynthetically Active Radiation.

DISTRICT	BLOCK	FAPAR
SITAPUR	AILIA	0.49
	BEHTA	0.44
	BISWAN	0.50
	GONDLAMAU	0.49
	HARGAON	0.50
	KASMANDA	0.52
	KHAIRABAD	0.48
	LAHARPUR	0.49
	MACHHREHTA	0.48
	MAHMOODABAD	0.48
	MAHOLI	0.49
	MISRIKH	0.48
	PAHALA	0.51
	PARSENDI	0.50
	PISAWAN	0.47
	RAMPUR MATHURA	0.40
	REUSA	0.45
	SAKRAN	0.48
	SIDHAULI	0.49

15.1.3. Total above ground biomass

The CASA (for Carnegie-Ames-Stanford Approach) model, introduced by Potter et al. (1993) and expanded here, is structured so that, for a given area, the amount ofphotosynthetically active radiation absorbed by green vegetation (APAR) multiplied by the efficiency by which that radiation is converted to plant biomass incrementequals to Above ground biomass.The CASA is a

simple terrestrial ecosystem model that combines satellite and field observations in estimating annual net primary production and decomposition. The modification was the incorporation of a structure that allows ε to vary seasonally and within biomes without recourse to ecosystem-specific ε values (Field et al., 1995). This structure is as

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depicted in the model below:

ε(x,t) = ε˚(x,t)*T1(x,t)*T2(x,t)*W (g MJ-1)

where ε is a corrected calculated variable intime and space; ε˚, the globally uniformmaximum value; T1, and T2 are temperaturesdepicting temperature suitability and W, theavailability of water. According to (Field etal., 1995) CASA assumes that each grid cell

(pixel) is well drained thus not limiting productivity by anaerobic conditions in supersaturated soils. They also found out that CASA's ability to track variation in crop yield was strongly dependent on NDVI data. For present study the AGB are given in Table. 2.

Above Ground Biomass(AGB) =εΣ FAPAR XPAR (5)

or

Above Ground Biomass(AGB) =εΣAPAR(6) The values of ε vary from 0.354 g C /MJ PARfor broadleaf evergreen trees to 0.135 g C/MJPAR for bare soil and desert for cropland Light Use Efficiency (ε) = 0.242 [18]

Table 2. Above Ground Biomass (Kg/ha)

DISTRICT	BLOCK NAME	AGB(g/m^2)	AGB(Kg/Ha)
SITAR	AILIA	362.24	3622.43
	BEHTA	327.47	3274.73
	BISWAN	368.12	3681.17
	GONDLAMAU	361.70	3616.96
	HARGAON	367.20	3671.95
	KASMANDA	384.99	3849.89
	KHAIRABAD	351.90	3519.03
	LAHARPUR	365.36	3653.56
	MACHHREHTA	356.38	3563.80
	MAHMOODABAD	357.15	3571.55
	MAHOLI	359.35	3593.48
	MISRIKH	353.12	3531.22
	PAHALA	374.78	3747.83
	PARSENDI	369.15	3691.46
	PISAWAN	343.96	3439.58
	RAMPUR MATHURA	297.27	2972.68
	REUSA	330.65	3306.47
	SAKRAN	354.05	3540.48
	SIDHAULI	365.21	3652.10

3.2 Estimation of Harvest Index(HI)

NDVI in the period of grain filling is recognized as one parameters which related to the yield formation, the Above Ground Biomass(AGB) was simulated by the available

NDVI values, and final Harvest Index(HI) can be calculated from the NDVI. The negative environmental effects on the efficiency of nutrient transfer (e.g. water stress and temperature stress) was considered to affect

the optimal Harvest Index(HImax). The finalHarvest Index(HI) was expressed as below: Harvested Index(HI) = HImax

	SIDHAULI	0.45

3.3 inal estimation of Rice yield

Using the computed AGB and HI_{NDVI} final RiceYield (WY) was calculated as:

7) Rice Yie

NDVIpre is the average value of NDVI form (8) emergence to heading date, and NDVIpost is the average value of NDVI from heading date to maturity. The default value of HImax andHIrange is 0.48 and 0.18 [19]

Table 3. Harvested Index from Remote Sensing Data.

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DISTRCT	BLOCK NAME	Rice Yield (Kg/ha)
SITAPUR	AILIA	1652.95
	BEHTA	1537.37
	BISWAN	1721.89
	GONDLAMAU	1577.38
	HARGAON	1669.13
	KASMANDA	1776.12
	KHAIRABAD	1600.89
	LAHARPUR	1692.35
	MACHHREHTA	1572.28
	MAHMOODABAD	1652.98
	MAHOLI	1630.87
	MISRIKH	1545.26
	PAHALA	1764.23
	PARSENDI	1711.02
	PISAWAN	1514.39
	RAMPUR MATHURA	1425.25
	REUSA	1545.57
	SAKRAN	1648.17
	SIDHAULI	1638.06

Table 4. Development Block wise Rice Yield.

DISTRICT	BLOCK	HI_{NDVI}
SITAPUR	AILIA	0.46
	BEHTA	0.47
	BISWAN	0.47
	GONDLAMAU	0.44
	HARGAON	0.45
	KASMANDA	0.46
	KHAIRABAD	0.45
	LAHARPUR	0.46
	MACHHREHTA	0.44
	MAHMOODABAD	0.46
	MAHOLI	0.45
	MISRIKH	0.44
	PAHALA	0.47
	PARSENDI	0.46
	PISAWAN	0.44
	RAMPUR MATHURA	0.48
	REUSA	0.47
	SAKRAN	0.47

Table 5. Comparison of Estimate yield and Govt. Agency Yield.

District	Govt. Agency Yield(Kg/ha)2014	Predicted Yield(Kg/ha)2015	Difference (Kg/ha)	Deference Percentage
Sitapur	1734	1625	109	6.28

16. Conclusions

The research was conducted based on the remote sensing data which combines the all major weather factors such as rain, temperature, humidity and wind. The NDVI, which being related to crop production processes directly, is one of the best driving factor in crop status analysis and Yield calculation. In this study, we analysed NDVI imagery from the Landsat satellite to monitor the development of biomass of rice crop in the Sitapur District for the year 2015.

Crop Yield Estimation Based...

The image acquisition was carried twice a month during cropping season and the time of peak growth or end of growing period and beginning of flowering is the period of maximum greenness or maximum photosynthesis and is called peak decadal. Peak decadal has the highest NDVI value of the cycle which is used for calculation of

Reference

Accumulated NDVI was used in conjunction with the Harvested Index to determine crop yields in AGB. Comparing the satellite results with the agricultural data of Uttar Pradesh, researchers discovered an accuracy of 93.72%.

[1]. Field, Christopher B.; Randerson, James T.; MalmstrOm, Carolyn M. Using Ecology and Satellite Data to Measure Global Primary Production. In 1995, REMOTE SENS. ENVIRON. 51:74-88.

Chinese scholars Hongwei Zhanga, Huailiang Chena, and Guanhui Zhoub [2]. A CASE STUDY OF XINXIANG USING A MODEL FOR FORECASTING WHEAT YIELD FROM MODIS-NDVI.Annals of the ISPRS

The Seven Volumes of the 2012 Yearbook of Photogrammetry, Remote Sensing, and Spatial Information Science.

Bauer, M.E. The use of remote sensing in crop distribution and yield estimation [3].

Advances in Agronomy 27 (1975): 271-30.

Biard, F., and D. Lepoutre [4]. Agri-Quest® Provides Real-Time Online Reporting on the State of Europe's Crops.An Instrument for Extracting Data and Benefits from Satellite Images. French company GEOSYS S.A. of Toulouse.

Crop biomass assessment using radiometric measurements. [5] Baret, F., G. Guyot, and D.J. Major. Photogrammetry, 1989, 43, pp. 241-256.

The development of a basic reflectance model for LAI estimate [6] / Clevers, J.G.P.W. published in Remote Sensing for Resource and Environmental Management: Symposium Proceedings. 1986;215-220 M.C.J. Damen, G. Sicco Smit, and H.TH. Vers Tappe, eds.

(Reference 7) Gilabert, M.A., S. Gandia, and J. Melia. Corn canopy spectral-biophysical connection analyses. Publication information: Remote Sens. Environ.

Using visible and near-infrared reflectances to estimate plant density [8].Price, J.C.

Environ. Remote Sensing. 41:29-34. 1992.

Aese, J.K., S.J. Mass, C.L. Wiegand, et al. Wheat spectral-biophysical data multi-site analysis. Environmental Remote Sensing 1990, 42(1):1-21.

Limitations and possibilities of vegetation indices. 10. Baret F, Guyot G. Environmental Remote Sensing 1991, 46, 213-222.

[11] Yang (W), Yand (L), and Merchant (J. W).Relationships, regional, and temporal variations in AVHRR-derived NDVI and ecoclimatological parameters. ACM/ASPRS, 1994, pp. 744-755.

In [12] we have Qiaoli Zheng, Guo-qing, and Shaofen Duan.Spectral reflectance from the maize canopy is used to calculate ZHAO LAI and above-ground biomass. Journal of the Borealli-Sinica Society of Agricultural

Scientists. 2008;23(1):219-222.

New Imaging Sensor Technologies Appropriate for Agricultural Management [13], written by S.M. Moran.

Association of Applied Biologists, United Kingdom, 2010:1-10, Remote Sensing in Agriculture.

[14]. Net assimilation rate of crop stands: study of the "Maximal Growth Rate Experiment" by Murata, Y. (2001). Effect of solar radiation, temperature, and age. IBP/PP, Proceedings of the Japanese Crop Science Society 44 (1975): 153–159.

Rice in Crop Physiology, T. Evans, Y. Murata, and S. Matsushima L. Published by Cambridge University Press in London in 1975 (pages 73–100).

Basics of Rice Crop Science, IRRI, Los Banos, Laguna, Philippines, 1981; Yoshida, S.

p. 269pp.

Estimating rice growth using vegetation reflectance spectra. [17] Su, M.-R., and C.-M. Yang. In 1999, the journal J. Photogram. Remote Sens.

Growth and community photosynthesis in early and late rice crops [18] by Shieh Y. J. Paper presented at the Symposium on the Causes of Low Yield of the Second Crop Rice in Taiwan and the Measures for Improvement (in Chinese). Page numbers: 91-100 in National Science Council, Taipei, 1978.

Harvest Index Model of Winter Wheat in China Utilizing Meteorological Data [19] by Xingjie Ji, Yongqiang Yu, Wen Zhang, et al. 2010;43(20):4158-41 Scientia Agricultura Sinica