Application of Remote Sensing and GIS for Crop Inventory – Crop Discrimination, Acreage and Yield estimation – A case study

Saharanpur district, Uttar Pradesh State (India)

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Résumé :

Ce travail analyse l'approche et les techniques d'évaluation des récoltes par la télédétection et la distinction basée sur la classification de maximum de vraisemblance, en utilisant des données optiques pour l'identification de récolte en saisons de Rabi et de Kharif. Des données satellitaires ont été utilisées pour réaliser l'inventaire des cultures. La présente étude a été conduite pour évaluer la contribution d'une analyse des images multi-temporelle afin d'élaborer l'inventaire d'utilisation des terres agricoles.

Cette étude a été effectuée pour la zone de Saharanpur de l'Etat d'uttar pradesh en Inde pour l'estimation de la surface cultivé des récoltes et la distribution des rendements, durant les années 2005 et 2006. Deux types de données ont été utilisées dans cette étude : IRS C1- LISS III de 15octobre, 2005 et IRS C1- LISS III de 12 février 2006. Dans cette approche, la limite administrative de la zone de Saharanpur était superposée sur l'image de télédétection pour extraire l'image de la zone de Saharanpur dans chacune des quatre bandes. Les surfaces cultivées ont été identifiées et estimées en suivant la classification automatique de maximum de vraisemblance.Les résultats obtenus de la classification des images multidate de Février et d'Octobre montrent des exactitudes de 91.41% et 97% respectivement pour Octobre et Février.

ملخص : يحلل هذا العمل منهجية و تقنيات تقييم المحاصيل بواسطة الكشف عن بعد و التمييز المرتكز على التصنيف المتشابه الأقصى، باستعمال معطيات ضوئية لمعرفة محاصيل فصلي الربيع و الخريف، و قد استعملت أيضا معطيات ساتلية لإعداد جرد للمحصول الزراعي.

تهدف هذه الدراسة لتقييم مساهمة تحليل الصور المتعددة الأزمنة لإعداد جرد لاستغلال الأراضي الزراعية. تم إجراء هذه الدراسة في منطقة ساهارانبور التابعة لولاية أوتار برادش في الهند لتقييم المردود الفلاحي خلال سنتي 2005 و 2006.

و قد تم استعمال نوعين من المعطيات في هذه الدراسة: IRS C1-L1SS III بالنسبة لـ 15 أكتوبر 2005 و IRS C1-L1SS III بالنسبة لـ 12 فيفري 2006.

في هذه الدراسة، قمنا بإسقاط الحدود الإدارية لمنطقة ساهارانبور في جميع النطاقات الأربعة.

و قد تم تحديد و تمييز المساحات المزروعة عن طريق التصنيف المتشابه الأقصى.

تبين النتائج المتحصل عليها عند تصنيف الصور المتعددة التواريخ لشهري فيفري و أكتوبر صحة الأرقام 91.41 % و 97 % على التوالي لشهري أكتوبر و فيفري.

الكلمات الأساسية : الكشف عن بعد، التصنيف الرقمي، المساحة، المردود.

Par ailleurs, l'image de distribution des rendements pour le mois de Février a été effectuée à partir de la relation entre NDVI et les rendements. On a observé que le rendement du blé est plus important (32 à 38 q/ha) couvrant 39% du secteur d'étude.

Mots clés : télédétection, classification automatique, superficie, rendement.

Abstract :

This paper reviews the application of remote sensing techniques and maximum likelihood classification for crop discrimination, using optical data for crop identification in both crop seasons (Rabi[1] and Kharif[2]).
Satellite data are extensively used to produce the crop and land use inventory. The present study was conducted to evaluate the contribution of multi-temporal images analysis to elaborate the cropland land use inventory.
This study has been carried out for Saharanpur district of Uttar Pradesh State for crop acreage estimation and yield distribution, during Rabi and kharif of the year 2005-2006. Two types of data have been used in this study – IRS 1C- LISS III for October 15, 2005 and IRS 1C- LISS III for February 12, 2006. In this approach, the district administrative boundary of Saharanpur district was overlaid over the remote sensing image to extract the image Saharanpur district in all four bands. Then crops area were identified and estimated by following supervised maximum likelihood digital classification. Statistic results of multidate images classification of March and October, show accuracies 91.41% and 97% respectively for October and February. As well as the yield distribution around 39% of geographical area of Saharanpur district between 32q/ha to 39q/ha.

Keywords : remote sensing, digital classification, crop inventory, acreage, yields.

Introduction

Agriculture constitutes the largest sector in economy of India. Majority of the population, directly or indirectly, dependent on this sector. It contributes about 24 percent of Gross Domestic Product (GDP) and accounts for half of employed labour force and is the largest source of foreign exchange earnings. It feeds whole rural and urban population. Realizing its importance, planners and policy makers are always keen to have reliable area and production statistics of agricultural crops well in time.
Policy makers primarily need accurate and timely statistics for the important crops such as wheat, cotton, rice, sugarcane, maize etc. However, in recent years, due to persistent hikes in the prices of essential commodities like pulses, onions, potatoes, chillies and tomatoes, these crops have also gained in economic importance. Crop distribution and acreage, as well as yield, is the basic information necessary for agricultural management and policy-making. Remote sensing of the extent and distribution of individual crop types has proven to be useful to a wide range of end-users, including governments, farmers, and scientists.
Satellites remote sensing appear to be an issue of technical improvements in the field of agricultural statistics, as a point of view accurately and quickly than a homogenized desirable ways and reliable results.

1. Objectifs of this study

The present study attempts to fulfill the following objectives:

- Discrimination and acreage estimation of kharif and Rabi crops using digital processing techniques of satellite data IRS – 1C LISS III,
- Yield prediction of rabi crops using relationship between NDVI and yield.

This paper presents an approach aiming the development of remote sensing techniques for crop area estimation to support crop-forecasting systems at a district level. The overall system design aimed to support crop area estimation through digital classification.

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[*] There are three major corp seasons in India, viz., Kharif, Rabi and Zaid
[1] The Rabi crops are sown in the period between October and December and harvested in April and May (wheat, barley, peas, and mustard).
[2] Kharif crops they are sown in the months of June and July and are harvested in autumn months, viz., in September and October (rice, maize, sugarcane, cotton).
The Zaid is the summer season crop. Rice, maize, vegetables, sunflower and groundnut are grown during this season

2. The Study area

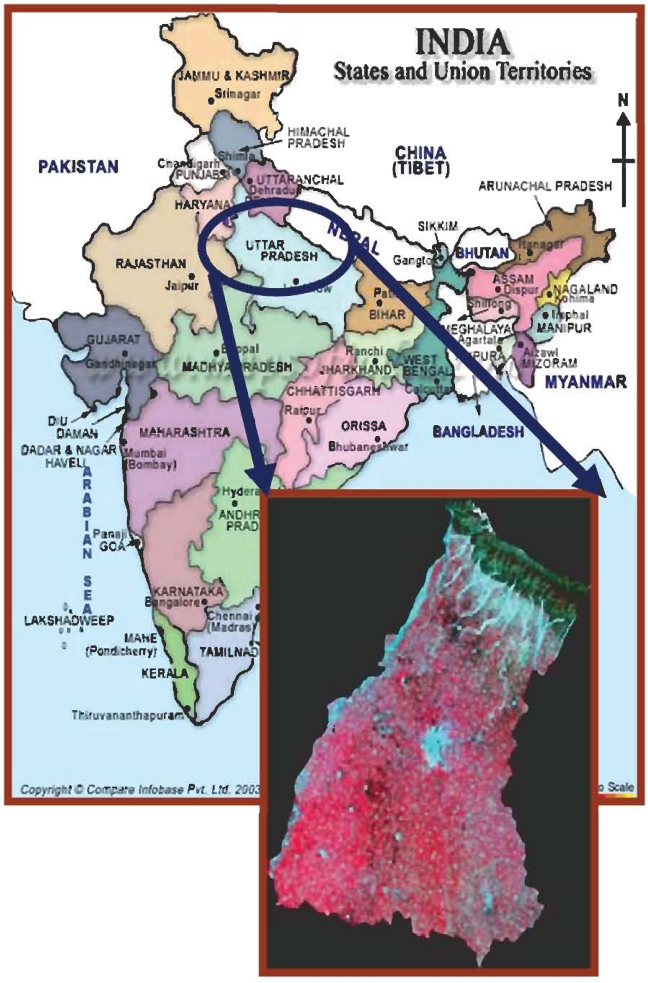


Fig. 1 Location of the study area (Official website of Govt of U.P. And Department of Agriculture, U.P)

Saharanpur district is bounded on the two sides i.e. in North by Dehradun and in west by Haridwar districts of Uttaranchal, on East by Ambala and Karnal district of Haryana state, and on South by Muzaffarnagar district of Uttar Pradesh. The total area of district is 3689 km2 with a density of 785 persons per square km. It has 11 blocks, namely Sadauli Qadeem, Muzaffarabad, Puwarka, Ballia Kheri, Sarsawan, Nakur, Gangoh, Rampur Maniharan, Nagal, Nanauta and Deoband.

2.1 Remote sensing data

IRS-1C LISS III (Indian Remote Sensing Satellite).
LISS III 15 Oct 2005 kharif season (Path No: 90 Row No: 50)
LISS III 12 Feb 2006 rabi season (Path No: 90 Row No: 50)

2.2 Complementary data

Survey of India (SOI) topographical maps sheets No 53/16 scale 1:50.000.
District map of Saharanpur from administration boundary.
Official website of Govt of U.P. And Department of Agriculture, U.P

3. Methodology followed

3.1 preparation of crop inventory

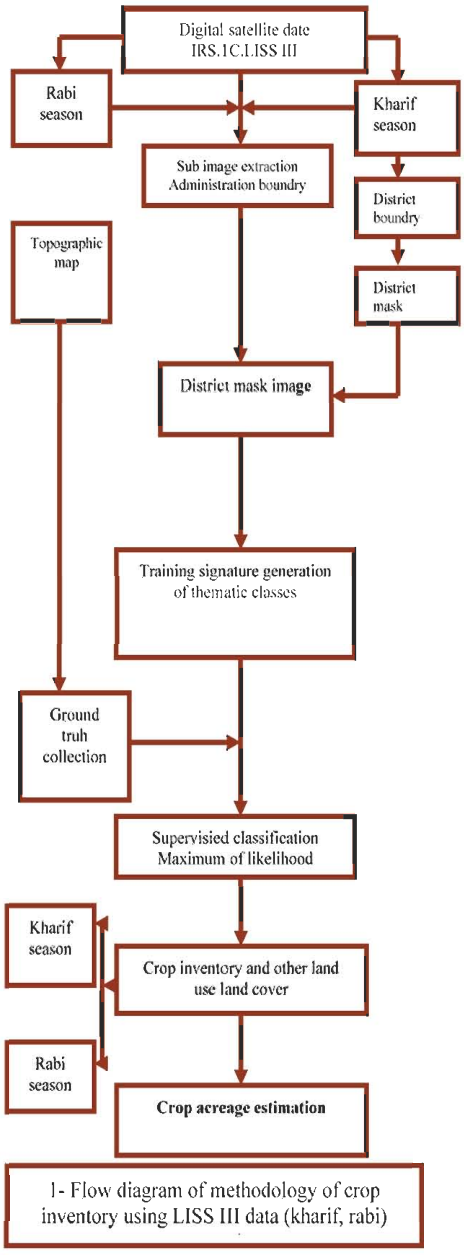
Crop identification and discrimination using remotely sensed data is based particularly upon the fact that individually crop has its own unique spectral signature.
Typical spectral reflectance of a particular crop

absorption due to pigments in visible region (0.4-0.7 um) and high reflectance in near infrared region because of interval cellular structure of leaves .Vigor of the crop is manifest in the absorption in the red and reflectance in the near infrared region *(Navalgund et al 2002).*

3.2 Spectral characteristics

Identification and discrimination of dominate crop wheat from other land use /land cover in the study area was carried out following digital supervised classification using IRS-C LISS III data. All classes of land use / land cover have distinct spectral responses in all four bands of IRS-1C LISS III data.

Low vigour wheat crops showed high spectral reflectance in band 4 (NIR) and band 2 (Red) compared to high and moderate vigor wheat crops.
Low vigor wheat crops due to low Lai, low biomass, low canopy moisture content, less chlorophyll content per unit area have high reflectance in band 2 and 4.
Sugarcane crop which are at maturity stage, shows different spectral response in all 4 bands as to compare to wheat crops. So, sugarcane crop can be spectrally separable from wheat crops. Fallow land, horticultural plantation other non-agricultural land cover classes were also spectrally separable from crop cover classes.

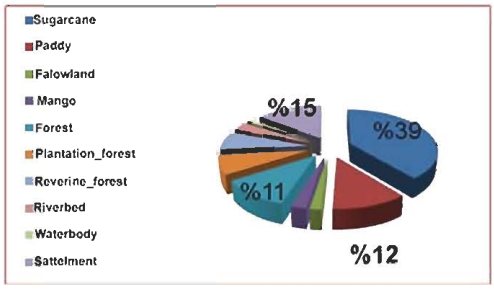


1- Flow diagram of methodology of crop inventory using LISS III data (kharif, rabi)

3.3 Crop acreage estimation

Wheat is the dominant crop in the study area during Rabi season. The crop acreage estimation and discrimination and other land use /land covers were carried out following digital supervised classification using maximum likelihood classifier (MLC) algorithm.

The false color composition (FFC) and digital classified image (LIIS III Rabi season), for kharif season the dominant crops are sugarcane and paddy, MLC also was carried for the crop acreage estimation and identification of this crops and other land use /land cover. The classified image for kharif season 2005 is given in fig2.



Graph. 1 Crop acreage estimation from digital classification IRS-1C LISS3 Kharif season

The classified image for Rabi season 2006 is given in fig3.

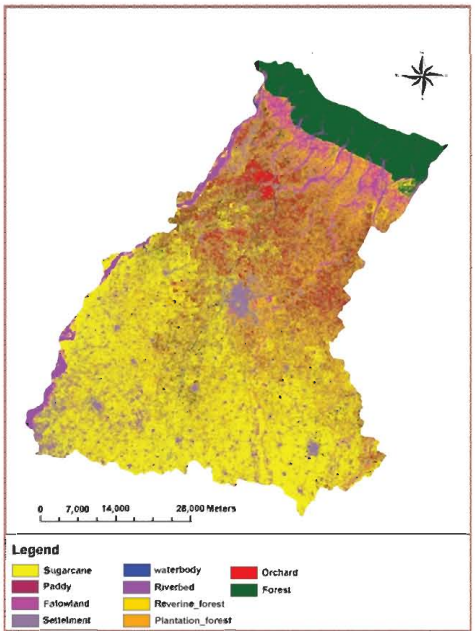


Fig. 2 Crop and land use inventory ,Saharanpur Dist,UP. IRS-1C LISS III October 15,2005.

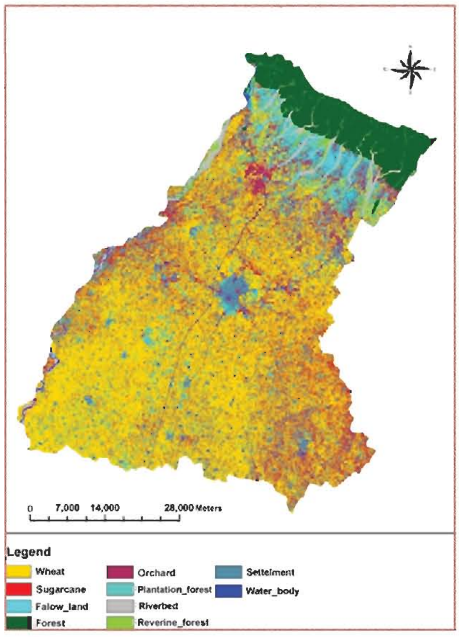
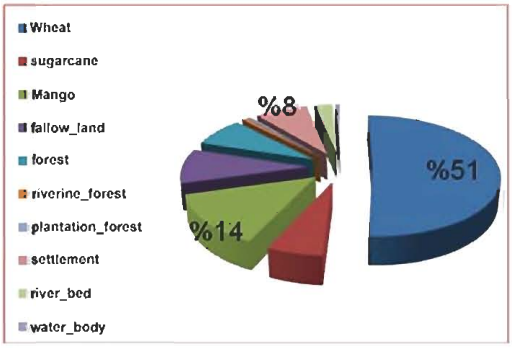


Fig. 3 Crop and land use inventory ,Saharanpur Dist,UP. IRS-1C LISS III Ferbruary 12,2006.

Area under various land use / land cover was derived from the classified image and given in the Graphe 1, the major area is under sugarcane 39.2%, paddy 11.6% and

Follow land 1.8%. From field observation it was found that this area includes rice harvested field and area kept ready for wheat sowing. Mango occupies 14 % of the geographical area.

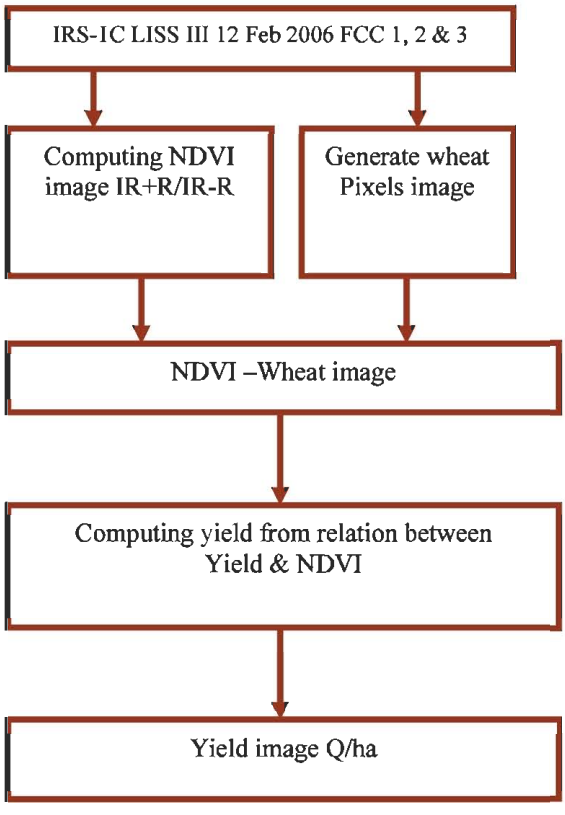
Area under various land use /land cover was derived from the classified image and given in the Graphe 2. The major area under wheat crop 50.89%, sugarcane 6.03% and fallow land 9.25 %. Wheat is the major Rabi season cereal grown in Saharanpur district.



Graph. 2 crop acreage estimation from digital classification IRS-1C LISS III rabi season

4. Crop yield estimation

For yield prediction of dominant Rabi crop wheat, we used relationship between yield and NDVI.
The flow diagram of the methodology of crop yield prediction using spectral indices is presented in the flow diagram *(Patel, N. R.; Manjunath, M. N.; Shukla, M. R. and Pande, L. M. (2004))*



2-Flow diagram methodology of crop yield prediction

In this study spectral indice was used, is NDVI.

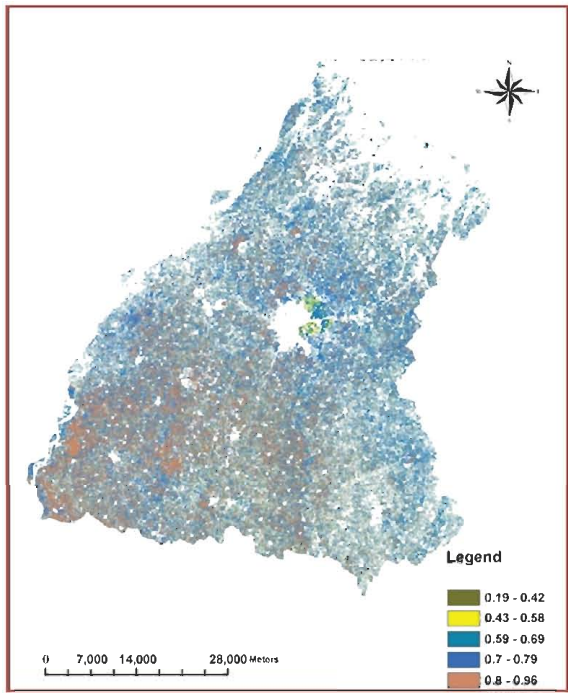


Fig. 4 Radiance NDVI of wheat crop ,Saharanpur Dist, UP IRS-1C LISS III February 12,2006.

NDVI image was prepared from corrected B2 and B3 bands of IRS 1B, LISS -III sensor to represent quantitatively the vegetation coverage over the area. The value of the prepared NDVI image was ranging from -0.19 to 0.96. Higher the positive value of NDVI, higher is the wheat crop and its vigour. In case of district Saharanpur, the wheat is one of the major crops during Rabi season. Hence, major part of cultivated area was under wheat crop. Due to this fact, the correlation between mean NDVI and yield of wheat is expected to be high.

4.1 Yield –NDVI relation for Saharanpur district

The NDVI values obtained from a combination of bands 2 and 3 of the IRS-1C LISS III, show better correlation with yield *(Relation between Yield and NDVI of Saharanpur district developed by ASD, IIRS was used, Saha, S. K; Patel, N. R. (2004))*

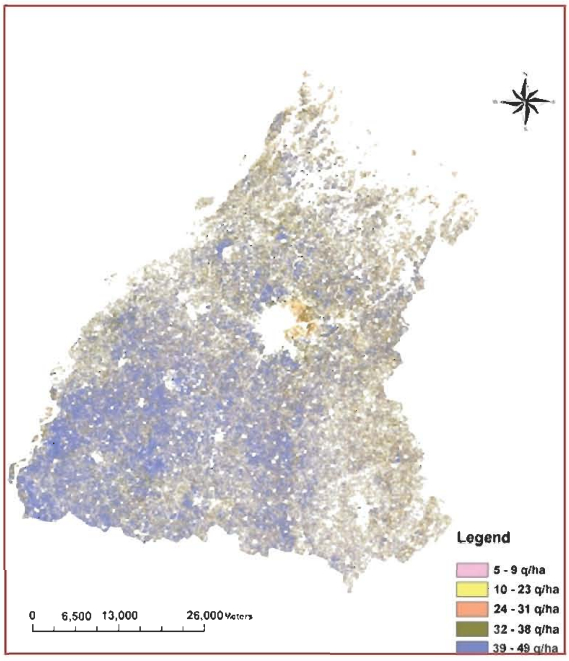


Fig. 5 Wheat yield distribution
(based on relation yield/NDVI) ,Saharanpur Dist.UP.
IRS-1C LISS III February 12,2006.

5. Conclusion

The results of the study lead to the following major conclusions:

Detailed discrimination and acreage estimation of major Rabi crop can be prepared by digital supervised classification of satellite data - IRS-1C LISS III.

The results of land use /land cover analysis reveal that the area of Saharanpur district fall under dominant kharif season sugarcane, the total cropped area (sugarcane and paddy) in kharif was 39.2%, 11.6% respectively. In Rabi season, wheat and sugarcane (50.89%, 6.03%) are the dominant crops. The major cropping system is the paddy-wheat followed by sugarcane.

IRS – 1C LISS III data can be used effectively for yield estimation of the dominant Rabi crop (wheat) using wheat yield – NDVI relationship. It was observed that the wheat yield in the study area is high (30 to 38 q/ha) covering 39.93% of study area.

It can be concluded that use of remote sensing data along with GIS was found as an effective tool for crop and land use inventory and acreage estimation, also for the prediction of crop yield and their distribution. This information is very useful components of agricultural statistics.

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