	21.04.2012	5	Good	ETM+L1T	LE71490382012112PFS00
150-38	20.11.2011	0	Good	ETM+L1T	LE71500382011324PFS00
	22.12.2011	0	Good	ETM+L1T	LE71500382011356PFS00
	08.02.2012	0	Good	ETM+L1T	LE71500382012039PFS00
	24.02.2012	0	Good	ETM+L1T	LE71500382012055PFS00
	28.04.2012	3	N/A	ETM+L1T	LE71500382012119PFS00
150-39	20.11.2011	0	Good	ETM+L1T	LE71500392011324PFS00
	22.12.2011	1	medium	ETM+L1T	LE71500392011356PFS00
	08.02.2012	0	Good	ETM+L1T	LE71500392012039PFS00
	24.02.2012	0	Good	ETM+L1T	LE71500392012055PFS00
	12.04.2012	0	Good	ETM+L1T	LE71500392012103PFS00

2.3 Methods

Satellite data was processed in ERDAS Imagine 9.2 and Arc GIS. The data downloaded from website was in tiff format so it was converted into image format to make it copmaitbale with sftware. This image consist of total seven nine bands including two thermal bandsthe data were processed for all bands except thermal bands as the thermal properties are not included. All images from November 2011 to April 2012 were stacked in a single composite file of 7 layers by layer stacking technique. This was required to analyze temporal changes in vegetation cover and identify crop growth stages with the help of crop phenology. To get the combine images of study area that includes three tiles, mosaicking was performed to join all the tiles with the reference of geographical coordinates.

2.3.1 Supervised Classification

Field survey data was used for supervised classification on the Landsat TM 4 layer composite pseudo color image from November 2011 to April 2012. Supervised classification indicates that the analyst influences the results by using the signature file as a sample of known identity (i.e., pixels already assigned to classes) to classify pixels of the unknown identity (i.e., to assign unclassified pixels to one of the several known classes). Though there are many supervised classifiers, the maximum likelihood classifier (MLC) was used. This was so because MLC is a well-known parametric approach based on the assumption that the data may be modeled by a set of multivariate normal distributions. Furthermore, MLC does not consider only cluster, but also its shape, size and orientation. Therefore, a pixel is assigned to the class or cluster with highest probability. The resulting maps have the same number of classes as the number of classes detected in field during field survey which makes it easier for class detection in unsupervised map.

2.3.2 Derivation of NDVI Values

Cropping intensity, crop types and different cropping patterns were assessed and observed using Normalized Difference Vegetation Index (NDVI), a special algorithm. The NDVI is a normalized difference measure was obtained by comparing the near infrared and visible red bands expressed by the following formula.

$$NDVI = \frac{(NIR - red)}{(NIR + red)}$$

Where: NIR: reflectance in near-infrared band, and red: reflectance in red band

2.4 Validation and Accuracy

To estimate the accuracy and consistency of satellite driven information, accuracy assessment studies were performed. First approach is the error matrix method, which uses unsupervised classification and geo-referenced data to have an accurate knowledge of the ground condition (Usman et al. 2015). A survey for ground trothing was conducted during March to capture peak Rabi cropping season and in April to take the samples of crop yield as April is harvesting time for mostly wheat crops. Because the study was regional based for detailed crop mapping, ground trothing was performed for the entire region. The Garmin GPS 60 was used for taking sample readings. If a class was detected 70% dominant of certain land use, the area was named as that class.

3. RESULTS AND DISCUSSION

3.1 Land Use Land Cover Classification

The total pixels containing wheat and Non-wheat area was calculated by attribute table. In Landsat 7 images Scan Line Corrector (SLC) failed after May 31, 2003. These products have data gaps, but are still useful and maintain the same radiometric and geometric corrections as data collected prior to the SLC failure. In this research, weighted average was used to convert area under patches into wheat and non-wheat area. The spatial resolution of Landsat-7 is 30 meters so one pixel contains an area of 30*30=900 m^2. Area except wheat was emerged into one class named as non-wheat area. LULC for wheat and non-wheat area in hectare and % of wheat area in study area is presented in Table 4:

Table 4: LULC for wheat area in hectare and % of wheat area in study area

Distributary	Wheat Area (Ha)	% Area of total area
Khurrian Wala	28867.95	87.22
Killian Wala	22423.20	71.07
Mungi	17974.34	79.18

3.2 Correlation between NDVI value and Yield

Total five satellite images from command area of each distributary were collected and processed for study area during whole Rabi season. NDVI value for each image was extracted and February images has maximum NDVI value due to the peak season of crop growth. To develop a relationship between NDVI values and crop yield, a correlation between max NDVI value and crop yield was drawn for each distributary. A correlation and trend line between crop yield and maximum NDVI value is drawn for all three distributaries as shown in Fig. 3 and 4. The coefficient of determination between yield and maximum NDVI value has been found 0.45 for Khurrian Wala distributary, 0.36 for Killian Wala distributary and 0.39 for Mungi distributary. Although there has been found less significant correlation between NDVI and yield but the trend line is found positive in all three distributaries. On the basis of correlation between NDVI and wheat yield, the total yield for each distributary was estimated (Table 5).

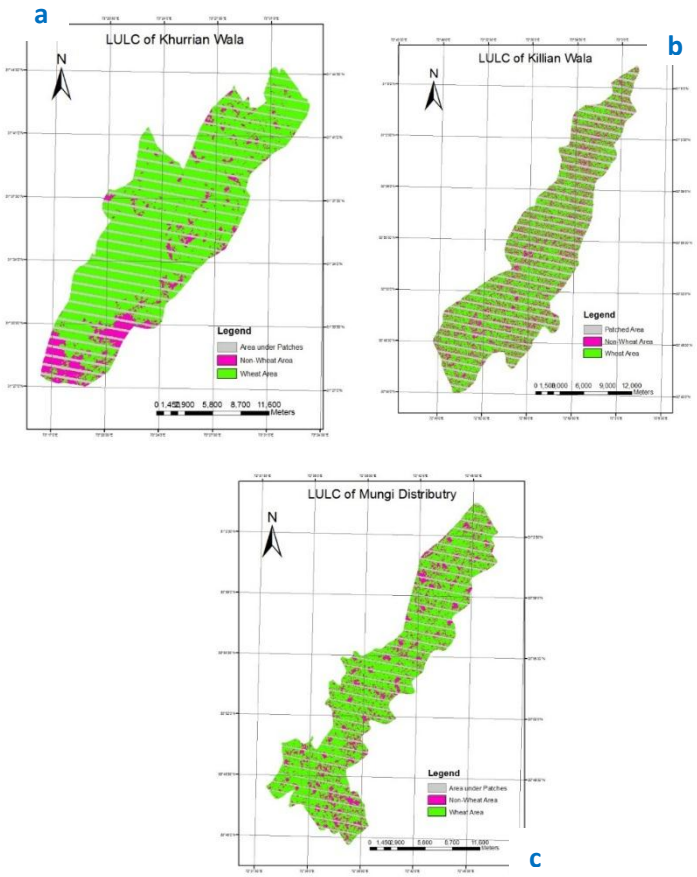


Figure 2: LULC for wheat of (a). Khurrian Wala, (b). Killian Wala, and (c). Mungi distributary

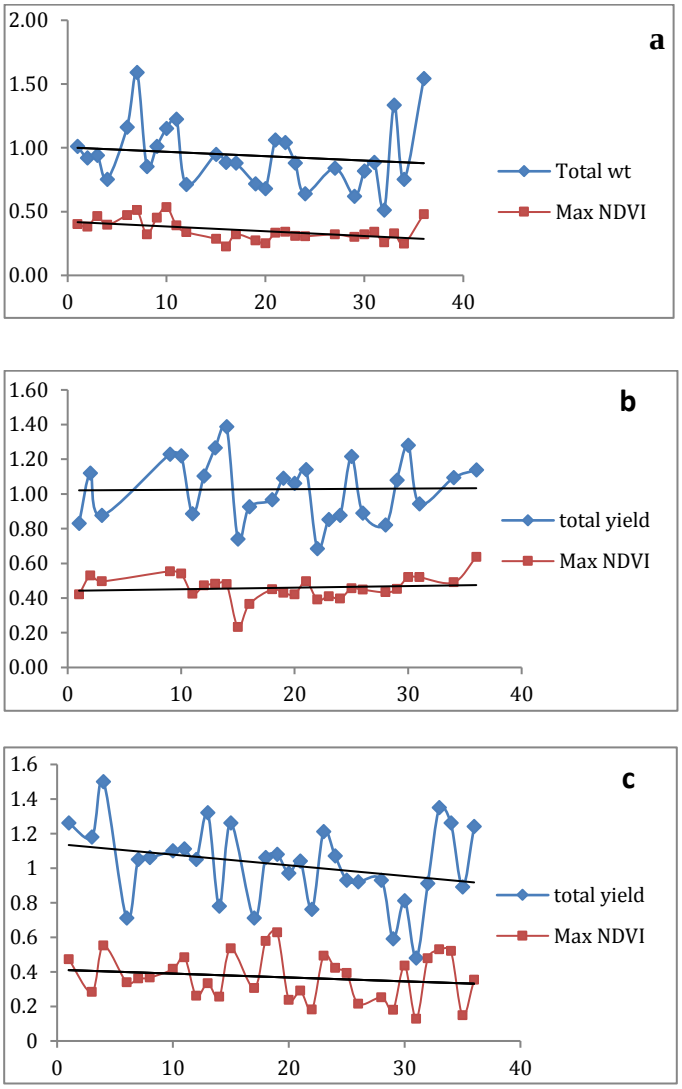
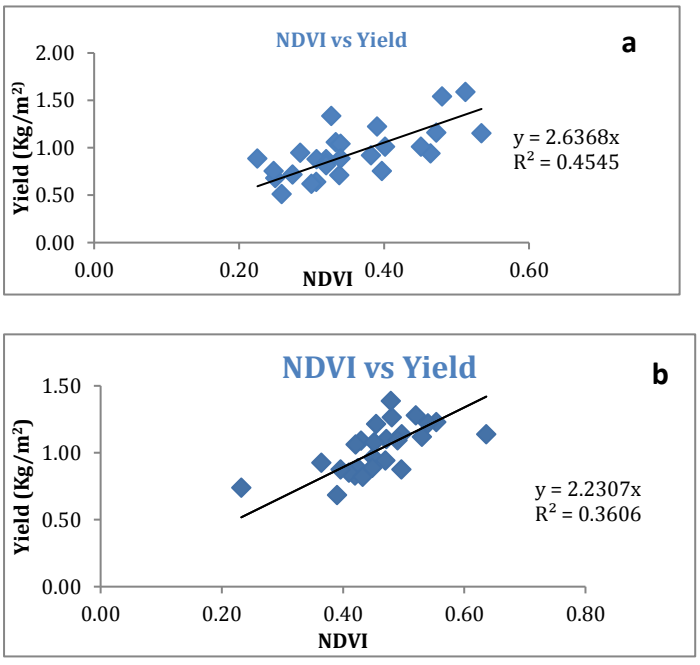


Figure 3: Trend line of yield and NDVI value of (a) Khurrian Wala (b) Killian Wala (c) Mungi Distributary.



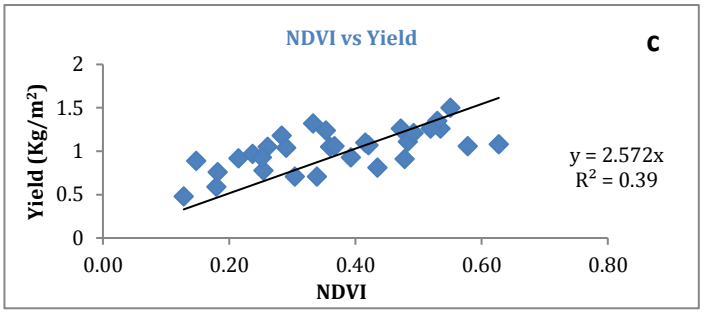


Figure 4: Correlation between NDVI and yield of (a) Khurrian Wala (b) Killian Wala (c) Mungi Distributary

Table 5: Total and average yield of command areas of all distributaries

Distributary	Wheat Area (Ha)	Total Production (Tons)	Average (Tons/Ha)	Average (Monds/Ac)
Khurrian Wala	22447.53	78129.88	3.48	34.80
Killian Wala	19083.51	73025.34	3.83	38.26
Mungi	15092.64	57392.48	3.80	38.02

4. DISCUSSION

The 87.22% of total command area of Khurrian wala distributary under wheat is good proportion of wheat crop due to the fact that only wheat and rice are the major crops in the command area. The result for killian wala is 71.07% of total command area and this relatively low proportion is due to sugarcane and maize are also the major crops along with wheat in command area. The mapping result for Mungi shows 79.18% of total command area is under wheat and this medium proportion for wheat crop is due to command area of Mungi has mix cropping zone with some early cotton, sugarcane, maize and fodder crops.

The average wheat yield in Pakistan is 2.83 Tons/Ha in 2010-11 and 2.71 Tons/Ha in 2011-12 and the total area under wheat was 2833000 Ha in 2010-11 and 2714000 Ha in 2011-12 (Economic Survey of Pakistan, 2011-12). The total availability of canal water to Punjab Province in Rabi season, 2010-11 was 18.73 MAF and in Rabi Season 2011-12 this amount reduced to 17.61 MAF. There was an overall change of -6% of canal water availability in two consecutive years. This is average yield of whole country and includes all area like arid, semi-arid, humid region and hilly areas where there is average yield is very low up to of 1.5tons/ha.

Overall decrease in wheat area and average yield is due to the problems which former is facing and they have begun to grow early BT cotton. As study area is very rich of agriculture, crust of the area is buildup of alluvial soils which come by floods and settled. The irrigation system of the study area comprises of very good network of main canals, link canals, branch canals and many distributaries which are providing water to agriculture land of the area. Very intensive agriculture practices are being carried out in the area, so on average basis, wheat production of 3.48 tons/ha to 3.83 tons/ha can easily be attained.

5. CONCLUSIONS AND RECOMMENDATIONS

Time series of Landsat-7 data with 30m spatial resolution and 16 days temporal resolution showed good results for mapping of LULC classes. The correlation between NDVI and crop yield offers good potential to estimate crop yield not at command area of canal level but at regional and country level. The area under wheat derived from LULC map on the basis of NDVI is good tool for area assessment. So, it is necessary to encourage and promote the applications of Remote Sensing and GIS for land, yield and water management analysis. Policy makers and Government agencies should adopt such techniques and tools for better and timely management of all resources including agriculture, water and forestry. Good results up to accuracy of 85% were obtained by the supervised classification of the NDVI profiles; it is also need to determine the variance within or between groups through statistical analysis. It is also recommended to use land cover product obtained from some high resolution like 10 m and 5m, satellite data.

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