THE USE OF RADARSAT AND LANDSAT IMAGE FUSION ALGORITHMS AND DIFFERENT SUPERVISED CLASSIFICATION METHODS TO IMPROVE LANDUSE MAP ACCURACY – CASE STUDY : SARI PLAIN – IRAN

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ABSTRACT:

Improving land use/cover map accuracy through different algorithms and techniques is a challenging task for the satellite image analysts. Image fusion algorithms are the most promising methods in land use land cover mapping using remotely sensing data. In this research an attempt has been made to evaluate and test image fusion techniques applied to Radarsat and Landsat TM images towards land use land cover mapping for Sari plain of Caspian Sea coast in northern part of Iran. After careful and necessary corrections and registration of all image data to the existing topographic maps, Radarsat and Landsat TM images were fused with different image fusion algorithms including principal component analysis (PCA), Brovey and Multiplicative algorithms. .Radarsat image and fused images were classified using different supervised classification schemes including Mahalanobis distance, maximum likelihood and minimum distance to mean classifiers. Due to the presence of clouds in Landsat image, this image was not classified. Error matrixes were used to study the accuracy of each classification results.
In total, map accuracies resulted from classification of Radarsat image were less than the results of classification of fused images. However, it is observed that a particular classification algorithm for Radarsat image had a good accuracy for mapping a certain land use land cover. With the comparison of accuracies of map resulted from different fused images, it is observed that   brovey algorithm had the highest accuracy among other algorithms. This might be due to the cloud eliminating effect of this technique in producing fused image. Results of this research also show that Mahalanobis algorithm for image classification in Radarsat and Landsat fused images has more accuracy than other supervised algorithms. Finally it is recommended to use a specific classification algorithm for mapping different land use land cover categories.

1- Introduction :

Earth observation systems have an important role to play in facilitating sustainable development at both global level as well as local levels. However, satellite and airborne remote sensing have been provided a wide range of data and information for almost past four decades. Aerial photographs, thermal infrared images, radar images, Landsat MSS and TM images, IRS LISS I/LISS II images, etc. are among the widely used airborne and satellite remote sensing data. Their high spectral, spatial and temporal resolution made them to be a useful input for mapping and planning projects. As far as cost and accuracy are concerned, they can be used to monitor and map different phenomena on the earth surface effectively.
Landuse map is very important in many studies and projects such as agriculture , civil engineering (road planning , urban planning ,…) , natural resource , watershed management and etc .
Land is a raw material of a site, which is defined in terms of a number of natural characteristics, namely, climate, geology, soil, topography, hydrology and biology (Aldrich, 1981). On the other hand, in remote sensing terminology, the land use is defined as human's activities on and in relation to the land, which are usually not directly visible from the imagery. Another important term in this context is land cover which describes the vegetational and artificial constructions covering the land surface (Burley, 1961). As the success of land use/land cover mapping is depended on the selecting an appropriate classification schemes, a number of schemes have been developed and adopted to describe the different land use /land cover categories in the interpretation of satellite/airborne images. Of the most important ones is the Anderson land use land cover classification system (Anderson et al. 1976). He defined a coarse level of mapping- level I and level II. Both are applicable to small scale satellite imagery. In India based on different satellite remote sensing data a number of land use/land cover classification systems have been developed.

Strahler (1980) used a prior probabilities in maximum likelihood classification. In this work, the improvement of classification accuracy from 58 per cent to 71 per cent has been reported. Pohl and Genderen (1998) have given a general definition of image fusion as "the combination of two or more different images to form a new image by using a certain algorithm. According to Wald, (1998) data fusion is a formal framework in which are expressed means and tools for the alliance of data originating from different sources, in order to obtain information of grater quality". Mohammed Shokr (2002) showed how ice surface temperature (derived from infrared sensors), microwave brightness temperature (observed from microwave radiometer) and radar imagery (from RADARSAT) can be combined to improve retrieval of ice types and thickness. Supapis Polngam 2001, used Radar and optical image fusion to coastal land cover mapping studies. Vastanha Kumaran 2001, used IRS and Radarsat image fusion for landuse mapping in India. Paola Almeida 2003 discussed the application of fusion techniques between Radarsat and Landsat images for landuse distribution at Cartagena, Colombia, using supervised classification.

In this research an attempt has been made to evaluate and test image fusion techniques applied to Radarsat and Landsat TM images towards land use land cover mapping for Sari plain of Caspian Sea coast in northern part of Iran.

2- Main body:

2.1- Study area

The study area, Sari Plain, situated in the northern part of Iran . Golestan province is in the Eastern boundary and Qaemshahr city is in the west of this area. Mazandaran forest, in the southern part and the Bay of Gorgan in the eastern part are the main features of the study area. An Average annual precipitation of 1104 mm and a minimum and maximum temperature of 5 ˚C and 20˚C made this part of Iran to be more humid than other part. The amount of moisture in this area is reported to be about 7.5 to 10 gr (Alijani 1997). The geographic location of this area is extended from 52d53'11.9249"E to 54d06'35.6832"E and 35d56'27.4614"N to 36d55'27.7861"N.

It is worth mentioning that in Sari plain, the sky is cloudy for almost 200 days of a year. This condition makes vital limitations for study of this area with optical remote sensing.

2.2- Data used

Following are the data used in this study:

1-C-band Radarsat, with spatial resolution of 12.5 meters and radiometric resolution of 16 bits (rice growing season) with HH polarization acquired on 22 June 1998 (figure 1a).

2-Landsat TM data acquired on 12 June 1998 (rice growing season) with spatial resolution of 30 meters (figure 1b).

3-1:50,000 Topographic sheets produced in 1955.
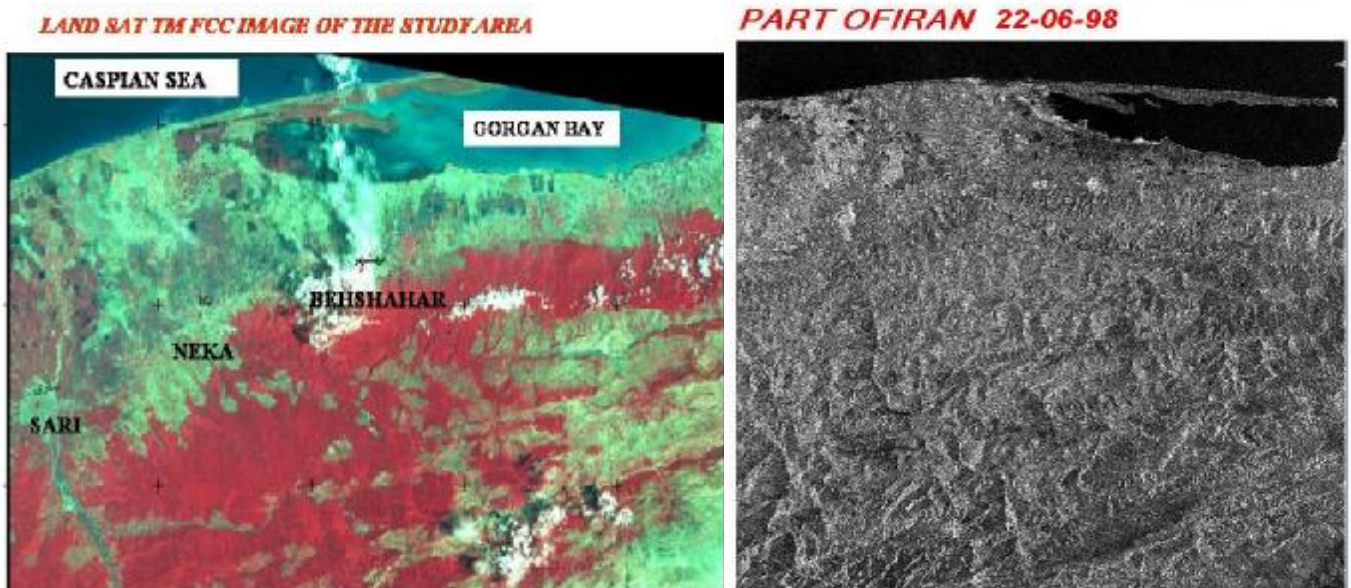
4-1:100,000 land use land cover map prepared in 1995.

Fig 1: a) Landsat TM image and b) Radarsat

2.3- Methodology
Following :

2.3.1- Data collection, input and corrections

 PCI Geomatica version 8.1, Erdas imagine version 8.6 and Arc/View GIS version 3.2a are softwares that used to read, rectify and analyze satellite and ancillary data. Radarsat image was imported to PCI Geomatica software with CDSAR module of this software and backscatter image was generated with SARSIG module of this software. Radarsat backscatter image and Landsat image registered using topographic maps and then exported to Erdas imagine software. Other stages of this research was performed in Erdas imagine software.

2.3.2- Classification of single image data set

An early examination of available data sets showed that due to the presence of clouds in landsat data it was not possible to use classification algorithms for land use land cover mapping purposes.   To evaluate accuracy of different supervised classification algorithms, on the available data sets, Radarsat and fused image of Radarsat and landsat were used.

2.3.2.1- Radarsat image classification

In this case, training areas were extracted from available landuse map. Then Radarsat image was classified with different classification algorithms (i.e. maximum likelihood classifier, Mahalanobis and minimum distance to mean classifier. Table1 shows classification error matrix for different classifiers.

Table 1: Error matrix for different classification of Radarsat Image.

	maximum likelihood classifier (MLC) %	Mahalanobis %	Minimum distance to mean %
Paddy rice	53.6	27.2	34.66
forest	6.10	21.83	21.44

As it is clear from table 1 the MLC algorithm has a higher accuracy for rice mapping but Mahalanobis distance has a higher accuracy for forest mapping in comparison with other algorithms. Also the MLC algorithm has better mean accuracy for all land use land cover. Table 2 shows the classification Error matrix for MLC algorithm.

Table 2: Error matrix for classification of Radarsat image with MLC algorithm

| Land use/ land cover	Rangeland	Agriculture	Forest	Rice	Water	Residential
Residential	2.92	0.50	2.64	8.27	0.01	30.19
Water	19.40	23.88	8.78	0.95	93.85	1.87
Rice	12.69	10.87	24.55	53.06	0.44	34.06
Forest	5.00	4.19	6.10	7.30	0.13	4.77
Agriculture	33.40	28.93	22.70	6.24	3.78	8.73
Rangeland	0	0	0	0	0	0

2.3.2.2- Radarsat and landsat image fusion

In this stage Radarsat and Landsat image of the study area were fused with different image fusion algorithms including PCA, Brovey and Multiplicative. First in PCA algorithm, , principal component of optical image data set were generated and then Radarsat image replaced with the first component (PC1) and inverse PCA function (IPCA) was

implemented. The resultant image is shown in figure2. In Multiplicative algorithm, Radarsat image multiplied to Landsat image (figure3) and in Brovey algorithm, the following fuction was run to produce fused image (figure4).

$$[DNB1 / DNB1 + DNB2 + \ldots + DNBn] \times [DNhigh\ res.\ image] = DNB1\_new$$
$$[DNB2 / DNB1 + DNB2 + \ldots + DNBn] \times [DNhigh\ res.\ image] = DNB2\_new$$

Where n is the number of bands (Erdas Imagine manual).

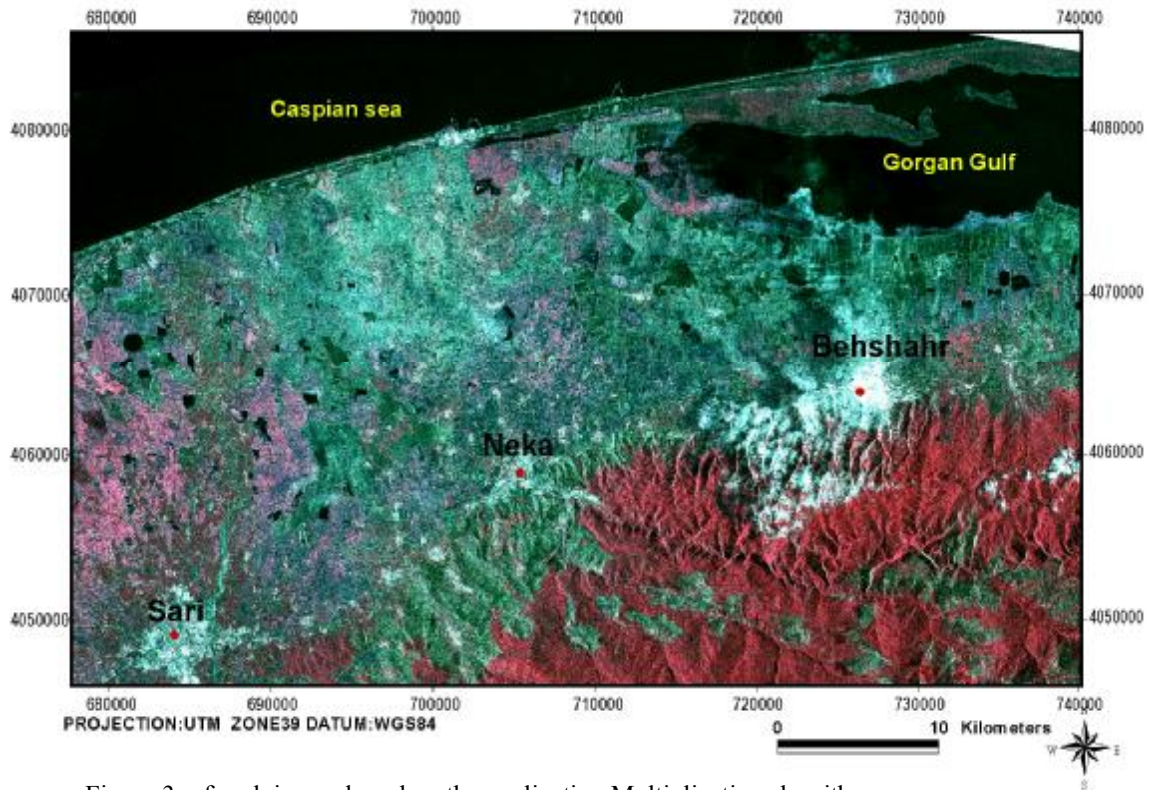Figure 2 : fused image based on the application PCA algorithm
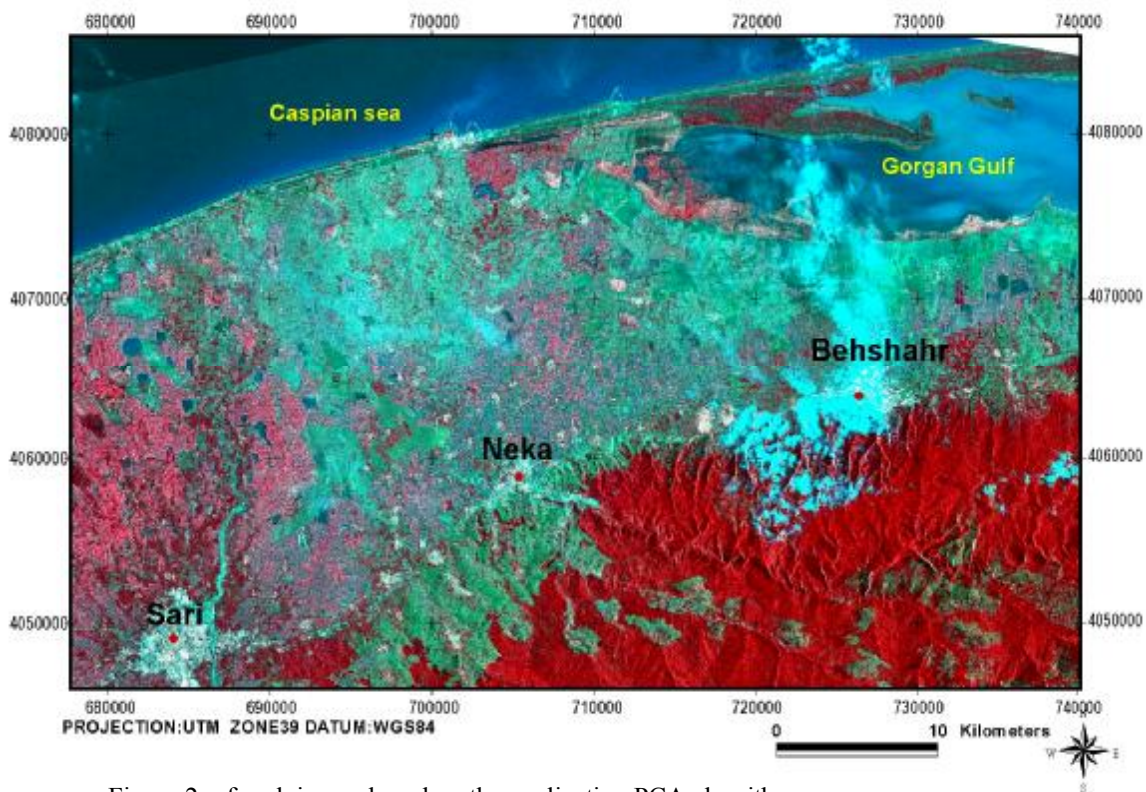
Figure 3 : fused image based on the application Multiplicative algorithm
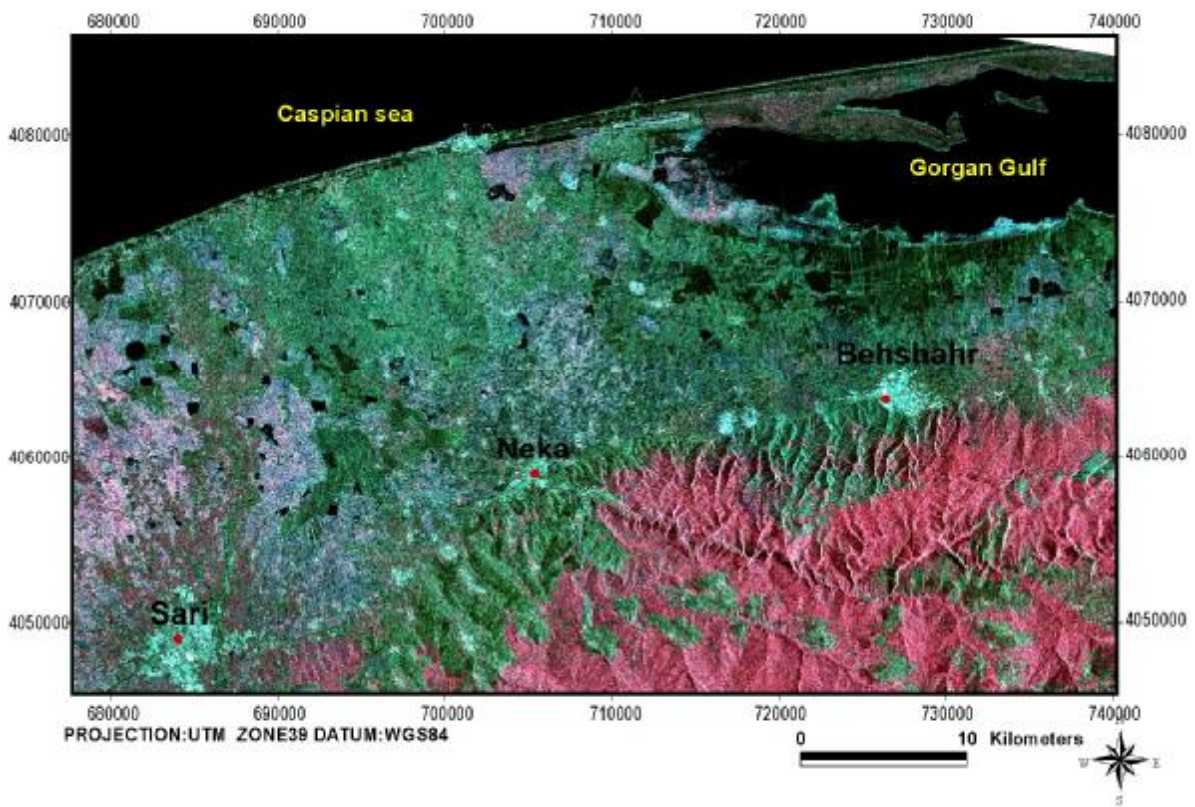

Figure 4 : fused image based on the application Brovey algorithm

2.3.2.3 - Image classification of fused image with Brovey algorithm

In this stage, same training sites which were used in Radarsat image classification were used for fused image classification. Classification performed with MLC, Mahalanobis distance and Minimum distance from mean algorithms. Comparison of the fused image shown that Brovey algorithm has more accuracy than other algorithms because this algorithm eliminated cloud cover areas and it has more accuracy than other algorithms (PCA and Multiplicative) for image classification.

Table 3 shows the classification error matrix of Mahalanobis distance algorithm. for fused images has more accuracy than other algorithms.

Table3- Error matrix for classification of Brovey fused image with Mahalanobis distance algorithm

Land use/ land cover	Rangeland	Agriculture	Forest	Rice	Water	Residential
Residential	5.74	43.83	0.62	2.78	12.32	84.15
Water	0	0.06	0	0.03	75.1	0
Rice	0.21	2.62	0.25	87.41	9.74	0.47
Forest	6.36	0.45	83.47	0.12	0	0
Agriculture	4.25	34.3	0.02	0.37	1.70	11.17
Rangeland	81.21	16.52	0.02	0.37	1.7	2.79

With a quick look at table2 and table3 it is clear that the classification accuracy is increased after the implementation of image fusion algorithms to the image data sets. As an example, the classification accuracy of residual area using Radarsat image classification is 30.19 percent whereas it is 84.15 percent in the classification of fused image with Brovey algorithm .

3- Results and discussions

This research was aimed to demonstrate microwave and optical fused image capabilities in increasing land use land cover mapping process. In this context, following remarks could be mentioned.

1- To map the areas that are most often cloudy in the year, optical remote sensing is handicap. So, the radar image could be of use to map land use land cover for such areas.

2- Due to the fact that vegetation cover are not clear on radar images, the use of Radarsat images alone aren't suggested for supervised classification.

3- Radarsat image fusion with optical data through Brovey algorithm has both advantages of microwave and optical images. Cloudy areas were eliminated from optical data and land use land cover specially vegetation cover were accurately classified.

4- It is observed that a particular classification algorithm for Radarsat image had a good accuracy for mapping a certain land use land cover. With the comparison of accuracies of map resulted from different fused images, it is observed that brovey algorithm had the highest accuracy among other algorithms. This might be due to the cloud eliminating effect of this technique in producing fused image. Results of this research also show that Mahalanobis algorithm for image classification in Radarsat and Landsat fused images has more accuracy than other supervised algorithms. Finally it is recommended to use a specific classification algorithm for mapping different land use land cover categories.

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