Determination of Paddy Rice Field Using Landsat 8 Images

Levent Genc[1], Melis Inalpulat[1], Unal Kizil[1] and Sefa Aksu[1]

***Abstract*—** Since rice is one of the important crops not only in Turkey but also in the world, it is vital to determine the paddy rice field as accurately as possible using fast and economical methods such as remote sensing and GIS . Landsat program has provided critical efforts to map the land use land cover in earth surface in different study areas since 1972. As of Spring of 2013 Landsat 8 data with 11 bands has been publicly available free of charge . In this study, Landsat 8 images were used to determine the paddy field in order to evaluate the rice production in 2013 in town of Biga, Çanakkale TURKEY. In order to determine the paddy field, land use land cover maps of Biga town was generated using Landsat data in six classes. Those were paddy field, Grassland, Forest, Water, Agriculture, and Residential areas. Remote sensing data is a useful tool for determination of the spatial distribution of the land cover and land use when appropriate image processing techniques were used. In this study, in order to obtain higher classification accuracy, two approaches were tested. Firstly, six band (band 2, 3, 4, 5, 6 and 7) images taken on May 18, June 19, July 21 and September 7 of 2013 was classified individually after radiometric correction applied. Then, image processing techniques such as Normalized Different Vegetation Index (NDVI), generated from original images and combined, Principle Component Analysis (PCA) and band combination techniques were used to create new images. These images were classified individually to calculate overall classification accuracy. The highest overall classification accuracy was obtained from 7 band PCA images which were transformed from 28 band images (%89). The lowest overall classification accuracy was obtained from four date combined NDVI images (%79)

***Keywords*—**Paddy rice field, Canakkale Biga, Landsat 8, Principal Component analysis, NDVI

I. Introduction

RICE is one of the world's major foods and paddy rice fields account for approximately 15% of the world's arable land [1]. Since paddy fields are irrigated almost all season, it is easy to classify comparing to upland fields and forests [2]. Many studies have proved that images such as Landsat and NOAA Advanced Very High Resolution Radiometer (AVHRR) has potential to identify paddy rice fields [3], [4], [5].

After Landsat 8 became available with no charge for civilian, many researchers started to use this data in different applications. Landsat 8 with improved spectral bands provided new opportunities for researchers to test old studies.

The main objective of this research is to develop a method that permits an increase in land cover classification accuracy (LCCA) using Landsat 8 data particularly in paddy rice field mapping. In order to reach the objective four Landsat 8 images from different dates were used with different image processing techniques in town of Biga, Çanakkale , TURKEY.

II. Materials And Methods

A. Study Area

Study was conducted in Biga, which is a town and district of Çanakkale Province in the Marmara region of Turkey (Fig. 1). It is located by the Biga River, 90 kilometers northeast from Çanakkale city. The district covers an area of 1354 km^2 and the town lies at an elevation of 21 m above sea level. The center coordinates of the study area are 40°13'22" N - 27°14'34" E.

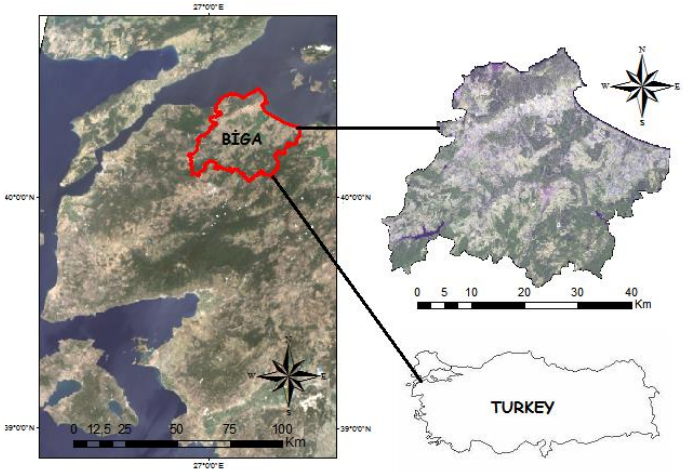

Fig. 1 Location of study area

B. Data and Image Processing

The determination of datasets for classification accuracy improvement was divided into four major stages [11] . The first stage in image processing was geometric correction.

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Once the raw data had been properly geo-referenced to real world coordinates, additional products created through processing could inherit the spatial context of the unprocessed data [6], [7]. In the second stage, after the Landsat 8 images have been properly corrected, it was possible to begin manipulating the images to produce information to obtain more interpretable images for the test site from the raw images such as components and indexes, [6], [7], [8], [10]. After transformations, PCA, NDVI and band manipulations were used to create new datasets. All datasets for the test site including original raw images were used to determine Land use land cover maps.

The third stage was the determination of land cover classes for the test Landsat 8 data with help of Google earth and field trips. For this purpose also, unsupervised classification was performed to determine the initial land cover pattern. The fourth stage was the processing of actual classification using supervised method [6], [7], [8], [10]. Training data were selected and accuracy assessment was performed according to Congalton and Green [12].

In order to extract the paddy rice field, four Landsat 8 images were used to determine the land use and land cover maps of town of Biga, Çanakkale Turkey. Data used in this study is described in Table I. Landsat 8 data were downloaded from USGS web pages with no charge for four different days: May 18, June 19, July 21 and September 07, 2013 with less than %5 clouds. Tiff format data were converted to img format when individual layer stack process applied. In order to test the band 1 capability, we created 6 and 7 band images that were used to generate the 24 and 28 bands images. The PCA was used in remote sensing for different purposes. Mathematical derivation of PCA and its application have been demonstrated by many researchers [6], [7], [8], [9]. The PCA has been used to correlate Landsat (TM) imagery to predict land cover change [10]. After 24 band data generated, 6 band PCA image was created. Similarly, 28 band data was used to obtain 7 band PCA image (Fig. 2).

Original 6 band images were used to calculate the NDVI images for each date (NDVI of May 18, June 19, July 21 and September 07) using band 4 (red) and 5 (NIR). Each NDVI images were combined and created new 4 band NDVI images that will used to generate NDVI 4 band classified map.

For this study, we also combined NIR, SWIR 1 and SWIR 2 bands to created new 12 band images. In order to see how band 1 affect the classification accuracy we combined the band 1, 5, 6, 7 and created new 16 band images (Fig. 2).

During the growth season, ground data were collected using GPS and camera from town of Biga for classification purposes. Approximately 25 ground signatures were collected from the field for classification.

TABLE I
LANDSAT DATA DESCRIPTIONS

Bands	Name	Wavelength (µm)	Resolution (m)
BAND 1	Coastal aerosol	0.43 - 0.45	30
BAND 2	Blue	0.45 - 0.51	30
BAND 3	Green	0.53 - 0.59	30
BAND 4	Red	0.64 - 0.67	30
BAND 5	Near Infrared (NIR)	0.85 - 0.88	30
BAND6	SWIR 1	1.57 - 1.65	30
BAND 7	SWIR 2	2.11 - 2.29	30
BAND 8	Panchromatic	0.50 - 0.68	15
BAND 9	Cirrus	1.36 - 1.38	30
BAND 10	Thermal Infrared (TIRS) 1	10.60 - 11.19	100
BAND 11	Thermal Infrared (TIRS) 2	11.50 - 12.51	100

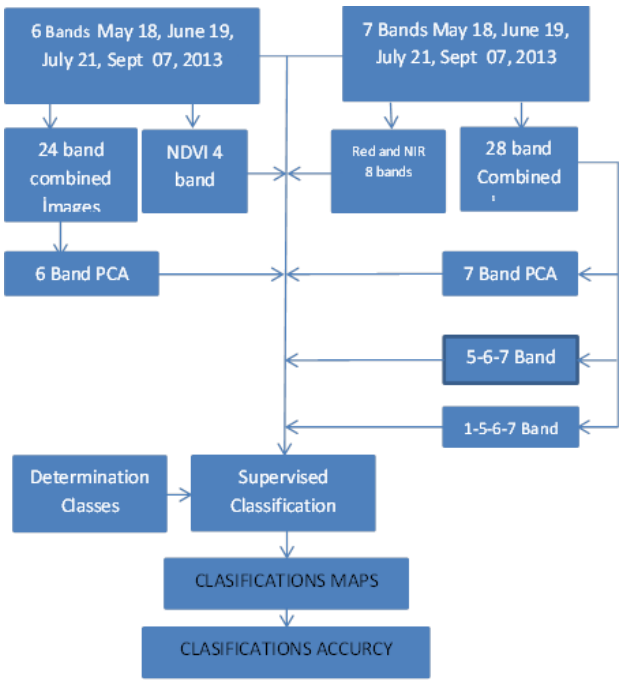

Fig. 2 Image processing algorithm

C. Classification and Accuracy Assessment

In order to obtain better results from classification, there were three main patterns that can be used. Those are spatial, temporal and spectral recognition approaches. Spectral pattern refers to the family of classification procedures that utilize this pixel-by-pixel spectral information as the basis for automated land cover classification. Spatial pattern recognition involves the characterization of image pixels on the basis of their spatial relationship with pixels surrounding them. Spatial pattern might consider such aspects as image texture, feature size, shape, directionality, and context. Temporal pattern recognitions utilize time to help in feature identification [6], [7].

Initially unsupervised classification method was used to determine certain number of classes in Biga boundary. After determining the class number, supervised classification with maximum likelihood analysis applied to all original and created images. Supervised classification is well known as controlled classification. Researchers supervise the pixel categorization process by using a combination of fieldwork, analysis of high resolution images, photography and maps, and expert knowledge [6].

When researchers use remotely sensed data for classification, an accuracy assessment must take place to determine the quality of the classification [12]. In this research, classification accuracy was assessed according to Congalton and Green [12] for all ten datasets.

III. Results and Discussion

All 9 datasets from Landsat 8 were classified using supervised classification (Figure 3-12 through Figure 3-6) and used to assess the accuracy for the test site (Table II). The idea here is to determine the dataset that produced the best overall and user accuracies for land cover classification and use this dataset to perform the classification to produce paddy rice field as accurately as possible.

After accuracy assessment was performed for every dataset, it was found that when the 1-5-6-7 band 16 band image was the best for discriminating the 6 classes based on the overall accuracy (87.89%) (Table II). It was also found that paddy rice field area of 16886 ha from land use land cover map of 1-5-6-7 images (Fig 3; Table III). Second highest classification accuracy obtained from PCA 6 band data (87.50%). Paddy rice field from this image also found to be 14973 ha (fig 4 Table III).

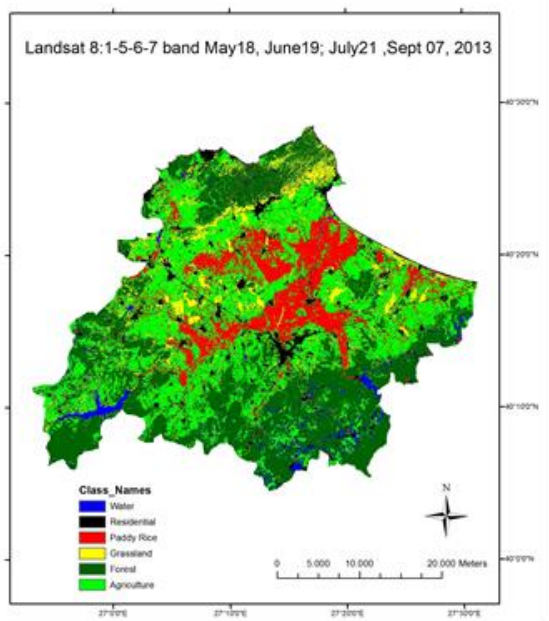

Fig 3. Band 1-5-6-7 from May 18, June 19, July 21 and September 07 2013

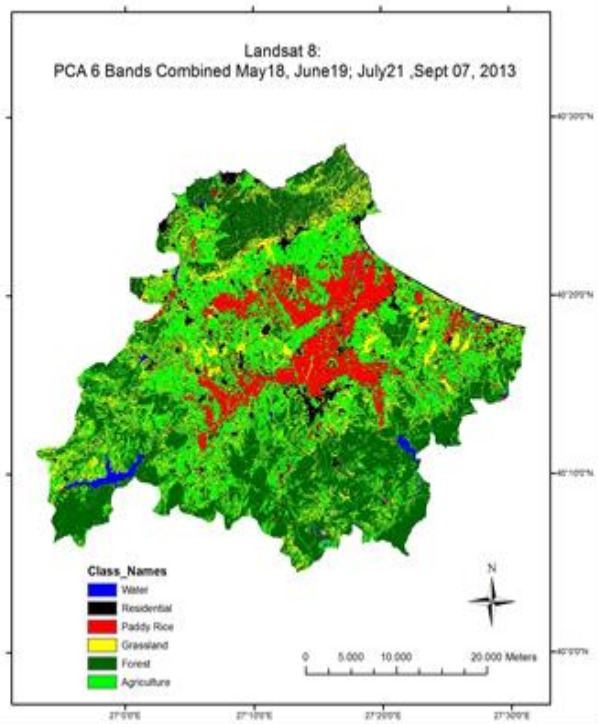

Fig 4. PCA6 band from May 18, June 19, July 21 and September 07- 2013

The lowest overall classification accuracy was obtained from 4 band NDVI images (79.69%) (Table II cont.). Paddy rice area from this image calculated as 18478 ha (Fig. 5 Table III cont.)

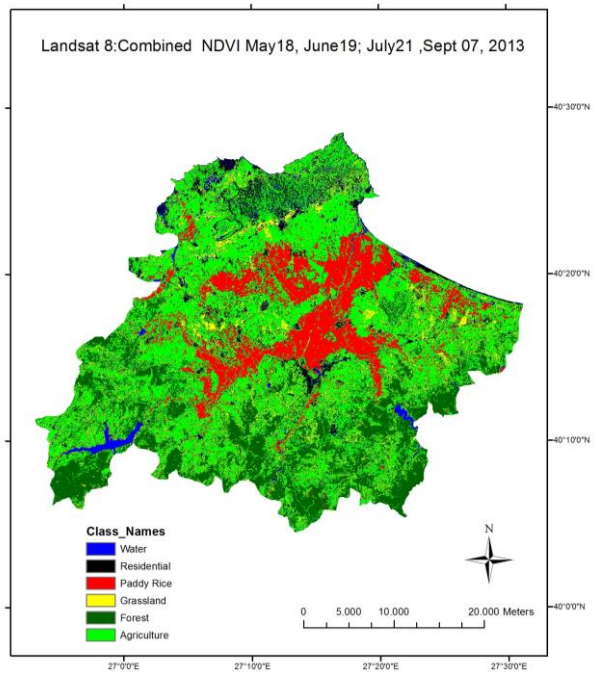

Fig 5. NDVI 4 band images generated from May 18, June 19, July 21 and September 07- 2013

TABLE II
CLASSIFICATION ACCURACY

	May 18	June 19	July 21	Sept 07	NDVI 4 band
Paddy Rice	75.76	73.53	68.57	76.47	76.32
Grassland	78.95	75.00	86.11	81.40	68.97
Forest	84.38	80.60	82.81	80.00	74.14
Water	100.00	90.00	100.00	95.00	100.00
Agriculture	85.51	90.28	86.49	86.76	86.36
Residential	90.63	77.78	77.78	84.62	69.57
overall	84.77	82.03	83.20	83.20	79.69
kappa	81.20	77.59	78.94	79.16	72.22

TABLE II cont.
CLASSIFICATION ACCURACY

	PCA6	1567	PCA 7	567
Paddy Rice	85.71	80.56	80.65	81.82
Grassland	85.00	86.67	79.41	77.42
Forest	85.51	90.00	87.14	83.82
Water	95.00	85.00	85	100
Agriculture	92.06	88.73	90.67	87.01
Residential	82.76	93.10	84.62	85.19
overall	87.50	87.89	85.94	85.16
kappa	84.50	84.79	82.19	81.3

TABLE III
LAND COVER LAND USE AREAS (ha)

	May.18	June 19	July21	Sept 07
Paddy Rice	13954.7	14916	15523.1	22114.9
Grassland	17853.8	15879.1	16213.9	41717.9
Forest	40888.1	42858.1	41721.8	1577.34
Water	1961.64	2420.55	1110.78	45602
Agriculture	45244.4	48020.8	50986.3	7086.06
Residential	12940.1	8748.36	7287.39	8073.99

TABLE III cont.
LAND COVER LAND USE AREAS (ha)

	PCA6	1567	PCA7	567	NDVI 4
Paddy Rice	14973.9	16886.3	11823.1	13433.9	18478.7
Grassland	19321	11445.9	14960.7	11322.7	11406.7
Forest	45824.1	44551.4	45078.4	45415.1	34590.6
Water	2016.81	3392.01	3174.66	1330.83	4192.47
Agriculture	40615	45358.4	49364.7	53266	57823.4
Residential	10093.7	11208.8	8440.92	8073.99	6352.02

IV. CONCLUSION

All images from Landsat TM datasets were analyzed with different image enhancement techniques. It was found that PCA and band combination of 567 bands and 1567 bands have higher overall operation accuracy than others. It was also noticed that paddy rice areas were determined by PCA7 images with a better accuracy. According to the agriculture state office information paddy rice are was 11350 ha. In this study PCA7 band determined the paddy rice field as 11823.1 ha. It was concluded that image processing techniques such as PCA, and band combination have potential to obtain higher overall classification accuracies.

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