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OBJECT AND PIXEL BASED LANDUSE LANDCOVER MAPPING AND COMPARISON, BASED ON MEDIUM AND HIGH RESOLUTION SATELLITE IMAGERY A CASE STUDY OF DEH AKRO-II AND CHOTIARI WETLAND COMPLEX, SINDH, PAKISTAN.

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Abstract: Climate change and anthropogenic activities badly affects the wetlands worldwide. Mapping of such changes set base of the recovery planning. This study aims to make a comparison between object based and pixel based techniques applied on medium, high and very high resolution images of Landsat 5 TM, Sentinel 2A and Planet Scope, respectively for developing Land Use and Land Cover (LULC) as they prove to be really effective in mapping and monitoring of wetland. LULC of two most badly effected wetlands complexes of Sindh, Pakistan, namely Deh Akro-II wetland complex and Chotiari wetland complex, have been developed and analyzed for changes over 30 years. For object based classification decision rule was applied on Landsat- 5 image of year 1990 and Sentinel 2A image for year 2020. However, supervised and unsupervised classification, Maximum likelihood and ISO cluster techniques have been used on very high spectral resolution imagery of Planet Scope. After classifications, accuracy assessment was performed by using random sampling technique. High accuracy of overall and kappa coefficient values shows that LULC classes were successfully developed by both pixels based and object based classification. Supreme level of kappa accuracy with 92.34% has been achieved when object based classification was performed on sentinel 2 image of Chotiari wetland complex, with overall accuracy of 94.22%. Whereas, maximum likelihood classification also resulted with very accurate results with over all accuracy of 96.40% and its Kappa coefficient is 93.49% for Deh Akro-I Wetland complex. Results revealed that major changes have been observed in water bodies and agriculture classes of both areas as water level of Deh Akro-II wetlands has been severely declined by 9.12 km2, while agriculture has been surprisingly increased up to
191.93 km2 in 30 years' time span. Contrary, water level of Chotiari wetland complex has been shockingly increased up to 82.69 km2 after the construction of reservoir in 2003. Results also illustrated that rest of the land covers of Chotiari wetland complex has been greatly overwhelmed

by upsurge of water level. This study revealed that remote sensing techniques are very effective for improved monitoring and mapping of wetlands and for betterment of wetlands health and flora and wildlife depends upon them.

Keywords: Object based classification; Pixel based classification; PlanetScope; Satellite imagery; Multiresolution; Wetlands

1. Introduction

Land use/land cover (LULC) is the result of human kind using natural resources according to their needs and requirements. Henceforth, data on LULC is fundamental for the determination, arranging and execution of land utilizing and can be applied to satisfy the essential necessities and for living. LULC is likewise useful in computing the elements of land cover alteration coming about out from the effects of intensification of population, exploitation of natural resources and disastrous effects of climate change on some delicate ecosystems like wetlands. Differences caused by LULC have an intense effect on earth and the environment [1,2]. On the other side, wetlands are undoubtedly useful ecosystem, existed on earth. They are characterized as regions that are transition among earthbound and marine environments; where the water-level is ordinarily on or close to the land [3]. They provide many critical and important functions like flood water storage, ground water recharge, protection of sea shore from erosion and habitat for both flora and fauna of several kinds and species. They are also of great importance for the economic growth of human as population living around them largely depends on wetlands for their livelihood [4,5,6, 7].

Environmental change and anthropogenic activities have cause excessive pressure on wetland's assets and they are responsible for worldwide disappearances of these valuable ecosystems. Therefore, more practical and versatile protection management systems are required for a superior comprehension of wetland environment properties and temporal variation [8, 9].

Even with all this advancement in technology it's not an easy task to monitor and analyze the wetland ecosystems and their ever changing dynamics. In this regard Remote Sensing (RS) proved to be pretty helpful, as it provides data from space vehicles, airborne instruments and even ground stations. Remote sensing gives the advantages of catching wide-ranging study regions at a similar condition of plant floristic or immersion, and moreover its spectral devices have the ability to distinct the difference in wetland surface settings. [10, 11]. Different water extraction methods have been developed including indices like Normalized Difference Water Index (NDWI) and classification methods like Pixel based and Object Based Image Analysis (OBIA) [12}. Pixel based techniques are widely used in LULC mapping in studies [03,06,13-16]. Not just pixels' spectral reflectance, "Object Orianted Image Analysis" (OBIA) also considered the size, shape and texture of the objects [17-20]. OBIA has been used by decades but by 1995 its use regarding wetland mapping has been drastically increased, studies like [20-27] used different medium and high resolution satellite images like Landsat 8 OLI, Landsat 7 ETM+, Landsat 5 TM, SPOT, Sentinel 2 and Quick Bird for object image analysis for the LULC mapping of wetlands and other land covers. A study has been conducted [28] to foster the GIS based LULC wetlands mapping inventory for the lower Sindh province in Pakistan by using Landsat TM and ETM informational index as a

result of high spectral resolution, concise coverage and minimal expense. Ahmed and Irum [29] led their examination on the rule based methodology of 'ENVI' to introduced the inferred change encounter inventory data for Kallar Kahar Wetland utilizing Quick bird and Corona images.
Present study aimed at making a comparison between object/rule based and pixel based classification, for two wetland complexes of Chotiari and Deh Akro-II in order to accurately identify and assess the LULC changes of different land cover over a time span of 30 years (1990 to 2020).

2. Materials and Methods

2.1. Study area

This study has been carried out on the regions: i) Deh Akro-II Wetland Complex, ii) Chotiari Wetland Complex/Reservoir. Both sites are part of Nara Canal Wetland Complex, Sindh Province, Pakistan (Fig 1). Deh Akro-II wetland complex consist of 36 lakes, located on a distance of 60km, north-west of city of Nawab Shah. These lakes are located in the middle of Nara desert and came into existence due to the seepage from Jamrao Canal and are also rain fed. The boundaries of wet lands are generally concealed with water-reed and other kinds of grasses. Deh Akro-II wetland complex has the characteristics of habitat of agriculture, wetlands, desert and marshes at the same time. The whole complex spreads over an area of 205 km2 and recognized as wildlife sanctuary as it hosts variety of wildlife including endangered species like Marsh crocodile crocodylus palustris, Hog deer, white-eyed pochard etc. Geomorphology of the area is composed of sand dunes, with east-west alignment and height of 5-10 meters as a result classic flat bottomed valleys sandwich between the dunes, comprise of perennial lakes. Soil types present in the area includes pure sandy soil in desert area and clay mixed sandy soil in low laying areas. This area has been internationally recognized as wildlife sanctuary in 1988 and Ramsar site in 2002. [30]
Chotiari wetland complex is located in the region of Sindh, Sanghar city with an elevation of 60 meters above sea level (Fig 1). Before the construction of reservoir in 2003, area was covered by several brackish and fresh water lakes, after the construction of reservoir, water body possesses a space of around 18 thousand hectares, with water stocking limit of 0.75 MAF, spreads on a space of around 160 km2. Reservoir was constructed to make better availability of irrigation water for agricultural activities in surrounding areas and to increase the capacity of already existing lakes. However, this construction came with it downsides as it has influenced and initiated several social and ecological issues in surrounding areas like destruction of arable lands, pastures and timberland (caused by water logging and salinity, which was result of leakage of water from reservoir) and dislocation of local population. The environment of this region is of tropical to subtropical kind. In this region precipitation is scanty and sporadic and is generally incessant among July and August when it midpoints 40 mm month to month. [31] Both the selected study areas are one of their kind with unique geological and geographical stings, as these multiple fresh water and brackish water lakes formed (because of the seepage from Nara Canal) in the middle of driest region in Pakistan, Nara desert. After their formation, unique type of ecosystem developed in these areas and now all the surrounding area human population as well as important and endangered wildlife species

depends upon them. Agriculture, cattle farming and fishing are now main source of livelihood for these people and it's all possible because of these one of a kind type of wetlands. According to some existing studies [30,31] it was observed that these lakes are badly degraded in past decades so LULC change analysis and proper monitoring is required to observe the amount of degraded or dried lakes and for better future decision management by concerned authorities.

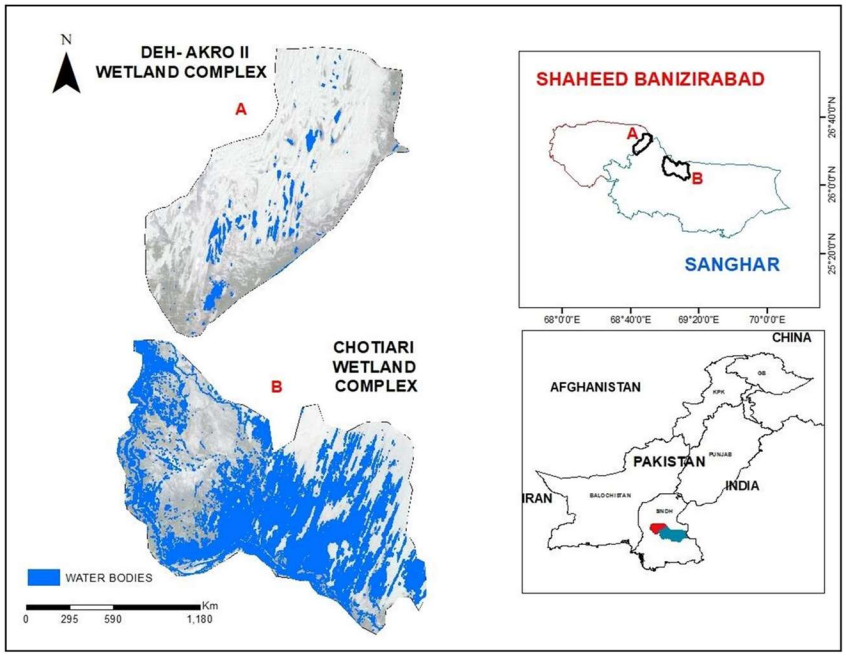


Figure 1. Location Map of Deh Akro-II Wetland Complex and Chotiari Wetland Complex.

2.2. Data collection and Methods

Object based temporal change analysis for last 30 years was performed to extract and analyze the LULC changes in both study regions. For OBIA, Landsat 5 (TM) image of year 1990 and for year 2020 multiple images of Sentinel 2-A were used for both sites. Images of both years were acquired in the months of September which is end of the monsoon season in study areas, so maximum amount of water can be observed. Spectral bands used in analysis were Blue (0.45 - 0.52 µm), Green (0.52 - 0.60 µm), Red (0.63 - 0.69 µm), NIR1 (0.76-0.90 µm), NIR2 (1.55-1.75 µm), and MNIR (2.08-2.35 µm) for Landsat 5, all of them have spatial resolution of 30 meters.

Spectral bands used in analysis for Sentinel 2 includes Blue (0.490 µm), Green (0.560 µm), Red (0.665 µm), NIR (0.842 µm), Vegetation Red Edge (0.865 µm), SWIR1 (1.610 µm), and SWIR2 (2.190 µm). Blue, green, red and NIR have spatial resolution of 10 meters and rest have 20 meter. To perform supervised and unsupervised classification, imagery of PlanetScope was used, containing four spectral bands named as Blue (0.455-0.515 µm), Green (0.500-0.590 µm), Red (590-670 µm) and NIR (0.780-0.860 µm) with each having very high spatial resolution of 3.7 meters.

Several pixels based techniques have been developed for different type of land covers abstraction from remote sensing satellite images; however, the majority of techniques don't give the necessary exactness and results in various inaccuracies [32]. An assessment was performed among object

LULC classification and pixel based (supervised and unsupervised) classification by using different medium and high resolution images. All the OBIA processing on both Landsat 5 and Sentinel 2A images have been performed in eCognition Developer 9.

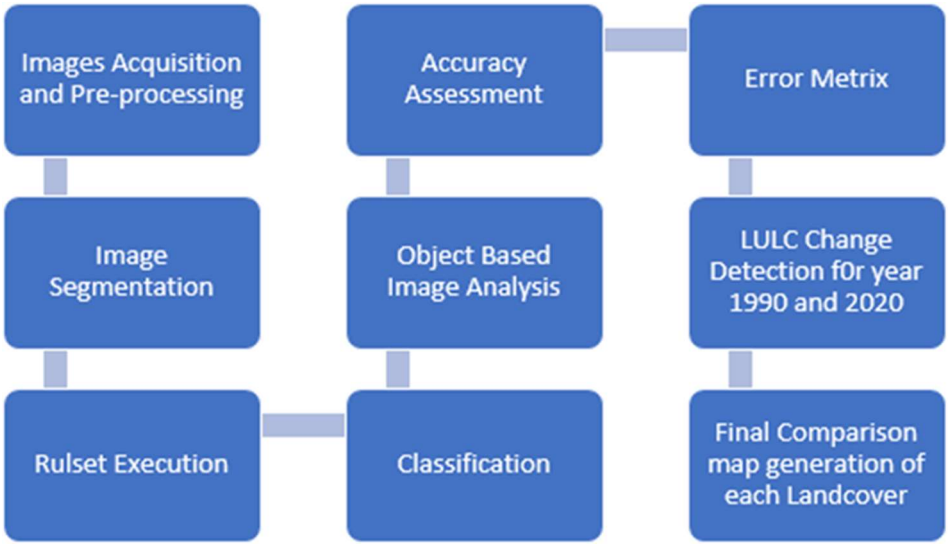
2.3. Image Segmentation

Image preprocessing involves band stacking (all 30 meter bands were stacked in case of Landsat 5 and all 10 and 20 meter' bands for Sentinel 2), mosaicking (study area of Chotiari wetland was covered in multiple scenes) and finally subset creation for study area. As a next step, image segmentation was performed as it was the important step for OBIA. Process of segmentation has revealed astounding prospective for LULC mapping, and especially accommodating in characterizing wetland LULC, even some of the researcher have utilized it in wetlands delineation and mapping [03,22,33-39]. Presently several kinds of segmentation algorithms are in practice being used for wetland LULC, however, in this study segmentation was performed with the help of multi resolution algorithm. In this type of segmentation, objects are created using a unique collaborative algorithm, where pixels are huddled until they reached a specified limit [40].

2.4. Image Classification

After image segmentation, next step was image classification, where all the images were classified with help of assign class algorithm. LULC classes for the year 1990 of both study areas have been classified into four classes

i.e. vegetation, agriculture, water and bare land with small scattered vegetation, whereas in year 2020 two more classes of submerged vegetation and buildup are added in both sites, these classes were previously not visible in 30m spectral resolution of Landsat 5 but easily identifiable in 10m spectral resolution of sentinel 2 band. The classification of each land cover was based on a number of decision rules determined according to feature attributes of the objects. These decisions of rules and thresholds have been decided and set through the process of trial and error, until the required level of accuracy has achieved. In this study, mean values of all the bands especially near infrared (NIR) and short wave infrared (SWIR) were used in classification of LULC. After classification, merge algorithm was applied on classes in order to merge the segments of same spectral properties. Further these all classes were exportedfrom eCognition in the format of shape files. Subsequently, final maps were created and samples were taken for accuracy assessment. For the comparison with other classifiers or for the purpose of LULC, Maximum Likelihood Classifier (MLC) is highly considered and recommended. This classifier has maintained high standard because of its amount, extent and positioning of samples, the nature of separate functions and the expressive assessment of the classification process [41,42,43,44,45]. MLC was applied on PlanetScope images of both study areas. Training samples were collected across the study regions by keeping in view the area and distribution of different land covers. For better understanding of unsupervised classification, technique of ISO Cluster was used and six land cover classes were developed.



Flow Chart explaining OBIA Methodology

3. Results and Discussions:

3.1 Accuracy Assessment

In order to compare and assess the results of applied RS classification, all the classified images were quantified with the help of confusion matrix, kappa coefficient, overall, producer and user's accuracy. For Deh Akro-II wetland complex, in the year 1990, over all accuracy was 92.46% while kappa coefficient observed with73.81%. However, for the year 2020, over all accuracy was 90.14% and kappa coefficient observed with 87.50%. For Chotiari Wetland Complex, overall accuracy for the year 1990 was 88.51% and kappa coefficient is 77.87%. Similarly, for year 2020, overall accuracy is 94.22% and kappa value is 92.34%. User and producer accuracy are mentioned in table 1:

Table 1. Users and Producers accuracy of Deh Akro-II wetland complex and Chotiari wetland complex for OBIA.

	Deh Akro-II wetland complex				Chotiari wetland complex			
Landcover Classes	**Producer Accuracy 1990**	**Users Accuracy 1990**	**Producers Accuracy 2020**	**Users Accuracy 2020**	**Producers Accuracy 1990**	**Users Accuracy 1990**	**Producers Accuracy 2020**	**Users Accuracy 2020**
Agriculture	40%	61.53%	79%	75.29 %	68%	53.12%	99%	73.57 %
Bare Land With Scattered	99.58%	95.98%	100%	91.86 %	100%	93.59%	89.61%	98.57 %

Vegetation								
Water	84%	75%	83.33%	100%	92.5%	90.24%	100%	100%
Natural Vegetation	28.57%	100%	81.53%	94.79 %	43.90%	90%	92.69%	98.50 %
Build-up Area	_____	_____	100%	93.10 %	_____	_____	100%	50%
Submerged Vegetation	_____	_____	96.61%	96.61 %	_____	_____	95.70%	100%

For accuracy assessment of supervised classification, raster classified image was vectorized in order to extract separate LULC classes. Nearly all the polygons of each class have been cross checked and error matrix was created. For Deh Akro-II wetland complex, observed Kappa coefficient was 93.49% and overall accuracy was 96.40%. For Chotiari Wetland Complex, overall accuracy was 97.37% and kappa coefficient resulted with 96.45% accuracy. However, for accuracy assessment of unsupervised classification, raster classified image was vectorized in order to extract separate LULC classes. Nearly all the polygons of each class have been cross checked and error matrix was created. For Deh Akro-II wetland complex, Kappa coefficient is 90.56% and overall accuracy of 86.32%has been observed (Table 2).

Table 2. Users and Producers accuracy of Deh Akro II wetland complex and Chotiari wetland complex for MLC and ISO.

	MLC				**ISO**			
	Deh Akro-II		**Chotiari**		**Deh Akro-II**		**Chotiari**	
Land cover Classes	**Producers Accuracy 2020**	**Users Accuracy 2020**	**Producers Accuracy 2020**	**Users Accuracy 2020**	**Producers Accuracy 2020**	**Users Accuracy 2020**	**Producers Accuracy 2020**	**Users Accuracy 2020**
Agriculture	51.29%	97.82%	77.98%	97.98%	63.29%	89.65%	88.89%	90.01%
Bare Land	96.53%	98.46%	99.85%	91.85%	94.32%	99.63%	98.28%	82.65%

Water	91.25%	73.93%	89.68%	98.90%	92.31%	86.37%	86.58%	97.49%
Scattered Vegetation	97.18%	96.40%	96.91%	98.29%	98.63%	86.54%	95.46%	94.28%
Build-up Area	100%	3.1%	60.39%	100%	91%	56%	58.65%	98.65%
Submerged Vegetation	99.72%	87.31%	100%	97.82%	79.72%	77.62%	54.23%	98.57%

Object based classification for both Wetland sites showing significant changes in water quantity from 1990 to 2020 which is also supported by the weather data record of same regions indicating a lot of changes in rainfall in last three decades [31]. In Deh Akro-II wetland complex, number of lakes has been dried and many others were acquired by aquatic vegetation in last 30 years. Classification results revealed 117% (10 to 1 sq.km) decline in water cover from 1990 to 2020. Even with much less amount of precipitation, a significant increment in agriculture and natural vegetation has been found in last 30 years (Figure 2a), This is mainly because of distribution of water form lakes and canals to barren land by locals (Rizwan et al, 2021). As in year 1990 agricultural area covered a land of 10.75 km2 while in year 2020 it increased up to 354% by covering an area of
48.83 km2 (Figure 2b).

Figure 2(c) shows changes in natural vegetation of Deh Akro-II wetland complex over a time span of 30 years. In year 1990, the area covered by natural vegetation was 57 km2 which is raised up to 248km2 in year 2020. As it can be easily observed form the maps, in year 1990 natural vegetation was only along the canal, whereas in year 2020 its showing scattered pattern in whole complex, especially around the lakes. It has been observed bare land of Deh Akro II wetland complex covered in scattered vegetation has been decreased up to 13% (Figure 2d). by converting into natural/scattered vegetation and agriculture. Results showed that in year 2020, two new classes of buildup and submerged vegetation were also extracted. These two types of Land covers were not visible in Landsat 5 image of 1990. Buildup area of Deh Akro-II wetland complex is really small villages and separate houses, made up of mud, so it was really difficult to distinguish them from bare land, but with the help of ground knowledge, they were identified quite easily in high resolution image of Sentinel 2A. In Deh Akro-II wetland complex, submerged vegetation was difficult to find with Landsat 5 image, as it was not much submerged vegetation in 1990, but in 2020 they were very clearly visible on sentinel 2A image. Figure 2 (e) and (f) are showing Submerged vegetation and buildup class of Deh Akro-II wetland complex. Buildup covers the area of 144 km2, whereas submerged vegetation covers 7.3 km2. A significant decline has been observed in water cover from 1990 to 2020 as large portion of the water bodies has been replaced with the submerged vegetation class.

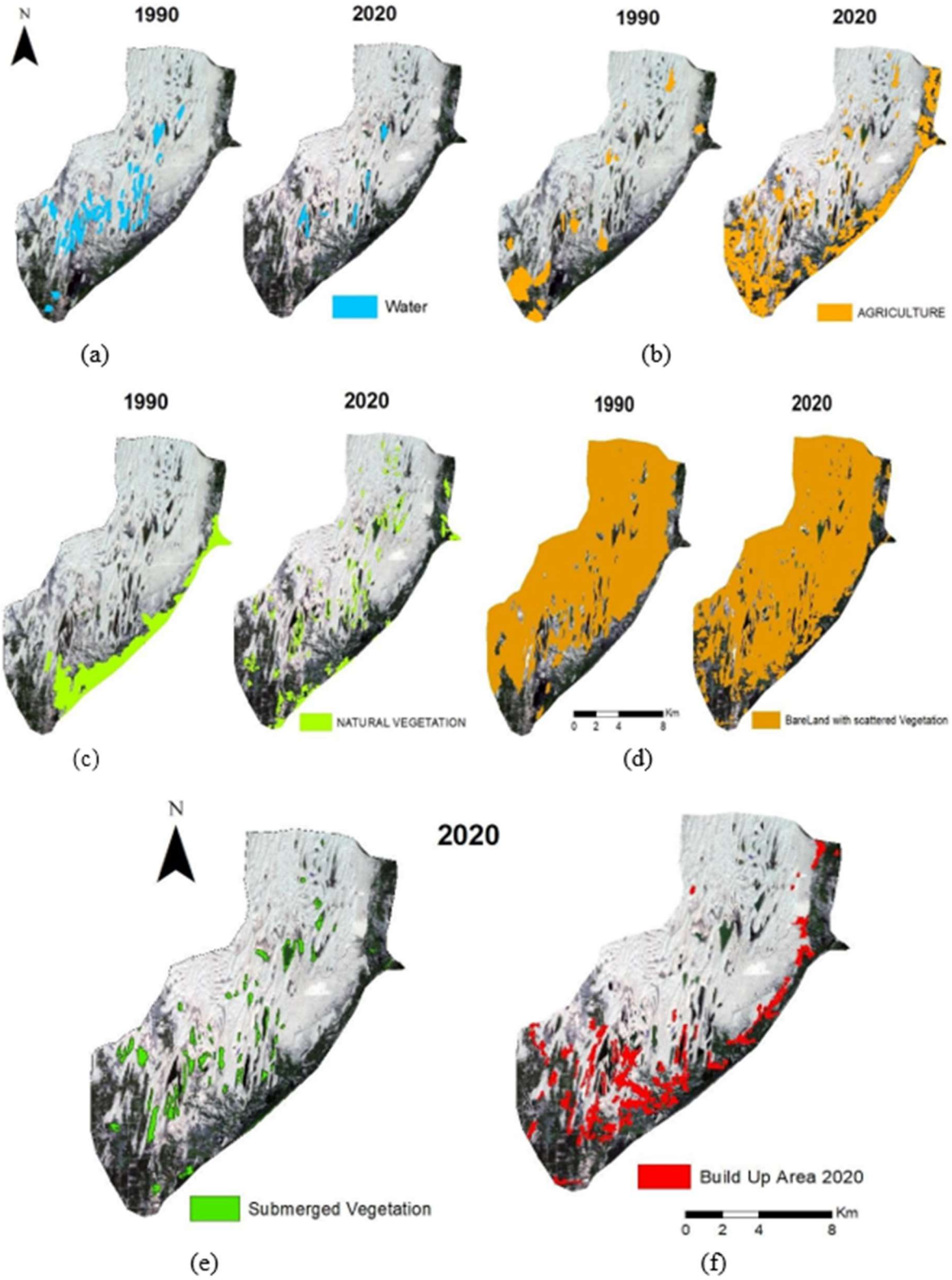

N
1990
2020
Water
(a)
1990
2020
AGRICULTURE
(b)
1990
2020
NATURAL VEGETATION
(c)
1990
2020
Km
0 2 4 8
BareLand with scattered Vegetation
(d)
N
2020
Submerged Vegetation
(e)
Build Up Area 2020
Km
0 2 4 8
(f)

Figure 2. Maps depicting the changes in (a) water bodies (b) agricultural area (c) Natural Vegetation (b)Bare Land for 30 years, (e) and (f) shows the Landcover of Submerged Vegetation and Buildup Area of Deh Akro- II wetland complex.

For Chotiari Wetland Complex, it has been observed that construction of water reservoir in 2003, supplemented the water cover and volume to a significant extent, previously which were in the form of scattered lakes [46]. Figure 3(a) shows that in 1990, area covered by water body was 71.84 km2, while in 2020 it has been raised upto 154km2 with an increment of 115%. However, on the other hand, agriculture and natural vegetation of Chotiari

wetland complex has been decreased due to increase in amount of water of reservoir. Agricultural cover of Chotiari wetland complex has been declined from 65.62 to 17.22 km2 in 30 years' time span (Figure 3b). This figure also illustrated that natural vegetation class observed with 57.44 % decline as most of the vegetated area has now been covered with reservoir water or its soil has been destroyed because of water logging and salinity [46]. Figure 3(c) shows the natural vegetation of both years.

Results of the study also illustrated that area of bare land with scattered vegetation has resulted with 45% decline from 91.65km2 to 62.66 km2 in 30 year span (Figure 3d). Spatial distribution of bare land is also different in both images because of volume of reservoir water. Buildup of Chotiari wetland complex has been comprised of very small villages with mud houses. It was extracted from Sentinel 2A image of 2020 with the help of ground knowledge. Figure 3(e) shows the buildup area of Chotiari wetland complex in year 2020, whereas figure 3(f) shows the Land cover class of submerged vegetation, which was only extracted for year 2020 as it was happened after the construction of reservoir.

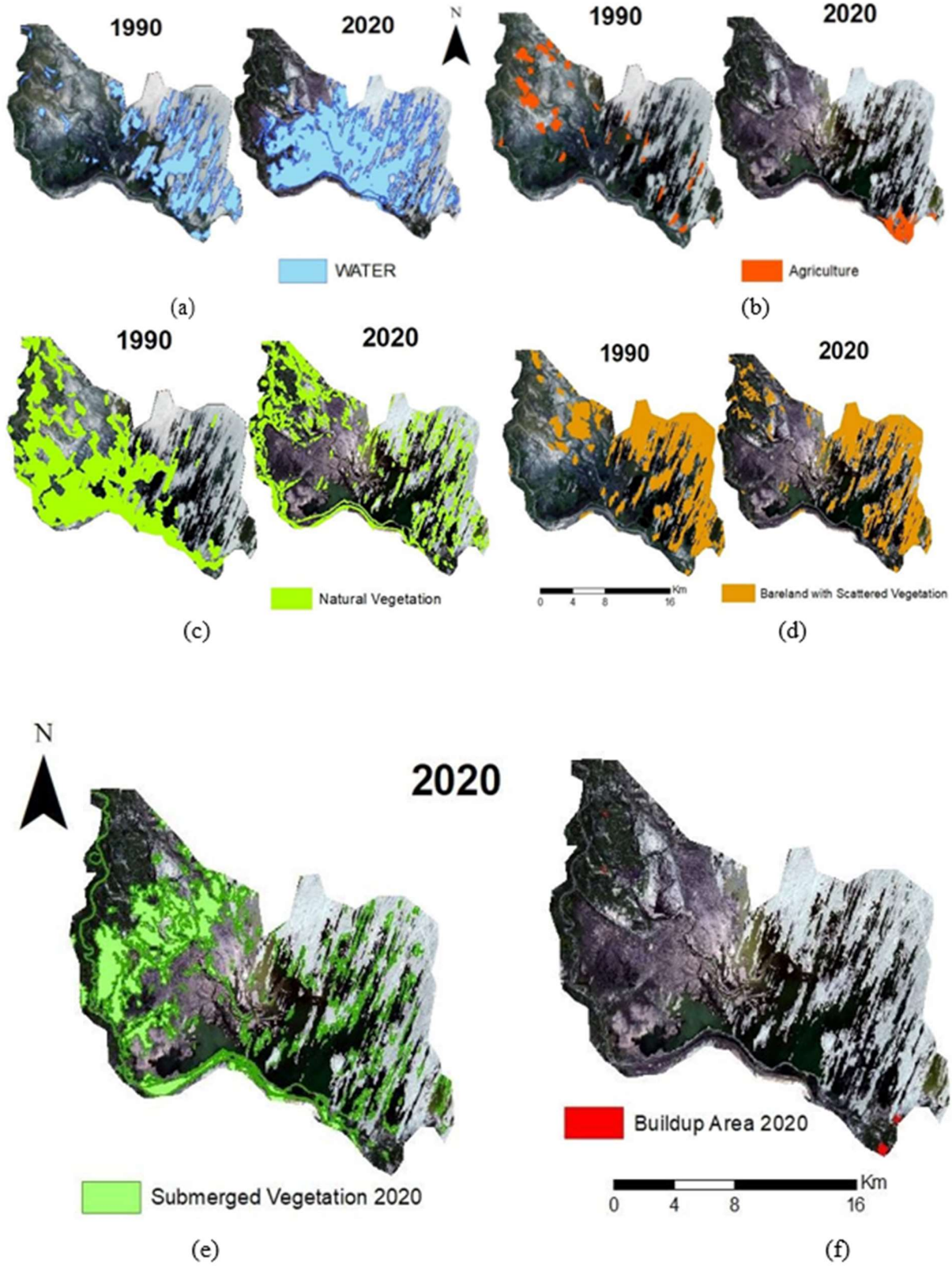
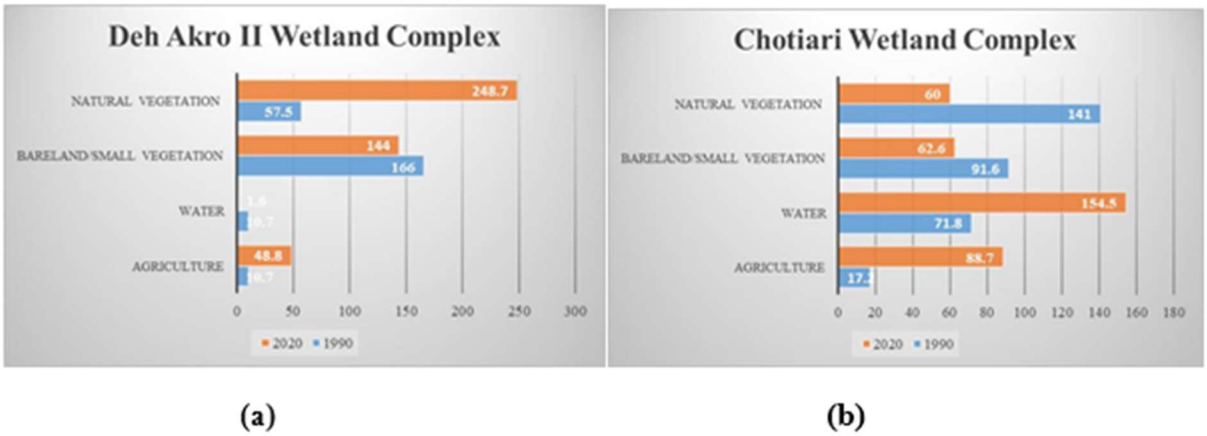

1990
2020
N
WATER
(a)
1990
2020
Agriculture
(b)
1990
2020
Natural Vegetation
(c)
1990
2020
Km
0 4 8 16
Bareland with Scattered Vegetation
(d)
N
2020
Submerged Vegetation 2020
(e)
Buildup Area 2020
Km
0 4 8 16
(f)

Figure 3. Showing the changes in (a) water bodies (b) agricultural area (c) Natural Vegetation (b)Bare Land for 30 years, (e) and (f) shows the Landcover of Submerged Vegetation and Buildup Area of Chotiari wetland complex.

Graphical illustration of LULC change of both study areas has been shown in figure 4(a) representing Deh Akro- II wetland complex and (b) Chotiari wetland complex.



(a) (b)

Figure 4. Change in LULC of (a) Deh Akro-II and (b) Chotiari Wetland Complex

Utilization of high resolution imagery of Planet scope for MLC provides quite promising results. All the LULC classes were quite accurate in comparison to the studies based on pixel based; even in some classes more accurate results were gained as compared to OBIA. Signature file of both sites contains the samples for classes of water, buildup, agriculture, bare land, submerged vegetation and scattered vegetation. Deh Akro-II wetland complex MLC classification shows quite high accuracy in most of land covers (Figure 5a). Similarly, MLC of Chotiari wetland complex also depicts quite high accuracy (Figure 5b).

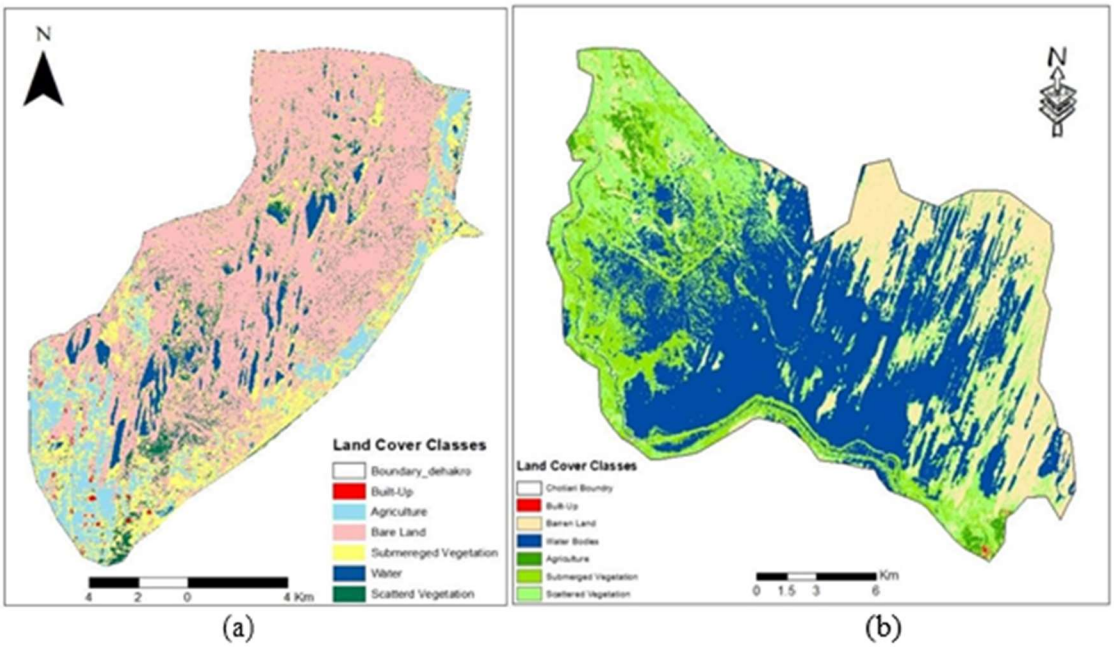


Figure 5. MLC classification of (a) Deh Akro-II wetland complex and (b) Chotiari wetland complex.

For unsupervised classification, algorithm of ISO cluster technique was performed. In ISO cluster classification, clusters are formed automatically from pixels. In this study, algorithm was asked to create 6 classes of water, buildup, submerged vegetation, agriculture, scattered vegetation and bare land. Figure 6 (a) and (b) shows ISO classification of Deh Akro-II wetland complex and Chotiari wetland complex respectively. Complex issue was faced in both pixels based and OBIA techniques as the buildup of both regions has comprised of small villages made up of small locally available sand and mud, so they were extremely difficult to extract and were greatly mixed with bare land class. So in OBIA trial and error method was applied on buildup class until desired results were acquired and in pixel based techniques samples for buildup class were taken very precisely, mainly based on ground knowledge.

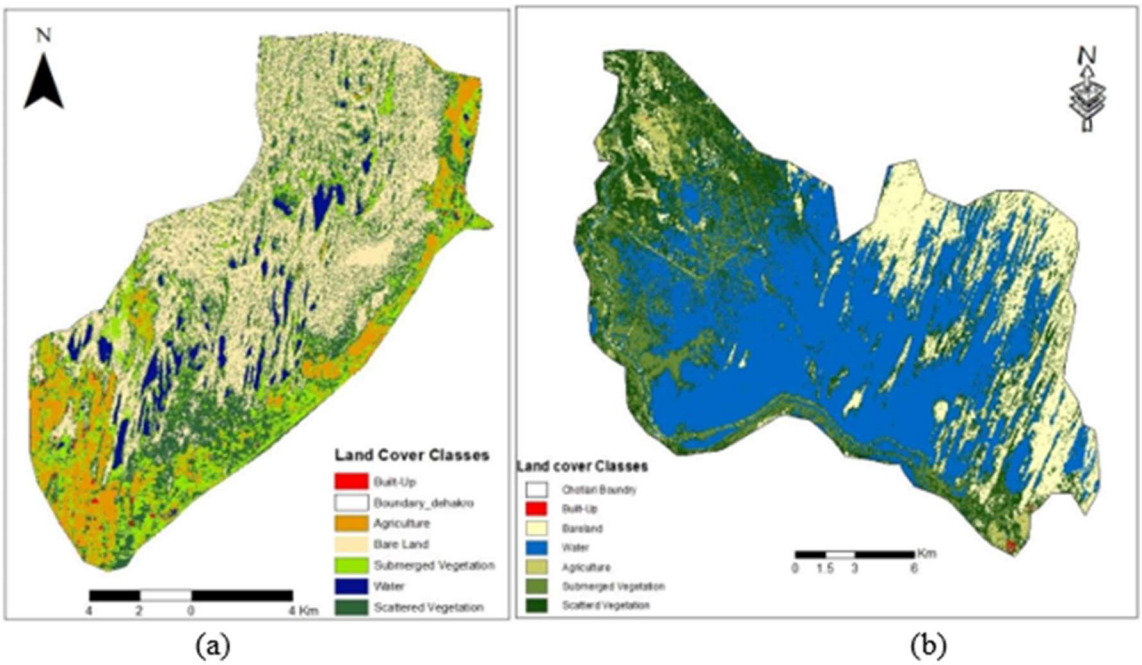


Figure 6. ISO cluster classification of (a) Deh Akro-II wetland complex and of (b) Chotiari wetland complex.

4. Conclusions

This study has made a comparison between different image classifying techniques as well as different satellite image products with varying spectral resolution. Two major types of the classifiers used for comparison i) pixel based and ii) object based. Study showed pixel based techniques has shown its high dependence on both spatial and spectral resolution of the used satellite image. OBIA technique has been found superior than its pixel based counterpart in this manner as segmentation process converts same surrounding pixels into one discreet object depends upon the scale size controlled by the user. For pixel based approach, supervised (MLC) and unsupervised (ISO) classifications have been used, whereas, for OBIA multi resolution segmentation and classification of LULC was performed based on user defined rule set. Exorbitant level of accuracy has been achieved with the used classifiers. OBIA has been applied to satellite observation for year 1990 with an overall accuracy of 92.64% and Kappa coefficient measuring a value of 73.81% for Deh Akro-II wetland complex. On the other hand, for the dame initial year, overall and Kappa accuracy for Chotiari wetland complex has given a maximum of 88.51 % and 77.87% respectively with the use of OBIA. For year 2020 high resolution imagery of Sentinel 2A was used which provides quite higher accuracy in comparison to the year 1990., On the other hand, Deh Akro-II wetland complex found with 90% overall and 87%Kappa accuracy However, for Chotiari wetland complex overall and kappa coefficient accuracy observed as 94% and 92%.

This research showed that MLC results were as accurate as OBIA due to the usage, of very high spectral resolution image of PlanetScope, with a pixel size of 3.7 meters. Results of MLC accuracy assessment were very good as overall accuracy of Deh Akro-II wetland complex was 96.40% and

kappa coefficient was 93.49% with overall accuracy of 97.37% for Chotiari wetland complex. Accuracy values of ISO cluster classification were also found quite extraordinary for Deh Akro-II wetland complex as overall observed accuracy was 86.32%, whereas Kappa coefficient was 90.56%.

Out of all these techniques best optimized results have been considered for extracting different land cover classes. There accuracy was measured with help of users and producer accuracy. Highest accuracy for OBIA was of user accuracy which gives 100% results for natural vegetation cover in year 1990 and water class of year 2020 for Deh Akro-II wetland complex. In producer's accuracy 100% accuracy of water and submerged vegetation class for Chotiari wetland complex has been achieved.

Over the time span of 30 years, several LULC changes have been observed with the help of OBIA classification technique. For Deh Akro-II wetland complex, water bodies have decreased up to 117% because of severe scarcity of water in area. However, agriculture has been increased on quite higher rate i.e.354%, as livelihood of local population now depends upon agriculture, and local government also provide lands to indigenous people for better production of food and cash crops. Natural vegetation around the complex has also increased by 333%, as a lot of vegetation has grown around the lakes and categorized as submerged vegetation in 2020. Study shows that bare land around the complex has diminished by 13.25% because of increase in agriculture and natural vegetation, small scattered vegetation has been found all around the complex.

For Chotiari wetland complex major change has been experienced by water bodies as before construction of water reservoir, there were multiple elongated lakes present in complex but after construction, water level has increased upto 115% and most of the area of complex has been overtaken by water cover. Rest of the land covers i.e. agriculture, natural vegetation and bare land has decreased up to 65.62%, 57.44% and 45.51% respectively, as their land has been occupied by water reservoir or soil has been damaged by leakage of water from reservoir creation, severe issue of water logging and salinity in area. This study revealed that adopted techniques are proven to be really effective for LULC of badly effected wetlands due to climate change and anthropocentric activities. These advanced and comparative LULC classification methods can be very useful for better monitoring, mapping of wetlands and for betterment of wetlands health in terms of flora and wildlife depends upon them. This study proves the efficacy of remote sensing techniques in evaluation and mapping of wetland studies in a reliable and cost effective manner.

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References

1. Majumder: B. Land use and land cover change detection study at Sukinda Valley using remote sensing and GIS. Bachelor Thesis, Department of Mining Engineering, National Institute of Technology Rourkela. (2010)
2. Change, I. P. O. C. (2014). Ipcc. Climate change.
3. Sugumaran, R.; Harkin,J.; and Gerjevic, J. Using remote sensing data to study wetland dynamics in Iowa. Iowa Space Grant Final Technical Report, University of Northern Iowa, 2004, pp. 1–17.
4. Ozesmi, S. L.; & Bauer, M. E. Satellite remote sensing of wetlands. Wetlands ecology and management, (2002), 10(5), 381-402.
5. Pietroniro, A.; Toyra, J.; Leconte, R.; & Kite, G. Remote sensing of surface water and soil moisture. GEOPHYSICAL MONOGRAPH-AMERICAN GEOPHYSICAL UNION, 2005, 163, 119.
6. Baker, C.; Lawrence, R.; Montagne, C.; and Patten, D. Mapping wetlands and riparian areas using Landsat ETMþ imagery and decision-tree-based models. Wetlands,2006, 26, pp. 465–474.
7. Mahdavi, S.; Salehi, B.; Amani, M.; Granger, J. E.; Brisco, B.; Huang, W.; & Hanson, A. Object-based classification of wetlands in Newfoundland and Labrador using multi-temporal PolSAR data. Canadian Journal of Remote Sensing, 2017, 43(5), 432-450.
8. Zedler, J. B.; Kercher, S.; Wetland resources: Status, trends, ecosystem services, and restorability. Annu. Rev. Environ. Resour. 2005, 30, 39–74.
9. Gardner, R. C.; Barchiesi, S.; Beltrame, C.; Finlayson, C.; Galewski, T.; Harrison, I.; ... & Walpole, M. State of the world's wetlands and their services to people: a compilation of recent analyses. Ramsar Briefing Note no 7, Gland, Switzerland: Ramsar Convention Secretariat, 2015.
10. Rundquist, D.; Narumalani, S.; Narayanan, R. A review of wetlands remote sensing and defining new considerations. Remote Sens. Rev. 2001, 20, 207–226.
11. Adam, E.; Mutanga, O.; Rugege, D. Multispectral and hyperspectral remote sensing for identification and mapping of wetland vegetation: A review. Wetl. Ecol. Manag. 2010, 18, 281–296
12. Gao, B. C. Normalized difference water index for remote sensing of vegetation liquid water from space. In Imaging Spectrometry, International Society for Optics and Photonics, 1995, Vol. 2480, pp. 225-236.
13. Jensen, J.R.; Narumalani, S.; Weatherbee, O.; Andmackey, Jr, H.E. Measurement of seasonal and yearly cattail and waterlily changes using multidate SPOT panchromatic data. Photogrammetric Engineering and Remote Sensing, 1993, 59, pp. 519–525.
14. Sader, S.A.; Ahl, D.; and Liou, W.S. Accuracy of Landsat-TM and GIS rule-based methods for forest wetland classification in Maine. Remote Sensing of Environment, 1995, 53, pp. 133–144.
15. LI, J.; and CHEN, W. A rule-based method for mapping Canada's wetlands using optical, radar and DEM data. International Journal of Remote Sensing, 2005, 26, pp. 5051–5069.

16. Phiri, D.; Morgenroth, J.; & Xu, C. Four decades of land cover and forest connectivity study in Zambia— An object-based image analysis approach. International Journal of Applied Earth Observation and Geoinformation, 2019, 79, 97-109.
17. Linli, C.; Jun, S.; Ping, T.; & Huaqiang, D. Comparison study on the pixel-based and object-LULC methods of land-use/cover classification with TM data. In June, 2008 International Workshop on Earth Observation and Remote Sensing Applications (pp. 1-5). IEEE.
18. Wu, Y.; Ke, Y.; Gong, H.; Chen, B.; & Zhu, L. Comparison of object-based and pixel-based methods for urban land-use classification from WorldView-2 imagery. In June, 2014 Third International Workshop on Earth Observation and Remote Sensing Applications (EORSA) 2014 (pp. 284-288). IEEE.
19. Adam, H. E.; Csaplovics, E.; & Elhaja, M. E. A comparison of pixel-based and object-based approaches for land use land cover classification in semi-arid areas, Sudan. In IOP Conference Series: Earth and Environmental Science, June, 2016(Vol. 37, No. 1, p. 012061). IOP Publishing.
20. Ye, S.; Pontius Jr, R. G.; & Rakshit, R. A review of accuracy assessment for object-based image analysis: From per-pixel to per-polygon approaches. ISPRS Journal of Photogrammetry and Remote Sensing, 2018, 141, 137-147.
21. Costa, M.P.F.; Niemann, O.; Novo, E.; and Ahern, F. Biophysical properties and mapping of aquatic vegetation during the hydrological cycle of the Amazon floodplain using JERS-1 and Radarsat. International Journal of Remote Sensing,2002, 23, pp. 1401–1426.
22. Antunes, A.F.B.; Lingnau, C.; Andda Silva, J.C. Object-LULC analysis and semantic network for high resolution image classification. Anais XI SBSR, Belo Horizonte, Brasil, INPE, 2003, pp. 273–279
23. Burnett, C.; Blaschke, T. A multi-scale segmentation/object relationship modelling methodology for landscape analysis. Ecol. Model. 2003, 168, 233–249.
24. Blaschke, T. Object based image analysis for remote sensing. ISPRS J. Photogramm. Remote Sens. 2010, 65, 2–16.
25. Listner, C.; & Niemeyer, I. Object-based change detection. Photogrammetrie - Fernerkundung - Geoinformation, 2011, (4), pp. 233-245.
26. Ma, L.; Li, M.; Blaschke, T.; Ma, X.; Tiede, D.; Cheng, L.; Chen, D. Object-based change detection in urban areas: the effects of segmentation strategy, scale, and feature space on unsupervised methods. Remote Sensing, 2016, 8 (9), pp. 761
27. He, Y.R.; Zhang, X.X.; & Hua, L.Z. Object-based distinction between building shadow and water in high resolution imagery using fuzzy-rule classification and artificial bee colony optimization. Journal of Sensors, 2016, 1–10. doi:10.1155/2016/2385039
28. Kazmi, S. J. H.; Qureshi, S.; Siddiqui, M. U.; & Arsalan, M. H. (2006, September). Depleting wetlands of lower Sindh, Pakistan: A spatio-temporal study through satellite remote sensing. In 2006 International Conference on Advances in Space Technologies, 1-5. IEEE Xplore Digital library

29. Ahmad, S. S.; Erum, S. Remote sensing and GIS application in wetland change analysis: case study of KallarKahar. Sci Technol ,2012 ,Dev, 31(3): 251-259.
30. Ramsar sites information service. https://rsis.ramsar.org/ris/1283 - (11-04-2020)
31. Rizwan, S.; Mahmood, K.; Ahmad, S. R.; & Rehman, S. U. Fractional Land Cover Classification and Temporal Change Evaluation of Deh Akro-II Wetland Complex and Chotiari Wetland Complex, Sindh, Pakistan, Using Google Earth Engine. REVISTA GEINTEC-GESTAO INOVACAO E TECNOLOGIAS, 2021, 11(4), 4258-4277.
32. Kaplan, G.; & Avdan, U. New mapping technique for water extraction using NDWI and land surface temperature – water extraction surface temperature index in Manuscript submitted for publication. 2016.
33. Costa, H.; Foody, G. M.; & Boyd, D. S. Using mixed objects in the training of object-based image classifications. Remote Sensing of Environment, 2017, 190, 188-197.
34. Burnett, C.; Aaviksoo, K.; Lang, S.; Langanke, T.; and Blaschke, T. An object-based methodology for mapping mires using high resolution imagery. In Ecohydrological Processes in Northern Wetlands, A. Ja¨rvet and E. Lode (Eds), 2003, pp. 239–244 (Tallinn, Estonia: Tartu University Press)
35. HESS, L.L.; MELACK, J.M.; NOVO, E.M.L.M.; BARBOSA, C.C.F; and GASTIL, M. Dual season mapping of wetland inundation and vegetation for the central Amazon basin. Remote Sensing of Environment, 2003, 87, pp. 404–428.
36. Stankiewicz, K.; Dabrowska-Zielinska, K.; Gruszczynska, M.; and Hoscilo, A. Mapping vegetation of a wetland ecosystem by fuzzy classification of optical and microwave satellite images supported by various ancillary data. In Remote Sensing for Agriculture, Ecosystems, and Hydrology IV, Proceedings of SPIE Volume 4879, M. Owe, G. D'Urso and L. Toulios (Eds), 2003, pp. 352–361 (Bellingham, WA: International Society for Optical Engineering).
37. Hurd, J.D.; Civco, D.L.; Gilmore, M.S.; Prisloe, S.; And Wilson, E.H. Tidal wetland classification from Landsat imagery using an integrated pixel-based and object-based classification approach. In ASPRS 2006 Annual Conference Proceedings (Maryland: American Society for Photogrammetry and Remote Sensing).
38. Costa, H.; Foody, G. M.; & Boyd, D. S. Using mixed objects in the training of object-based image classifications. Remote Sensing of Environment, 2017, 190, 188-197.
39. Hossain, M. D.; & Chen, D. Segmentation for Object-Based Image Analysis (OBIA): A review of algorithms and challenges from remote sensing perspective. ISPRS Journal of Photogrammetry and Remote Sensing, 2019, 150, 115-134
40. Baatz, M.; & Schäpe, A. Multiresolution segmentation: An optimization approach for high quality multiscale image segmentation. AGIT-Symposium Salzburg, 2000, 12–23.
41. Ediriwickrema, J. Hierarchical maximum-likelihood classification for improved accuracies. IEEE Transactions on Geoscience and Remote Sensing, 1997, 35, pp. 810–816.

42. Erbek, F.S.; Ozkan, C.; and Taberner, M. Comparison of maximum likelihood classification method with supervised artificial neural network algorithms for land use activities. International Journal of Remote Sensing, 2004, 25, pp. 1733–1748.
43. South, S.; Qi, J.; and Lusch, D.P. Optimal classification methods for mapping agricultural tillage practices. Remote Sensing of Environment,2004, 91, pp. 90–97.
44. Lo, C.P; and Choi, J.M. A hybrid approach to urban land use/cover mapping using Landsat 7 Enhanced Thematic Mapper Plus (ETMþ) images. International Journal of Remote Sensing, 2004, 25, pp. 2687– 2700.
45. Jensen, R.J. 2005, Introductory Digital Image Processing: A Remote Sensing Perspective (Upper Saddle River, NJ: Prentice-Hall).
46. Magsi, H.; & Torre, A. Proximity analysis of inefficient practices and socio-spatial negligence: Evidence, evaluations and recommendations drawn from the construction of Chotiari reservoir in Pakistan. Land Use Policy, 2014, 36, 567-576.