COMPARISON OF LISS-III AND AWiFS SENSORS DERIVED SPECTRAL INDICES FOR WHEAT YIELD ESTIMATION OF RUPNAGAR DISTRICT OF PUNJAB, INDIA

J.Mukherjee, Girmay Gebru, Anil Sood[a], S.K.Bal and R.K.Mahey*

Department of Agricultural Meteorology, Punjab Agricultural University, Ludhiana, 141004, India
[a]Punjab Remote Sensing Centre, Punjab Agricultural University Campus, Ludhiana, 141004, India
* Department of Agronomy, Punjab Agricultural University, Ludhiana, 141004, India

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ABSTRACT:

Prediction of crop yield is important for advanced planning and taking various policy decisions. Conventional techniques of crop monitoring and yield estimation through ground survey and crop cutting experiment is costly and time consuming. The present study was carried out in Rupnagar district of Punjab, India. IRS LISS-III and AWiFS data of February, March 2004, 2006 and 2008 of the district was analyzed through supervised Maximum Likelihood classification approaches. Crop acreage was estimated through district boundary mask and sample segment approaches. Wheat yield estimated through regression analysis between yield and vegetation spectral indices (RVI, NDVI, DVI, TVI, SAVI and IPVI) agrometeorological indices (GDD, PTU, HTU, TD) and through trend analysis. The study has shown that, wheat acreage of district is estimated better from LISS-III data (RD = -1.5 percent) compared to AWiFS (RD = 9.41 percent). In both LISS-III and AWiFS, acreage was estimated better through complete enumeration (district boundary mask) compared sample segment approach and from smaller sample segments (5 km x 5 km) compared large sample segments (10 km x 10 km). Among vegetation indices, RVI of both LISS-III and AWiFS had higher correlation coefficient with wheat yield of district (r = 0.89 and 0.91, respectively). Among the agrometeorological indices AGDD and Evaporation aggregated at reproductive phase of the crop has explained wheat yield up to 81 percent with SEOE of 178.97 kg/ha.

1. INTRODUCTION

Agriculture is the backbone of the economy of most of the nations in the world by providing livelihood for 60 per cent of the world population (FAO 2000). Wheat is an important staple cereal of the world both from the point of view of gross acreage cultivated and grain production annually. It is cultivated on about 213.6 M ha of land with a total production of 576.31 M tones and average productivity is 26.98 Q/ha (FAO 2000). Moreover, it is the dominant grain of world commerce because it is easily transported, stored and used to produce a large variety of foods that include many kinds and types of breads, cakes, noodles, breakfast foods, biscuits, cookies, and confectionary items (Gooding and Davies 1997). is the second largest producer of wheat occupying land area of 26.74 M ha with annual production of 74.25 M tones which makes 12.5 1and 12.9 per cent of area and wheat production of the world, respectively (FAO 2000). Punjab is a major wheat growing state of India, which contributes 20.2 per cent of the wheat production of the country from just 1.53 per cent of the total geographical area of the country. Wheat is cultivated on an area of about 3.38 M ha with the annual production of about 15 M tones and productivity of 46.96 Q/ha. The state contributes 70 per cent of wheat to the national pool of food grains (Sood *et al* 2000).

Corresponding author: Dr. J.Mukherjee, mjoydeep2k@yahoo.com, joydeep@pau.edu

In India, crop statistics is collected through ground survey and crop cutting experiments. These techniques are however unable to meet the much desired requirement of pre harvest forecast for advanced policy and decision because of the following major limitations: Field surveys are complex, expensive, time consuming, tedious and require a lot of manpower (Verma *et al* 2003); are often subjective, influenced by personal bias, prone to large errors due to incomplete ground observation (Singh *et al* 2003) and more importantly, production estimates are available late after the crops are actually harvested (Mahey *et al* 1995). Hence objective, standardized and possibly cheaper and faster methods of crop growth monitoring and early crop yield estimation are imperative.

A large number of pre harvest production estimation techniques are currently under use. These ranges from sophisticated crop growth simulation models to simple empirical statistical techniques. Crop simulation models require verified commuter (software) programs and a detailed input data, which is not usually readily available. Hence empirical regression models based on weather and spectral observations are most feasible alternatives.

With the above points in view, this study was proposed with the following objectives

- To compare Indian Remote Sensing Linear Imaging Self Scanning III (IRS LISS-III) and Advanced Wide Field Sensors (AWiFS) data for wheat-area estimation
- To compare IRS LISS-III and AWiFS sensors derived vegetation indices for wheat yield prediction.

2. MATERIALS AND METHODS

Study area description

Location: The study is conducted in Rupnagar district of Punjab, India located between 30°32' - 31°24' latitude North and 76°18' - 76°55' longitude East. The district adjoins Una District (Himachal Pradesh) in the north-east, Hoshiarpur District in the north-west and Ludhiana and Patiala Districts in the south-west. The district comprises seven blocks namely Rupnagar, Kharar, Chamkaur Sahib, Anandpur Sahib, Morinda, Majri and Nurpur bedi (Fig. 1).

Climate: The climate of Rupnagar district is characterized by its hot summer and cold winter. In general, the year may be divided into four seasons: 1) cold winter season (middle of November to February). 2) hot summer season (May to June), 3) the southwest monsoon season (July and middle of September) and 4) the post-monsoon or transition season (mid September to middle of November). The temperature ranges from minimum of 4° C in winter to 45° C in summer. May and June are generally hottest months and December and January are the coldest months. Relative humidity is high, averaging about 70 per cent during monsoon. The average annual rainfall in district is 775.6 mm. About 78 per cent of the annual rainfall is received during the period from June to September.

Soils: The soils of the district vary in texture generally from loamy to silty clay loam except along the Sutlej River and chaos where some sandy patches may be found.

Crop Production: Agriculture, like rest of Punjab, is the main activity in the district. Main food crops grown include wheat, Paddy and maize covering an area of 87,000, 47,000 and 24,400 ha respectively. Sugarcane and cotton are also grown to a limited extent. The area is characterized by two growing seasons-*kharif* and *rabi*. Wheat is grown in *rabi* season mainly under irrigation (80 per cent).

Satellite Data: Single date cloud free IRS LISS-III and AWiFS digital data acquired first week of March, 2004 which coincides with maximum vegetative stage of wheat was analyzed in Punjab Remote Sensing Center (PRSC), Ludhiana. The FCC of AWiFS scene covering the district is presented in Fig. 3.

The spatial resolution of LISS-III (23.5 m) is higher than spatial resolution of AWiFS (56m) but the temporal and radiometric resolution of AWiFS is much better than that of LISS-III. Both the sensors have same spectral resolution (four bands from green to middle infrared). Specifications of IRS LISS-III and AWiFS data is given in Table 1.

Corresponding author: Dr. J.Mukherjee, mjoydeep2k@yahoo.com, joydeep@pau.edu

Table 1: Specifications of LISS-III and AWiFS Sensors

Specification	AWiFS	LISS-III
Spectral Band (µm)	0.52 - 0.59	0.52 - 0.59
	0.62 - 0.68	0.62 - 0.68
	0.77 - 0.86	0.77 - 0.86
	1.55 - 1.77	1.55 - 1.77
Spatial Resolution (m)	56	23.5
Swath width (km)	740	140
Repeativity (days)	5	24
Quantization (bit)	10	8

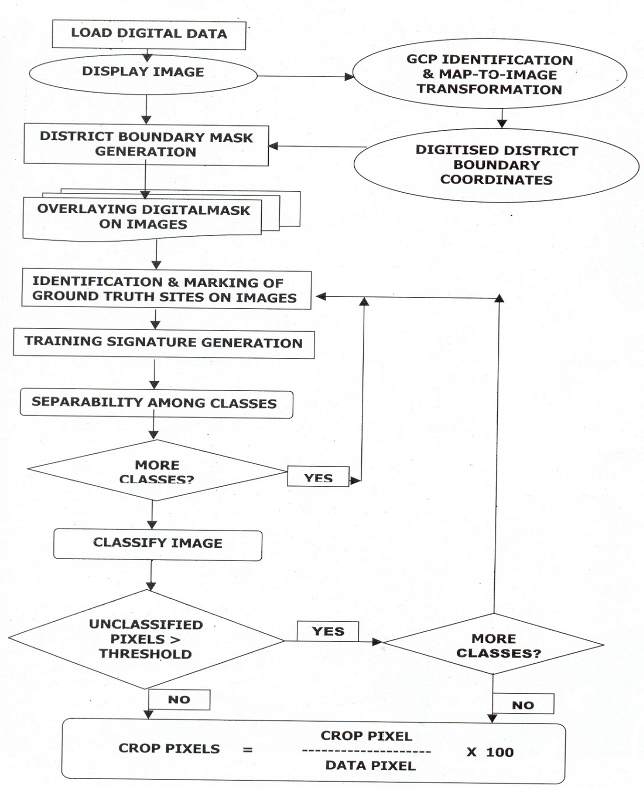

Figure. 1 Methodology for supervised image classification and yield estimation

3. RESULTS AND DISCUSSION

3.1 Comparison of sensors

The FCCs and corresponding classified image of LISS-III and AWiFS through district and block boundary mask is shown in Fig. 2.

The study has shown that wheat acreage of the district was estimated from 83,890 ha to 85,690 ha from LISS-III data while it was estimated from 96,100 ha to 98,150 ha from AWiFS data against the 87,000 ha BES estimate. Over all accuracy remote sensing estimate was found with in -4 to 12 percent of the BES estimate.

The estimates of crop acreage from LISS-III was found with a RD of -4 per cent from BES estimate while it was within RD of 12 per cent in case of AWiFS. This might be attributed to the higher spatial resolution of LISS-III (23 m) compared to AWiFS (56 m). This agrees with the findings of earlier studies by Potdar *et al* (1991), Dadhwal *et al* (1991).

Another surprising finding is that LISS-III consistently underestimated while AWiFS consistently overestimated the acreage under wheat of the district in all sample segment sizes. The underestimation in case of LISS-III could be due to difficulty to identify unirrigated wheat fields with its lower radiometric resolution (8 bit) as compared to higher radiometric resolution of AWiFS (10 bit). On the other hand, an overestimation of AWiFS might be related to its lower spatial resolution compared to LISS-III which leads to a problem of mixed pixels i.e. non wheat parcels are included in the AWiFS pixels. A similar result was reported by Yadav *et al* (1995).

Full district of Rupnagar is covered by 675,063 pixels of AWiFS and 3,833,409 pixels of LISS-III, which means LISS-III require more computer space.

The swath width of AWiFS is 740 km compared to 140 km of LISS-III which means one scene of AWiFS covers total geographical area of 547,600 km^2, while one scene of LISS-III covers geographical area of 19,600 km^2. That is one scene of AWiFS covers an area of as much area as covered by 28 LISS-III scenes. Moreover, AWiFS the higher temporal

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Corresponding author: Dr. J.Mukherjee, mjoydeep2k@yahoo.com, joydeep@pau.edu

resolution (5 days) compared to LISS-III (24 days), would provide an opportunity for monitoring the production

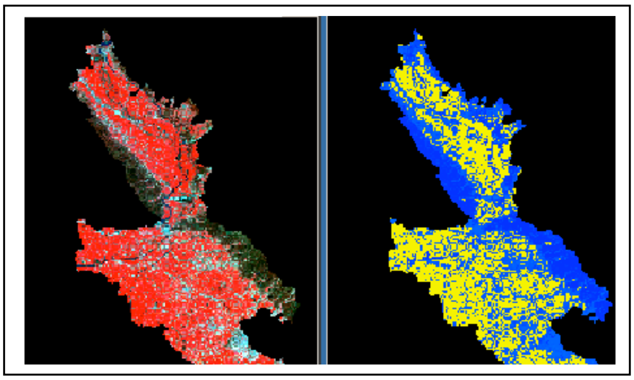
One pixel in AWiFS represents an area of 3136 m^2 or 0.31 ha while one pixel of LISS-III represents an area of just 525 m^2 or 0.0525 ha. It means LISS-III has higher discrimination capability compared to AWiFS i.e. land cover types or parcels smaller than 0.31 ha are averaged out in case of AWiFS while in LISS-III they can be sensed separately.

AWiFS has higher radiometric resolution of 10 bit data i.e. it records reflectance from an object in the interval of 2^{10} (1028) compared to of 2^8 (256) bit in LISS-III. In this regard AWiFS can discriminate objects which have smaller difference in intensity of reflectance than do LISS-III.

3.2 The relationship between vegetation indices and wheat yield

It has been observed that yield of wheat had a strong correlation with NDVI, DVI, RVI, SAVI, TVI and IPVI. The correlation coefficient varied between 0. 81 and 0.91 for vegetation indices derived from AWiFS data while the correlation coefficient was between 0.78 and 0.89 vegetation indices derived from LISS-III data. Among the vegetation indices, RVI had highest correlation coefficient with wheat yield in both from AWIFS data (r = 0.91) and LISS-III data (r = 0.89). The correlation coefficient between the vegetation indices and wheat yield is shown in Table 9.

Among all the various vegetation indices, RVI (r = 0.89) had higher correlation coefficient followed by NDVI (r = 0.86) and TVI (0.86), SAVI (r = 0.86), IPVI (r = 0.86) in LISS-III data. DVI had lowest correlation coefficient. Similar relationship was obtained from AWIFS data. Moreover, the correlation coefficients between vegetation indices from AWiFS and wheat yield were higher than correlation coefficients between vegetation indices from LISS-III and wheat yield. Highest wheat yield (4267 kg/ha) recorded in block Morinda was associated with the highest vegetation indices in both LISS-III and AWiFS.



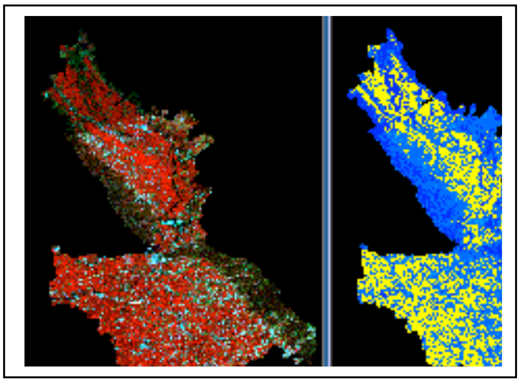


Figure.2: FCC (left) and corresponding classified images (right) through district boundary mask approach from AWiFS (top) and LISS-III (bottom) data. Note: Red color shows vegetation cover and yellow indicates wheat fields

From the above study it can be concluded that:

1. Yield estimation was better from AWiFS data compared to LISS-III, which could be because of the higher radiometric resolution of the former sensor.
2. Among the various vegetation indices RVI had higher correlation with wheat grain yield in Rupnagar district.
3. The prediction equation developed by stepwise regression techniques revealed yield can be estimated successfully up to 90

Corresponding author: Dr. J.Mukherjee, mjoydeep2k@yahoo.com, joydeep@pau.edu

percent accountability from remote sensing approach.

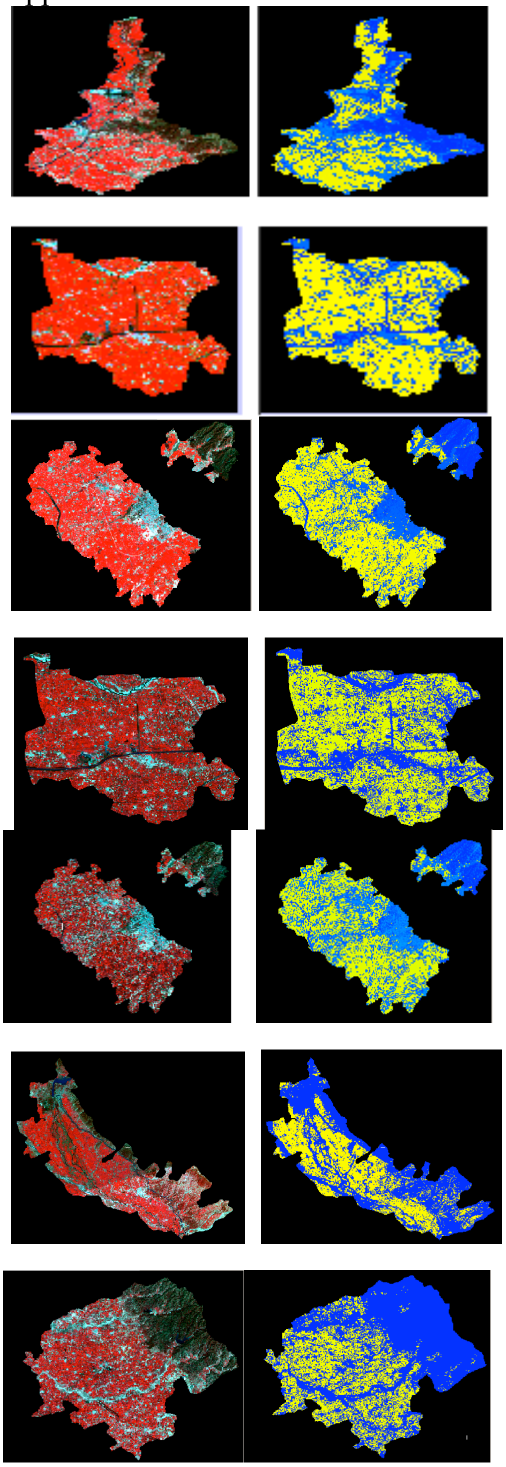


Figure 3. FCC and corresponding classified images of AWiFS (left) and LISS-III (right) through block boundary mask, Rupnagar district.

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Corresponding author: Dr. J.Mukherjee, mjoydeep2k@yahoo.com, joydeep@pau.edu