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The Utilization of MODIS and Landsat TM/ETM+for Cotton Fractional Yield Estimation in Burewala

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Keywords: *Crop yield, EVI, cotton fraction, Landsat, MODIS dataset, NDVI, remote sensing.*

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THE UTILIZATION OF MODIS AND LANDSAT TMETM+FOR COTTON FRACTIONAL YIELD ESTIMATION IN BUREWALA

Strictly as per the compliance and regulations of:

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Farooq Ahmad [α], Kashif Shafique [σ], Sajid Rashid Ahmad [ρ], Shafeeq-Ur-Rehman [Ѡ], Rao Mansor Ali Khan[¥] & Abdul Raoof [§]

Abstract- Estimates of crop yield are desirable for managing agricultural lands. Remote sensing is the one technology that can give an unbiased view of large areas, with spatially explicit information distribution and time repetition, and has thus been widely used to estimate crop yield and offers great potential for monitoring production, yet the uncertainties associated with large-scale crop yield estimates are rarely addressed. In this study, we tried to estimate cotton cropped area using the supervised classification; planting dates for 11 years (1998 to 2009) of Landsat imagery, and fractional yield using MODIS (Terra) the normalized difference vegetation index (NDVI), and enhanced vegetation index (EVI) in an intensive agricultural region of Burewala, Punjab province of Pakistan. Vegetation indices are widely used for assessing and monitoring ecological variables such as vegetation cover and above-ground biomass. Monitoring the spatial distribution of cotton yield helps identifying sites with yield constraints. The newly available satellite images from the MODIS sensor provide enhanced atmospheric correction, cloud detection, improved geo-referencing, comprehensive data quality control and the enhanced ability to monitor vegetation development. The high temporal resolution of the MODIS datasets can provide an efficient and consistent way for biomass and fractional yield monitoring and assessment. The reflected radiation provides an indication of the type and density of canopy. The condition, distribution, structure and the development of the vegetation through the phenological stages can affect the relation between yield and NDVI. The high spatial resolution Landsat images were applied to extract the area under cotton cultivation within the landscape and to determine the cotton fraction among other land uses within the coarse spatial resolution MODIS pixels.

Keywords: Crop yield, EVI, cotton fraction, Landsat, MODIS dataset, NDVI, remote sensing.

I. Introduction

The high temporal resolution of the MODIS datasets can provide an efficient and consistent way for biomass and yield monitoring (Dalezios et al., 2001; Alexandridis and Chemin, 2002). Increased knowledge about the spatial distribution of cotton yield (Shi et al., 2007) in Burewala, Punjab province of Pakistan, supports the optimal provision of resources (Macdonald and Hall, 1980; Hutchinson, 1991; Lobell et al., 2003; Hongo and Niwa, 2012).

Remote sensing imagery offers unique possibilities for spatial and temporal characterization of the changes. The basic requirement is the availability of different dates of imagery which permit continuous monitoring of change and environmental developments over time (Lu et al., 2004; Nasr and Helmy, 2009; Ahmad, 2012d). Long-term observations of remotely sensed vegetation dynamics have held an increasingly prominent role in the study of terrestrial ecology (Budde et al., 2004; Prasad et al., 2007; Ouyang et al., 2012; Ahmad, 2012). A major limitation of such studies is the limited availability of sufficiently consistent data derived from long-term remote sensing (Ouyang et al., 2012; Ahmad, 2012). The benefit obtained from a remote sensing sensor, thereby, largely depends on its spectral resolution (Jensen, 2005; Ahmad, 2012), which determines the sensor's capability to resolve spectral features of land surfaces (Fontana, 2009; Ahmad, 2012). One of the key factors in assessing vegetation dynamics and its response to climate change is the ability to make frequent and consistent observations (Thomas and Leason, 2005; Ouyang et al., 2012; Ahmad, 2012). Photosynthetically active vegetation is characterized by very low reflectance values (Jensen, 2005; Ahmad, 2012a) in the red part of the electromagnetic spectrum due to the absorption of solar radiation by the leaf pigments involved in photosynthesis (Lillesand et al., 2004; Ahmad, 2012a), and by increased reflectance in the near infrared portion of the spectrum due to reflection of incoming solar radiation at the leaf internal structures (Gitelson and Merzlyak, 1996; Fontana, 2009; Ahmad, 2012a). With regard to the monitoring of terrestrial vegetation, the Normalized Difference Vegetation Index (Rouse et al., 1973; Tucker, 1979; Ahmad, 2012a) is the most commonly used index and serves as a measure of photosynthetic activity within a certain area (Fontana, 2009; Ahmad, 2012a).

Los et al. (1994) and Sellers et al. (1996) were the first to derive land surface parameters with realistic seasonal and spatial variations for the globe from NDVI data collected by the AVHRR satellite (Los et al., 2000;

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Ahmad, 2012a). Estimation of land surface vegetation parameters from satellite is based on the spectral properties of vegetation; vegetation strongly absorbs visible light, using the energy for photosynthesis, and strongly reflects near-infrared (NIR) radiation (Rouse et al., 1973; Los, 1998; Los et al., 2000; Ahmad, 2012a; Ahmad, 2012b). Changes in vegetation spectral response caused by phenology can conceal the longer term changes in the landscape (Hobbs, 1989; Lambin, 1996; Dennison and Roberts, 2003; Ahmad, 2012d). Multi-temporal data that captures these spectral differences can improve reparability of vegetation types over classifications based on single date imagery (DeFries et al., 1995; Ahmad, 2012d).

The Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument onboard the Terra satellite platform (Huete et al., 2006; Carrão et al., 2008; Ahmad, 2012c). Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning (Salomonson and Toll, 1991; GSFC/NASA, 2003; Huete, 2005; Ahmad, 2012c). There are now over 13 years of MODIS Terra data (first image, February 24, 2000), available producing high quality scientific products with calibration specifications of 2% reflectance and 5% radiance and geolocation of 50 m (Huete, 2005; Ahmad, 2012c).

The MODIS sensor has 36 spectral bands extending from the visible to the thermal infrared wavelengths [between 0.405 and 14.385 μm] (Running et al., 1994; Zhan et al., 2000). The MODIS land bands have a heritage related to the Landsat TM, with additional spectral capabilities added in the short-wave and long-wave infrared (Justice et al., 1998; Jin and Sader, 2005). Several researchers have used MODIS to detect changes in land cover (Zhan et al., 2000; 2002; Roy et al., 2002; Korontzi et al., 2004; Jin and Sader, 2005).

A remote sensing sensor is a key device that captures data about an object or scene remotely. Since objects have their unique spectral features, they can be identified from remote sensing imagery according to their unique spectral characteristics (Xie, 2008; Ahmad, 2013). A good case in vegetation mapping using remote sensing technology is the spectral radiances in the red and near-infrared (NIR) regions, in addition to others. The radiances in these regions could be incorporated into the spectral vegetation indices (VI) that are directly related to the intercepted fraction of photosynthetically active radiation (Asrar et al., 1984; Galio et al., 1985; Xie, 2008; Ahmad, 2013). Such evaluations often require the use of vegetation indices calculated from archived satellite data.

The NDVI is chlorophyll sensitive; the EVI (Liu and Huete, 1995; Justice et al., 1998; Huete et al., 1999) is more responsive to canopy structural variations, including canopy type, plant physiognomy and canopy architecture (Gao et al., 2000; Huete et al., 2002). The two VIs complement each other in global vegetation studies and improve upon the detection of vegetation changes and extraction of canopy biophysical parameters (Huete et al., 1999; 2002).

The NDVI can be a useful tool to couple climate and vegetation distribution and performance at large spatial and temporal scales (Pettorelli et al., 2005; Aguilar et al., 2012; Ahmad, 2012; Ahmad, 2013a) because vegetation vigor and productivity are related to temperature-precipitation and evapotranspiration. The NDVI serves as a surrogate measure of these factors at the landscape scale (Wang et al., 2003; Groeneveld and Baugh, 2007; Aguilar et al., 2012; Ahmad, 2012; Ahmad, 2013a). The NDVI product works optimally with cloud filtering, radiometric calibration, precise geolocation, and a snow mask. In addition, the product performs best using top-of-canopy reflectance inputs, corrected for atmospheric ozone, molecular scattering, aerosol, and water vapour (Huete et al., 2006; Ahmad, 2012; Ahmad, 2013a).

Accurate evaluation of vegetation response across multiple-year time scales is crucial for analyses of global change (Running and Nemani, 1991; Sellers et al., 1994; Stow, 1995; Justice et al., 1998; Fensholt, 2004; Baugh and Groeneveld, 2006; Ahmad, 2012e), effects of human activities (Moran et al., 1997; Milich and Weiss 2000; Thiam, 2003; Baugh and Groeneveld, 2006; Ahmad, 2012e) and ecological relationships (Baret and Guyot, 1991; Asrar et al., 1992; Begue, 1993; Epiphanio and Huete, 1995; Gillies et al., 1997; Baugh and Groeneveld, 2006; Ahmad, 2012e).

a) Study Area

Burewala (Figure 1) lies in the Punjab province of Pakistan from 29° 52' 28" to 30° 22' 12" North latitude and 72° 30' 04" to 72° 59' 35" East longitude.

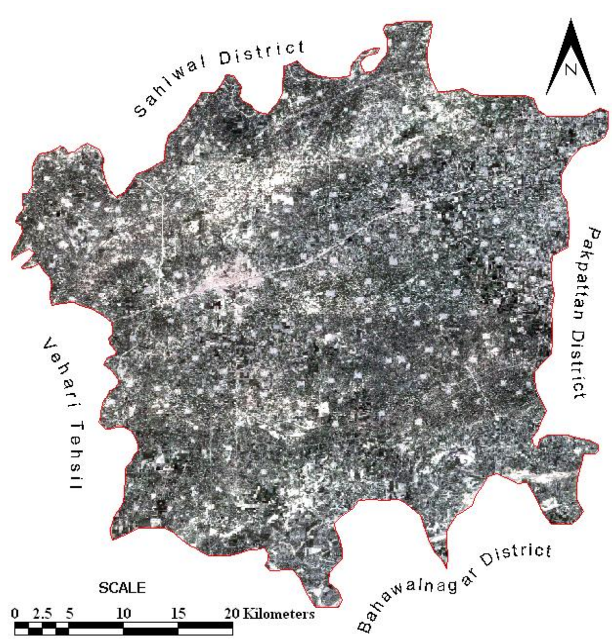

Figure 1 : Burewala - Landsat TM 2nd August, 2009 image

Source: http://glovis.usgs.gov/

II. Research Design and Methods

In this research paper four Landsat TM/ETM+ scenes of 20th August, 1998; 15th August, 1999; 20th August, 2001 and 2nd August, 2009 (path 150; row 39) were used to detect and recognize the cotton-pixels and cotton cropped areas in Burewala. These vital steps are: image registration and image enhancement as discussed by Macleod and Congalton (1998), Mahmoodzadeh (2007) and Al-Awadhi et al., 2011. These scenes were corrected and geo-referenced using projection UTM, zone 43 and datum WGS 84. The Landsat has a long history of dataset, it is very helpful to map long-term vegetation cover and study the spatio-temporal vegetation changes (Schroeder et al., 2006; Xie, 2008; Ahmad, 2012d).

Radiometric enhancement is performed to produce a homogenous radiometric set of data (Richard et al., 2005; Ahmad, 2012d). So that, false changes are not introduced by factors such as: modification of the spectral distribution due to atmospheric conditions, different path radiance and seen angle variation (Ulbricht and Heckendorf, 1998; Ahmad, 2012d). Ideally, all images would be calibrated to standard reflectance units (Nasr and Helmy, 2009; Ahmad, 2012d). However, when comparing images to detect change, it is sufficient to convert raw digital counts to be consistent with a chosen reference image (Symeonakis et al., 2006; Ahmad, 2012d). Histograms equalization and histogram matching were generated in order to identify the suitable contrast stretching level to optimize the balance (Singh, 1989; Ahmad, 2012d) for Landsat TM/ETM+ images. Landsat TM/ETM+ different bands have used in order to estimate the vegetation quantities parameter based on vegetation indices (Ahmad, 2012e). While all dimensions of remotely sensed data are relevant, for practical purposes it is the temporal information that has been most useful for monitoring of major crop types with remote sensing (Smith and Ramey, 1982; Badhwar, 1984; Hall and Badhwar, 1987; Price et al., 1997; Wardlow et al., 2007; Singh, 2012).

The MODIS (Terra) NDVI/EVI (MOD13A1) data products for research area were acquired, in this case data were downloaded from the Land Processes Distributed Active Archive Center (LPDAAC). Tile number covering this area is h24v05, reprojected from the Integerized Sinusoidal projection to a Geographic Lat/Lon projection, and Datum WGS84 (GSFC/NASA, 2003; Ahmad, 2012; 2012d). A gapless time series of MODIS (Terra) NDVI/EVI composite raster data from February, 2000 to February, 2013 with a spatial resolution of 500 m (Table 1) was utilized for calculation of the cotton fractional yield (Figure 2). The datasets provide frequent information at the spatial scale at which the majority of human-driven land cover changes occur (Townshend and Justice, 1988; Verbesselt et al., 2010; Ahmad, 2012). MODIS products are designed to provide consistent spatial and temporal comparisons between different global vegetation conditions that can be used to monitor photosynthetic activity and forecast crop yields (Vazifedoust et al., 2009; Cheng and Wu, 2011). Details documenting the MODIS (Terra) NDVI/EVI compositing process and Quality Assessment Science Data Sets can be found at NASA's MODIS web site (MODIS, 1999; USGS, 2008).

Table 1: MODIS (Terra) Bands used in this research study

Bandwidth specifications (nm)	Band 3: 459-479
	Band 4: 545-565
	Band 5: 1230-1250
	Band 6: 1628-1652
	Band 7: 2105-2155
Spatial resolution (m)	500
Radiometric resolution (bits)	12
Time window	16-days

Earth location data is available at sub-pixel accuracy. This extraordinary geolocation accuracy is achieved due to several reasons (Wolfe et al., 1995; 2002; Fontana, 2009; Ahmad, 2012): First, the spacecrafts carrying MODIS are very stable and provide highly precise external orientation knowledge. Second, the MODIS instrument was designed to give precise interior orientation knowledge (Khlopenkov and Trishchenko, 2008; Fontana, 2009; Ahmad, 2012). Third, an accurate global DEM (Logan, 1999; Fontana, 2009; Ahmad, 2012) is used to model and remove relief-induced distortions. Fourth, a global set of GCPs based on Landsat imagery served to determine biases in the sensor orientation, which were finally used to improve geolocation processing (Ackerman et al., 1998; 2006; Fontana, 2009; Ahmad, 2012).

The NDVI is successful as a vegetation measure is that it is sufficiently stable to permit meaningful comparisons of seasonal and inter-annual changes in vegetation growth and activity (Choudhury, 1987; Jakubauskas et al., 2002; Chen et al., 2006; Zoran and Stefan, 2006; Nicandrou, 2010; Ahmad, 2012; Ahmad, 2012d; 2012e). The strength of the NDVI is in its ratioing concept (Moran et al., 1992; Ahmad, 2012), which reduces many forms of multiplicative noise (illumination differences, cloud shadows, atmospheric attenuation, and certain topographic variations) present in multiple bands (Chen et al., 2002; Nicandrou, 2010; Ahmad, 2012; Ahmad, 2012d).

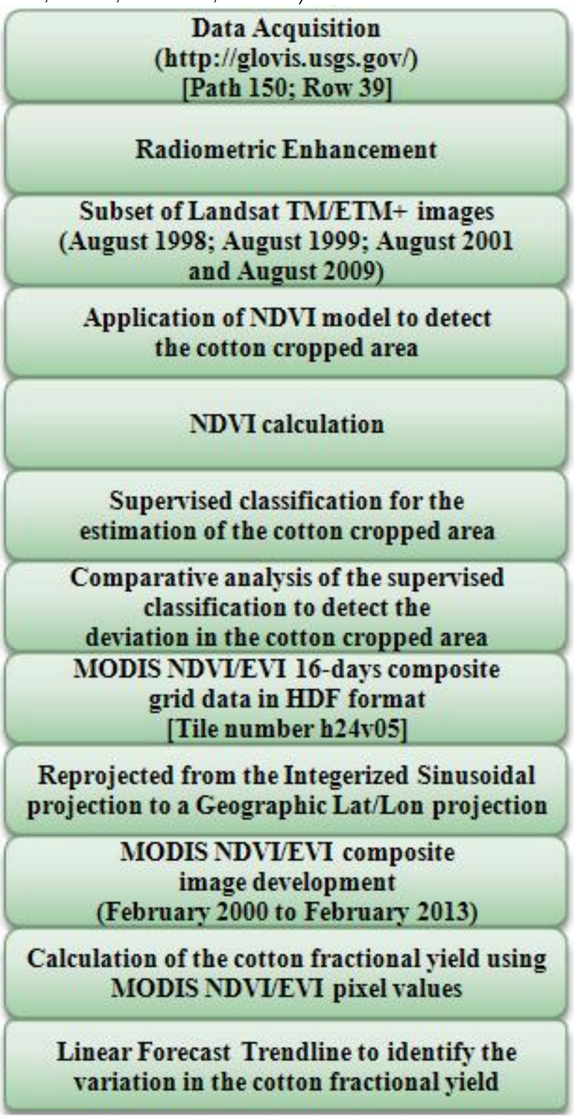

Figure 2 : Scheme for research design and methods

The NDVI,spectral vegetation index which measures soil and vegetation moisture (Singh, 1989; Lyon et al., 1998; Mambo and Archer, 2007; Ahmad, 2013a), has been widely used for environmental change monitoring (Young, 1998; Lillesand and Kiefer, 2000; Eastman, 2003; Lillesand et al., 2004; Mambo and Archer, 2007; Ahmad, 2013a). The index can be used to identify areas showing distressed or degraded vegetation, leading to identification of possible degraded areas (Barrow, 1991; Booth et al., 1994; Mambo and Archer, 2007; Ahmad, 2013a). The NDVI captures the marked contrast between the strong absorptance in the visible wavelengths and strong reflectance in the near-infrared wavelengths which uniquely characterize the presence of photosynthetically active vegetation (Tucker, 1979; Wessels et al., 2004; Ahmad, 2013a). The NDVI is an indicator of vegetation health, because degradation of ecosystem vegetation, or a decrease in green, would be reflected in a decrease in NDVI value (Meneses-Tovar, 2011; Ahmad, 2013a).

The NDVI is highly correlated with vegetation parameters such as green leaf biomass and green leaf area (Justice et al., 1985; Ahmad, 2013a), and it also is directly related to plant vigor, density, and growth conditions (Holben, 1986; Ahmad, 2013a), now it is widely accepted as a primary tool for monitoring land degradation (Huang et al., 2010; Ahmad, 2013a). In arid and semi-arid lands, seasonal sums of multi-temporal NDVI are strongly correlated with vegetation production (Prince and Tucker, 1986; Prince, 1991; Nicholson and Farrar, 1994; Nicholson et al., 1998; Wessels et al., 2004; Ahmad, 2013a).

The NDVI values range from -1 to +1; because of high reflectance in the NIR portion of the EMS, healthy vegetation is represented by high NDVI values between 0.1 and 1 (Liu and Huete, 1995; USGS, 2008; 2010; Ahmad, 2012). Conversely, non-vegetated surfaces such as water bodies yield negative values of NDVI because of the electromagnetic absorption property of water. Bare soil areas represent NDVI values which are closest to 0 due to high reflectance in both the visible and NIR portions of the EMS (Townshend, 1992; Ahmad, 2012). The NDVI is related to the absorption of photosynthetically active radiation and basically measures the photosynthetic capability of leaves, which is related to vegetative canopy resistance and water vapour transfer (Wan, 2003; Rahman et al., 2004; Ahmad, 2012; 2012d).

The NDVI is the most commonly used index of greenness derived from multispectral remote sensing data (USGS, 2010; Ahmad, 2013a), and is used in several studies on vegetation, since it has been proven to be positively correlated with density of green matter (Townshend et al., 1991; Huete et al., 1997; Huete et al., 2002; Debien et al., 2010; Ahmad, 2012a; 2012d; Zaeen, 2012; Ahmad, 2013a). The NDVI provides useful information for detecting and interpreting vegetation land cover it has been widely used in remote sensing studies (Dorman and Sellers, 1989; Myneni and Asrar, 1994; Gao, 1996; Sesnie et al., 2008; Karaburun, 2010; Ahmad, 2012b; Ahmad, 2013a).

The EVI is an 'optimized index' designed to enhance the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a de-coupling of the canopy background signal and a reduction in atmosphere influences (Liu and Huete, 1995; Justice et al., 1998; Huete et al., 1999; Ahmad, 2012e), and minimizes canopy-soil and aerosol variations and improves sensitivity over dense vegetation conditions (Qi et al., 1994; Ahmad, 2012c). The two products more effectively characterize a global range of vegetation states and processes, and improve upon the extraction of canopy biophysical parameters (Jiang et al., 2008; Ahmad, 2012c).

ERDAS imagine 2013 and ArcGIS 10 software were used for application of NDVI model to detect the cotton cropped area and calculation for Landsat TM/ETM+ images (path 150; row 39) of 20th August, 1998; 15th August, 1999; 20th August, 2001 and 2nd August, 2009 respectively. The supervised classification was applied upon the images for the estimation of the cotton cropped area. Further, comparative analysis was carried out upon supervised classification to detect the deviation in the cotton cropped area in Burewala. Calculation of the cotton fractional yield using MODIS (Terra) NDVI/EVI pixel values of the selected villages; Chak 44/KB, Chak 305/EB, Chak 487/EB and Chak 529/EB of Burewala was carried out and linear forecast trendline was plotted to identify the variations in the cotton fractional yield dataset of Chak 44/KB from February 2000 to February 2013. Standard multispectral image processing techniques were generally developed to classify multispectral images into broad categories of surface condition (Shippert, 2004; Ahmad, 2012f). ERDAS imagine (ERDAS Imagine, Inc., 2010) and ENVI tools, applicable to a variety of applications, distinguish and identify the unique resource information present in the scene and map them throughout the image (Research System, Inc., 2004).

III. Results

Figure 3, 4, 5 and 6 (Table 2) shows classified NDVI for Landsat TM/ETM+ scenes of 20th August, 1998; 15th August, 1999; 20th August, 2001 and 2nd August, 2009 respectively. The NDVI model was applied upon the Landsat TM/ETM+ using ERDAS imagine 2013 software while ArcGIS 10 was used for NDVI calculation. Further, ArcGIS symbology tool was used to develop NDVI classes and recognize the cotton cropped areas in Burewala. The NDVI is an effective vegetation measure since it is sufficiently stable to permit meaningful comparisons between seasonal and interannual changes in vegetation growth and activity (Cheng and Wu, 2011). This is because it can reduce different forms of multiplicative noise present in multiple bands (Myneni et al., 1995; Cheng and Wu, 2011). The significance of NDVI index may vary according to habitat type (Pettorelli et al., 2005; Hamel et al., 2009; Ahmad, 2013a). Vegetation indices may employ simple ratios of any two single wavelength combinations. These ratios were found to be fairly effective in normalizing the effect of reflectance variation in soil background (Colwell, 1973; Cheng and Wu, 2011).

Remote sensing data provides systematically high-quality spatial and temporal information about land surface features, including behaviour of agricultural crops and cumulative environmental impacts on crop growing conditions (Liu and Kogan, 2002). Remote sensing techniques have been employed to estimate various plant parameters (Wiegant et al., 1979; Price, 1995; Mirik et al., 2007; Cheng and Wu, 2011) and crop yield (Cheng et al., 2004; Cheng, 2006; Cheng and Wu, 2011). Remote sensing provides quantitative information on agricultural crops instantaneously and nondestructively (Clevers, 1988; Mirik et al., 2006; Cheng and Wu, 2011), and the spatial and temporal distributions of crop production offer valuable information for agricultural management and biogeochemical modeling efforts (Lobell et al., 2003; Sönmez and Sarı, 2006; Cheng and Wu, 2011).

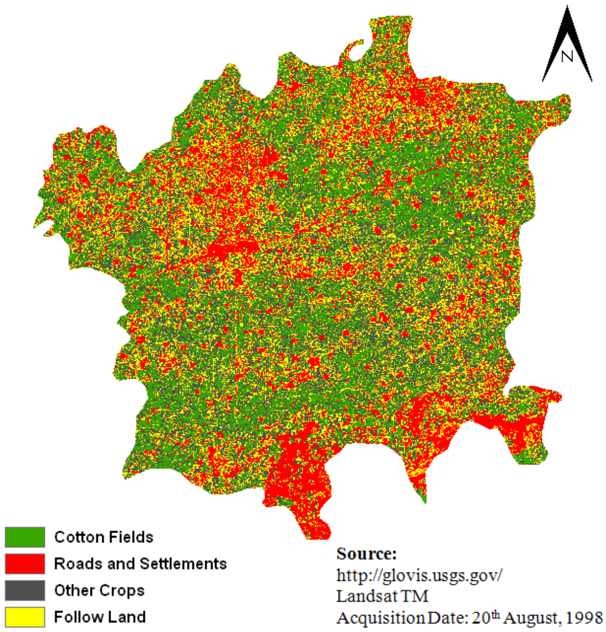

Figure 3 : Classified NDVI 1998, Burewala

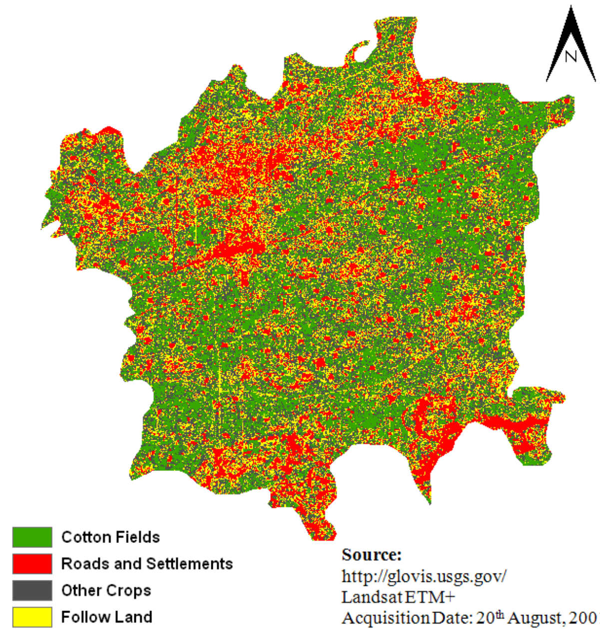

Figure 4 : Classified NDVI 1999, Burewala

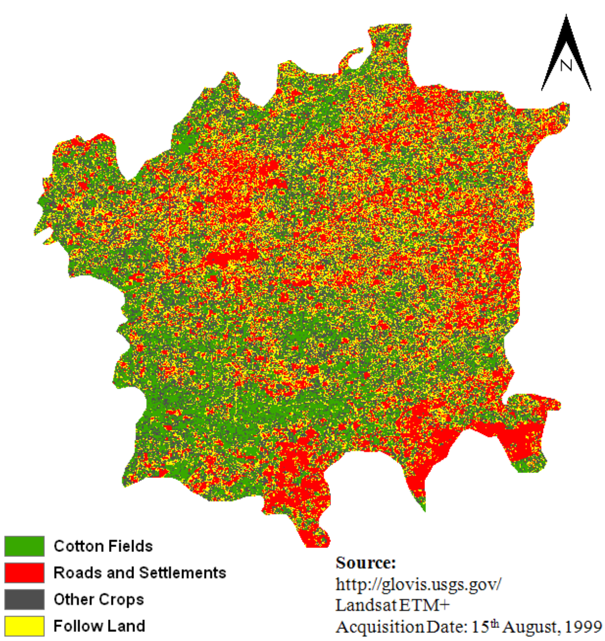

Figure 5 : Classified NDVI 2001, Burewala

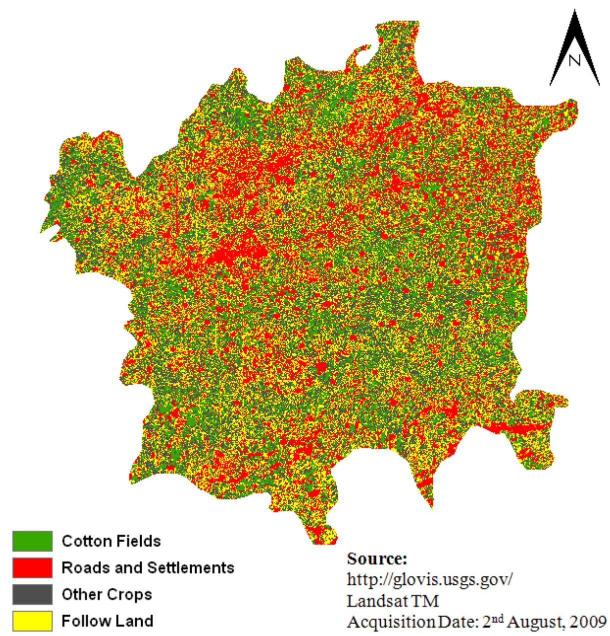

Figure 6 : Classified NDVI 2009, Burewala

Table 2: NDVI values of Landsat images

Image Acquisition Date	Maximum NDVI	Minimum NDVI	Mean NDVI	Standard Deviation
20th August, 1998 (Landsat TM)	0.61	-0.19	0.23	0.13
15th August, 1999 (Landsat ETM+)	0.51	-0.26	0.11	0.12
20th August, 2001 (Landsat ETM+)	0.56	-0.24	0.21	0.14
2nd August, 2009 (Landsat TM)	0.54	-0.15	0.20	0.11

The NDVI (Sellers, 1985) as an indicator of vivid green vegetation and as a descriptor of ecosystem functions has proved to be very valuable for assessing ecological responses to environmental changes (Pettorelli et al., 2005; Alcaraz-Segura et al., 2009; Höpfner and Scherer, 2011; Ahmad, 2012a). The NDVI can be used not only for accurate description of vegetation classification and vegetation phenology (Tucker et al., 1982; Tarpley et al., 1984; Justice et al., 1985; Lloyd, 1990; Singh et al., 2003; Los et al., 2005;

Ahmad, 2013a) but also effective for monitoring rainfall and drought, estimating net primary production of vegetation, crop growth conditions and crop yields, detecting weather impacts and other events important for agriculture and ecology (Kogan, 1987; Dabrowska-Zielinska et al., 2002; Singh et al., 2003; Chris and Molly, 2006; Baldi et al., 2008; Glenn et al., 2008; Ahmad, 2012b; Ahmad, 2013a).

Figure 7, 8, 9 and 10 shows the supervised classification for Landsat TM/ETM+ scenes of 20th August, 1998; 15th August, 1999; 20th August, 2001 and 2nd August, 2009 respectively. The supervised classification was applied upon the Landsat TM/ETM+ using ERDAS imagine 2013 software to detect cotton cropped areas in Burewala. The approach supervised classification which is part of post classification comparison method or direct classification method. This approach is based on the natural groupings of the spectral properties of the pixels which are usually selected by the RS software without any influence from the users (Al-Awadhi et al., 2011).

Figure 7 shows the supervised classification for Landsat TM image of 20th August, 1998. The findings showed that the cotton fields were 591.44 km^2 (47.77%), roads and settlements 402.34 km^2 (32.50%), and other crops 206.06 km^2 (16.65%) while the follow land was 38.13 km^2 (3.08%). The accuracy assessment is given in Table 3.

Figure 8 shows the supervised classification for Landsat ETM+ image of 15th August, 1999. The findings showed that the cotton fields were 528.38 km^2 (42.68%), roads and settlements 404.55 km^2 (32.68%), and other crops 257.13 km^2 (20.77%) while the follow land was 47.91 km^2 (3.87%). The accuracy assessment is given in Table 3.

Soil compaction negatively affects crop growth characteristics (Lowery and Schuler, 1991; Kulkarni and Bajwa, 2005), yield (Johnson et al., 1990; Kulkarni and Bajwa, 2005), and root development and distribution (Taylor and Gardener, 1963; Unger and Kaspar, 1994; Kulkarni and Bajwa, 2005). However, bare soil reflectance may be affected by the impact of tillage practices and moisture content (Barnes et al., 1996; Kulkarni and Bajwa, 2005). The wavelengths detected as responsive to soil compaction were close to each other, they may had similar information about the vegetation vigor. In the red portion of spectrum the wavelengths ranged from 620 to 700 nm (Thenkabail et al., 2000; Kulkarni and Bajwa, 2005). In this region of visible spectrum, a mixed spectral signature was produced from cotton bolls and the yellow and brownish green leaves. Some exposure of cotton stems as leaves had fallen and more soil exposure caused the mixed signature (Rosenthal and Gerik, 1991; Kulkarni and Bajwa, 2005).

Figure 9 shows the supervised classification for Landsat ETM+ image of 20th August, 2001. The findings showed that the cotton fields were 702.61 km^2 (56.76%), roads and settlements 319.58 km^2 (25.81%), and other crops 175.56 km^2 (14.18%) while the follow land was 40.22 km^2 (3.25%). The accuracy assessment is given in Table 3.

Figure 10 shows the supervised classification for Landsat TM image of 2nd August, 2009. The findings showed that the cotton fields were 494.11 km^2 (39.91%), roads and settlements 509.13 km^2 (41.13%), and other crops 213.58 km^2 (17.25%) while the follow land was 21.15 km^2 (1.71%). The accuracy assessment is given in Table 3.

Figure 11 shows the comparative analysis of the supervised classification for Landsat TM/ETM+ scenes of 20th August, 1998; 15th August, 1999; 20th August, 2001 and 2nd August, 2009 respectively. The findings showed that the area of the cotton fields decreased from 591.44 km^2 (47.77%) on 20th August, 1998 to 494.11 km^2 (39.91%) on 2nd August, 2009 (Table 3).

Remote sensing provides a viable source of data from which updated land-cover information can be extracted efficiently and cheaply in order to invent and monitor these changes effectively (Mas, 1999; Ahmad, 2013a).

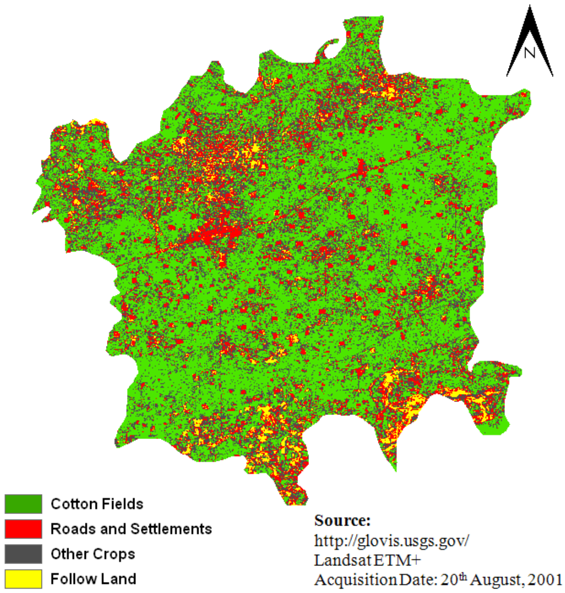

Figure 7 : Supervised Classification 1998, Burewala

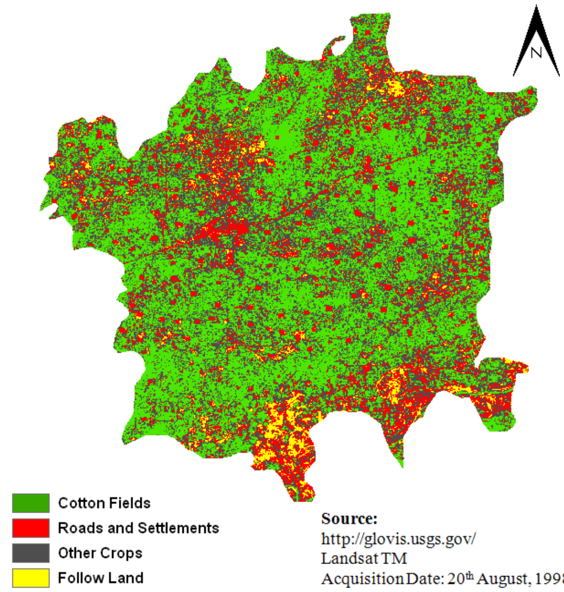

Figure 8 : Supervised Classification 1999, Burewala

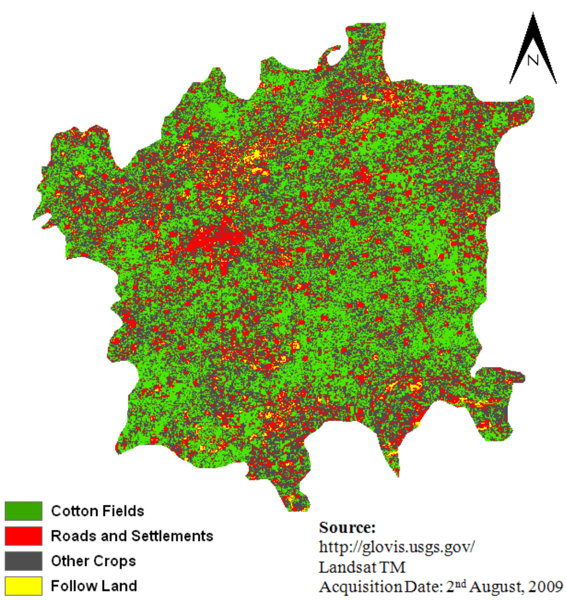

Figure 9 : Supervised Classification 2001, Burewala

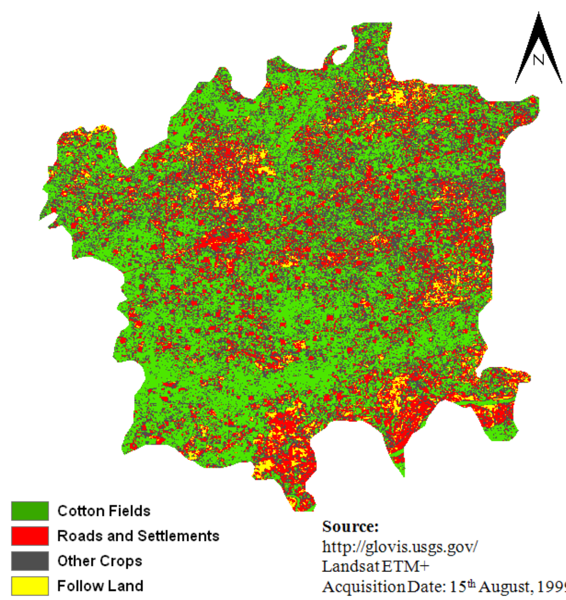

Figure 10 : Supervised Classification 2009, Burewala

Table 3 : Supervised Classification of Landsat TM/ETM+ images

Image Acquisition Date	Classes	Area (km^2)	Area (%)	Accuracy Assessment (%)
20th August, 1998 (Landsat TM)	Cotton Fields	591.44	47.77	86.13
	Roads and Settlements	402.34	32.50	89.62
	Other Crops	206.06	16.65	85.47
	Follow Land	38.13	3.08	88.75
	SUM	1237.97	100	-
15th August, 1999 (Landsat ETM+)	Cotton Fields	528.38	42.68	87.38
	Roads and Settlements	404.55	32.68	92.35
	Other Crops	257.13	20.77	92.15
	Follow Land	47.91	3.87	85.44
	SUM	1237.97	100	-

20th August, 2001 (Landsat ETM+)	Cotton Fields	702.61	56.76	85.47
	Roads and Settlements	319.58	25.81	85.77
	Other Crops	175.56	14.18	85.16
	Follow Land	40.22	3.25	90.15
	SUM	1237.97	100	-
2nd August, 2009 (Landsat TM)	Cotton Fields	494.11	39.91	92.18
	Roads and Settlements	509.13	41.13	89.34
	Other Crops	213.58	17.25	88.32
	Follow Land	21.15	1.71	85.47
	SUM	1237.97	100	-

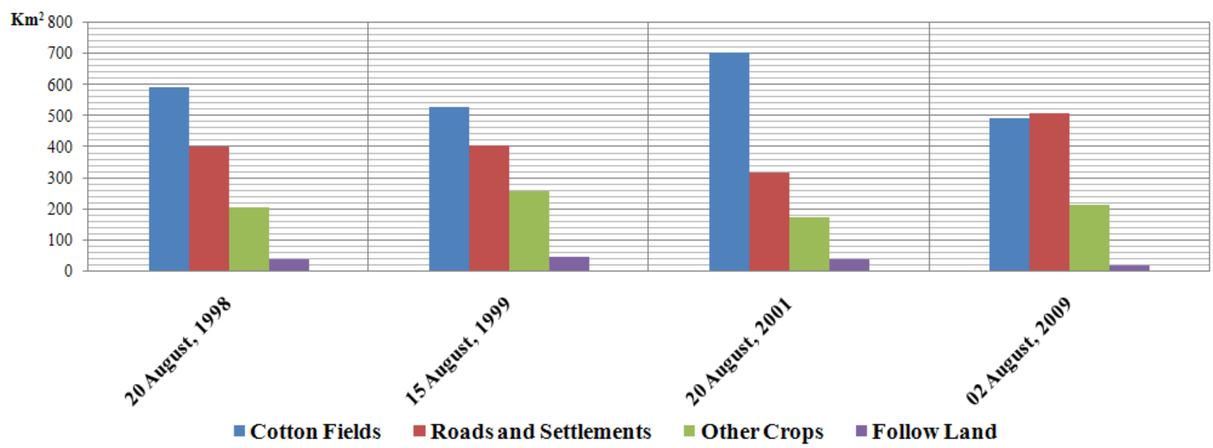

Figure 11 : Comparative Analysis of Supervised Classification of Landsat TM/ETM+ Images

Figure 12 shows NDVI/EVI phenological profile for Chak 44/KB; Figure 13 shows NDVI/EVI phenological profile for Chak 305/EB; Figure 14 shows NDVI/EVI phenological profile for Chak 487/EB and Figure 15 shows NDVI/EVI phenological profile for Chak 529/EB, Burewala, Punjab province, Pakistan. The NDVI/EVI pixel values were used to calculate fractional yield (Shinners and Binversie, 2007) from February 2000 to February 2013. The NDVI pixel values showed theoretical yield and EVI pixel values showed actual yield (Table 4). Further, linear forecast trendline was plotted upon the fractional yield dataset of Chak 44/KB to investigate the general trend during the entire period (Figure 16). The linear forecast trendline showed that fractional yield at Chak 44/KB was decreasing. The tendency of decreasing in the fractional yield from February 2000 to December 2004 was low and the tendency from January 2005 to February 2013 was high.

Vegetation phenology refers to the relationship between climate and periodic development of photosynthetic biomass (Ahl et al., 2006; Ahmad, 2012a). Satellite monitoring of vegetation phenology has often made use of a vegetation index such as NDVI because it is related to the amount of green leaf biomass (Lillesand and Kiefer, 2000; Beurs and Henebry, 2004; Ahl et al., 2006; Ahmad, 2012a). The potential solution to provide more frequent high resolution surface observations is to fuse Landsat observations with data from other remote sensing systems, such as MODIS (Singh, 2012). The MODIS NDVI datasets provides unique opportunities for monitoring terrestrial vegetation conditions at regional and global scales (Yang et al., 1997; Piao et al., 2006; Ahmad, 2012), and has widely been used in research areas of net primary production (Potter et al., 1993; Paruelo et al., 1997; Piao et al., 2006; Ahmad, 2012), vegetation coverage (Tucker et al., 1991; Myneni et al., 1997; Los et al., 2001; Zhou et al., 2001; Piao et al., 2003; Piao et al., 2006; Ahmad, 2012), biomass (Myneni et al., 2001; Dong et al., 2003; Piao et al., 2006), and phenology (Reed et al., 1994; Moulin et al., 1997; Piao et al., 2006; Ahmad, 2012).

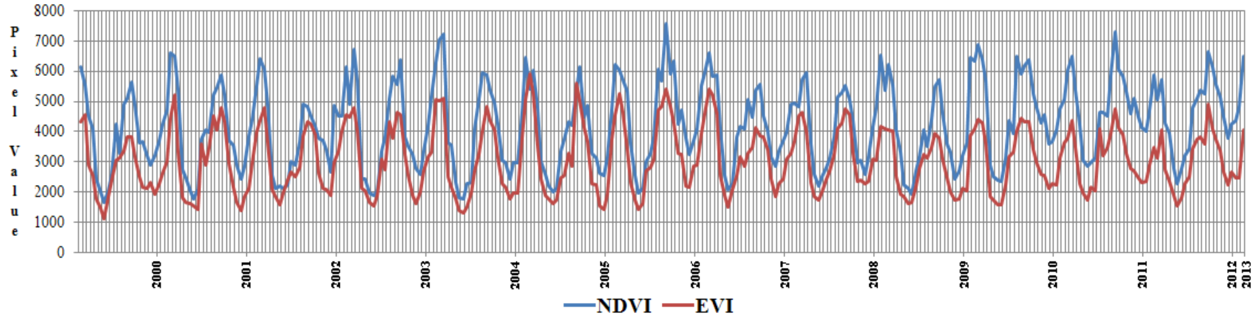

Figure 12 : NDVI/EVI phenological profile for Chak 44/KB *Processed by the author*

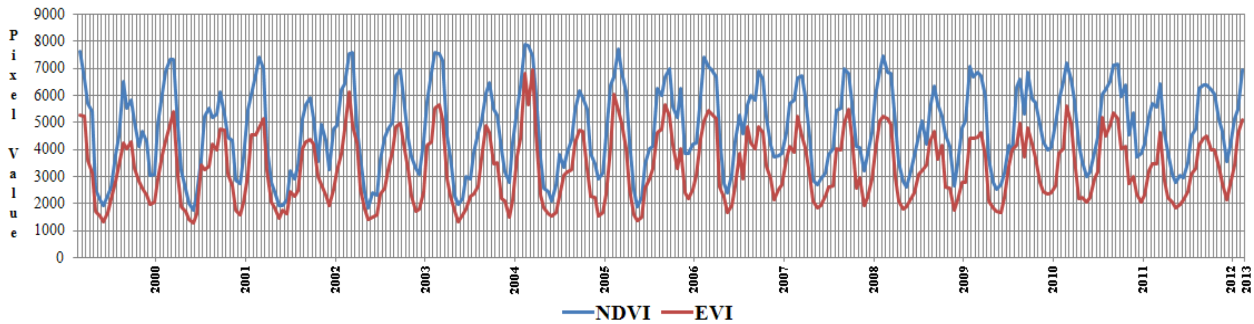

Figure 13 : NDVI/EVI phenological profile for Chak 305/EB *Processed by the author*

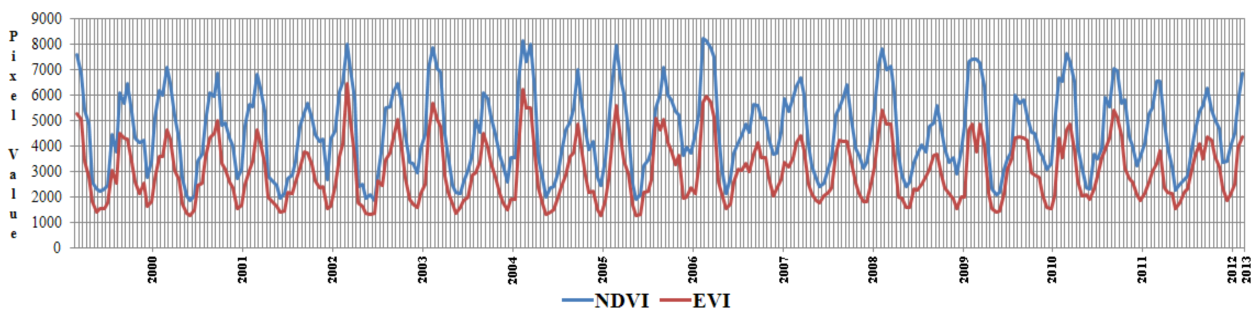

Figure 14 : NDVI/EVI phenological profile for Chak 487/EB *Processed by the author*

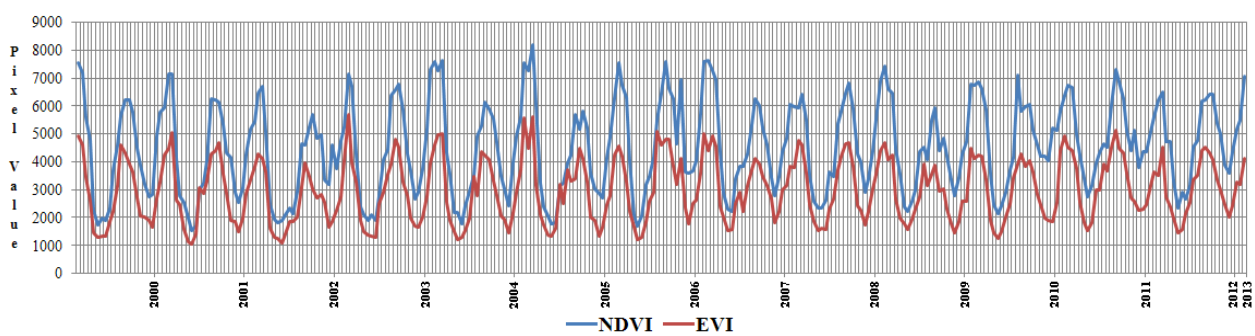

Figure 15 : NDVI/EVI phenological profile for Chak 529/EB *Processed by the author*

Table 4 : MODIS (Terra) EVI/NDVI and Fractional Yield dataset of Chak 44/KB

Image Acquisition (Month/Year)	EVI Pixel Value	NDVI Pixel Value	Fractional Yield (%)	Image Acquisition (Month/Year)	EVI Pixel Value	NDVI Pixel Value	Fractional Yield (%)
Feb. 2000	4320	6127	70.51	Feb. 2007	5409	6605	81.89
May 2000	1108	1664	66.59	May 2007	2055	2288	89.82
Aug. 2000	3826	5102	74.99	Aug. 2007	4122	5381	76.6
Nov. 2000	2104	3222	65.3	Nov. 2007	1845	2858	64.56
Feb. 2001	4419	6595	67.01	Feb. 2008	4498	4819	93.34
May 2001	1520	1771	85.83	May 2008	1987	2501	79.45
Aug. 2001	4051	5442	74.44	Aug. 2008	4733	5528	85.62
Nov. 2001	1647	2898	56.83	Nov. 2008	2267	2602	87.13
Feb. 2002	4360	6397	68.16	Feb. 2009	4049	6222	65.08
May 2002	1958	2110	92.8	May 2009	1665	1923	86.58
Aug. 2002	4305	4834	89.06	Aug. 2009	3923	5463	71.81
Nov. 2002	2076	3414	60.81	Nov. 2009	1709	2434	70.21
Feb. 2003	4447	4902	90.72	Feb. 2010	4404	6864	64.16
May 2003	1537	1879	81.8	May 2010	1559	2345	66.48
Aug. 2003	4623	5571	82.98	Aug. 2010	4327	6165	70.19
Nov. 2003	1615	2783	58.03	Nov. 2010	2554	4549	56.14
Feb. 2004	4986	7037	70.85	Feb. 2011	3778	6040	62.55
May 2004	1294	1795	72.09	May 2011	2164	2983	72.54
Aug. 2004	4820	5857	82.29	Aug. 2011	4740	7275	65.15
Nov. 2004	2148	2983	72.01	Nov. 2011	2679	5094	52.59
Feb. 2005	5892	5400	109.11	Feb. 2012	3102	5055	61.36
May 2005	1598	1994	80.14	May 2012	1785	2768	64.49
Aug. 2005	5599	5380	104.07	Aug. 2012	3564	5251	67.87
Nov. 2005	2242	3144	71.31	Nov. 2012	2639	4480	58.91
Feb. 2006	5230	6031	86.72	Feb. 2013	4059	6476	62.68
May 2006	1607	2145	74.92				
Aug. 2006	5379	7564	71.11				
Nov. 2006	2173	3766	57.7				

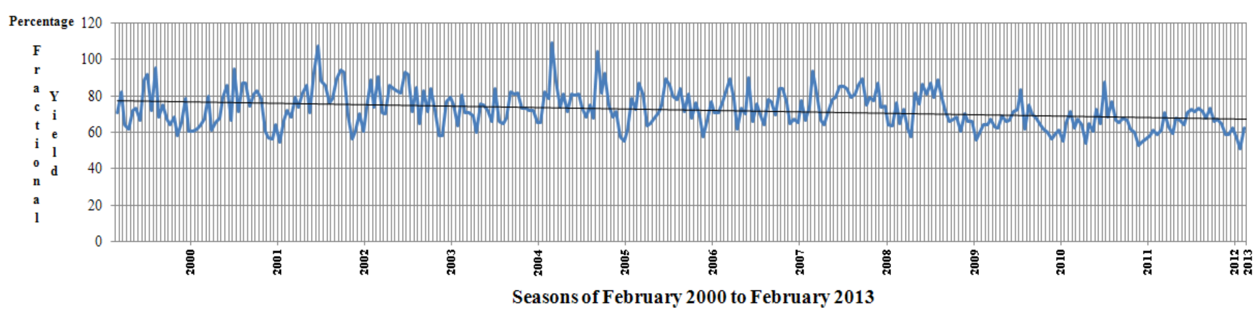

Figure 16 : Linear forecast trendline for the dataset of Chak 44/KB *Processed by the author*

IV. Discussion and Conclusions

As the use of space and computer technology developed, humankind has a great advantage to produce this much important research projects with the help of technology in an easier, more accurate way within less time than of other ways. As a result, all these can have a very effective role in helping the country to increase the amount and the quality of agricultural products (Akkartala et al., 2004; Ahmad, 2012; Ahmad, 2012e). With the continuous development of computer network, space technology and remote sensing, demand on automated, real-time and in-orbit processing become more urgent than ever before for change detection (Mouat et al., 1993; Ahmad, 2012d). To achieve this, the challenges to the technology include the full automation for image registration, image matching, feature extraction, image interpretation, image fusion, data-cleaning, image classification, and data mining and knowledge discovery from GIS database (Liu and Zhou, 2004; Jianya et al., 2008; Ahmad, 2012d). The vegetation indices incorporate a ratio of NIR and red bands, with NDVI being the most frequently used because of its simplicity and robustness. Even so, this index performed relatively poorly for comparison across our multiple year dataset (Baugh and Groeneveld, 2006).

The NDVI exhibits scaling problems, asymptotic signals over high biomass conditions, and is very sensitive to canopy background variations with NDVI values particularly high with darker canopy backgrounds (Vermote and Vermeulen, 1999; Vermote et al., 2002; Ahmad, 2012b).

RS data can be used to evaluate model performance (Kite and Droogers, 2000; Vazifedoust et al., 2009), or to initialize, drive, update or re-calibrate models (Droogers and Bastiaanssen, 2002; Vazifedoust et al., 2009). When the error between model results and data is low, RS-based initialization of models would, in principle, be sufficient to provide spatially distributed information (Vazifedoust et al., 2009).

Roth (2002) studied the effect of water stress and soil compaction on cotton canopy and showed that canopy reflectance is affected by water stress and canopy reflectance changes were greatest at 555 nm in the green band, 670 nm in the red band and 760 nm in the near infrared band (Kulkarni and Bajwa, 2005). The NDVI can more accurately represent the yield when using higher spatial and temporal resolution satellite data (Li et al., 2007) and the pixel-based modeling revealed a general spatial trend of higher cotton yield (Ruecker et al., 2007).

The methodology presented in this research paper has several desirable properties. Since it treats each pixel individually without setting thresholds or empirical constants, the method is globally applicable (Vermote and Vermeulen, 1999; Vermote et al., 2002; Ahmad, 2012c). The overall accuracy of the results exceeded 85%, the level that the US Geological Survey (Anderson et al., 1976; Sader et al., 2001; Ahmad, 2013a) uses as a threshold to define acceptability (Sader et al., 2001; Ahmad, 2013a). This study also identified several data acquisitions and processing issues that warrant further investigation. Studies are under way to assess the importance of coordinating and timing field data collection and image acquisition dates as a means of improving the strength of the relationships between image and land condition trend analysis (Senseman et al., 1996; Ahmad, 2012e) ground-truth data.

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