Survey and Analysis on Wetland Detection Technique through Satellite Imagery

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Abstract- *Wetlands are most important and valuable ecosystem for maintaining biodiversity on the planet. In present scenario wetlands are vulnerable to climate change and land conversion activities like agriculture and urbanization. Due to their important fine temporal scale monitoring of sensitive wetlands are required. For this purpose few tools are specified to monitor the wetland at landscape scale. To understand better wetland detection technique a detailed survey on different wetland detection methodology using satellite imagery is performed. Its aim to identify the best techniques to detect wetland changes in present scenario so that appropriate changes on studied techniques according to needs in different wetland areas analysis can be suggested.*

Keywords - *wetlands, spectral mixing analysis, change vector analysis, classification analysis tree, digital depth model.*

I. INTRODUCTION

United States army corps of engineers defines wetland as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support and that under normal circumstances support a prevalence of vegetation typically adapted for life in saturated soil condition" [10]. Lake fringes and shallow lakes meet the above criteria. Urban development and agricultural management comes under anthropogenic activities has reason for significant loss of wetland.

Wetlands provide a variety of ecological services that play major role on ecosystem function. Wetlands minimize sediment loss, purify surface water, control river volume enhance aquifer recharge. The size, shape and distribution of wetland are largely determined by topographic, geologic and hydrologic conditions. The role of wetlands in increasing on urban areas requires we have to understand the wetlands distribution and density.

At present three primary inventory techniques used to map wetland ecosystem on site evaluation, aerial photo interpretation and digital image processing.

On site measurement provide highly detailed data such as floral and faunal species, soil characterization and water chemistry. Hydrology and vegetation patters understand by aerial photography. SPOT and Landsat are satellites used to generate map of variety of wetland in Canada and US. IRS-LISS-II were used to map wetland meadows. Several wetland mapping studies indicate that Landsat based classification given higher accuracies than other space borne sensors. SAR imagery has much application in flood studies.

II. METHODOLOGY USED FOR WETLAND DETECTION

A. *Spectral mixture analysis*

Spectral mixing analysis is a method of finding endmembers which is fractional abundance of distinctive spectra within the mixed pixel spectrum. Mixed pixel is a pixel which contains more than one class or feature. Pure pixels have one class type or feature. Endmember is a pure pixel value of selected type or class, significant physical view component are shown by spectral endmember and are subjected to spectral measurement on the ground. SMA work well in water environments and the areas where high spectral contrast between different classes.

Mathematically,

SMA equation be $MM_i = jME_{i,j} + r_i$ and j=1

Where MM is the measured value of mixed pixel in band i ,ME is measured value of endmembers r is root mean square (rms).

B. *Change Vector Analysis (CVA)*

Two spectral channel used by change vector analysis (CVA) for mapping both magnitude of change and direction of change between two input images it is consider for each date.

Change detection procedure

In CVA equation Euclidean distance of spectral changes is calculated among the three vertices greenness, brightness and wetness. It is a variation of the Pythagorean Theorem.

$Cm = (CB1 – B2)^2 + (G1 – G2)^2 + (W1 – W2)^{0.5}$

Where Cm is change magnitude.

1, 2 refer respective component value for distinct imagery dates.

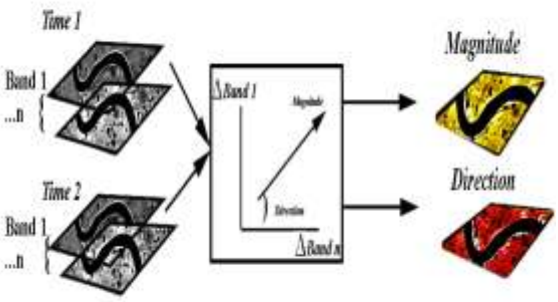

Fig 1. Change vector analysis [19]

C. Classification tree analysis(CTA)

Classification tree analysis used variety of spectral and ancillary data sources and produce highly accurate classification on the basis of rule based technique same like as neural network. Dichotomous decision tree has formed using categorical and continues data. It does not assume normal distribution in the present data set and it is non parametric technique. The CTA algorithm works like to reduce both inter-class and intra-class variability of training data values through binary splitting recursively. The binary splits result are displayed as branching dichotomous trees that present as readily interpretable illustration within the variable data classification and splits are applied in the classification of image. Highly accurate land-cover classification is achieve by decision tree which uses combination of multispectral and ancillary data, decision trees can easily processed and it provide valuable insight into ecological conditions.

D. Automated object based wetland inventory

Wetlands are classified in each wetland map by through mean Pdep value of terrain object which is greater than equal to threshold. Then absolute difference between object based wetland and reference wetland along with person coefficient (r) is calculated.

A threshold is selected minimize the absolute difference and maximize the person coefficient (r) between the two images. A threshold is selected for each distinguish site and average threshold of all site are than calculate. Large wetland can also be mapped by using (scale parameter = 20) the threshold for mean Pdep can determine by iteratively assigning small threshold value and result of small scale parameter be compared with other small parameter threshold value result. The wetland which are not classified as wetland using small scale parameter is classified as wetland for given threshold then those threshold is selected for large scale parameter.

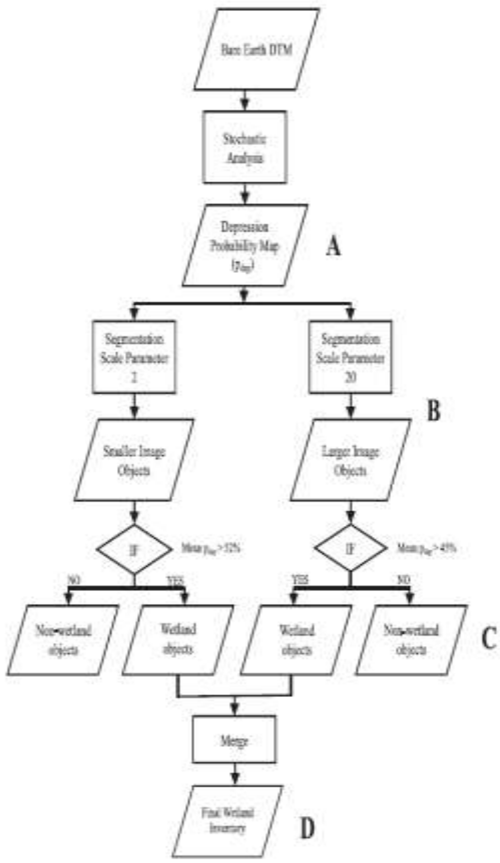

Fig 2. Automated object based wetland inventory[5].

E. Digital depth model

Digital depth model is the concept of delineating the morphometry which is based on the digitizing the contour lines of the multiple dates that is shown on shoreline. The water level changes given vertical information which is connected to the shoreline is viewed as horizontal information of lakes bed. For producing digitize contour line knowing water level on the different dates are very important and pre-request for image acquisition. The produced contours are subjected to create digital depth model that elaborate the lake bed morphometry accurate elaboration of multi temporal shorelines is challenge for observation point of water bodies.

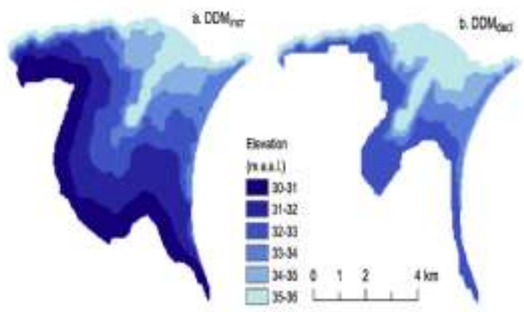

Fig 3. DDMs created from increasing water level (a) and declining water level (b) [6].

F. Rule based classification and taguchi optimization technique

In this method preprocessing is done in both in both Landsat and TerraSAR-X satellite images. ISODATA method is used to remove speckles from TerraSAR-X image, gap filling and pan-sharpening is applied on Landsat imagery and gaps problem of Landsat is fixed and spatial resolution be enhanced. In object oriented rule based classification method in first stage taguchi optimization technique is used to drawn optimum segmentation combination. In Second stage rules are define which are based of classification. Three classes water, urban and vegetation are generate using Landsat image and water and non-water bodies are classified through TerraSAR-X satellite image. Two class of water bodies are subtracted from Landsat and TerraSAR-X images and flooded areas be extracted. In last stage confusion matrixes created for check the reliability of flooded area map. This method is described in the fig 4 see below.

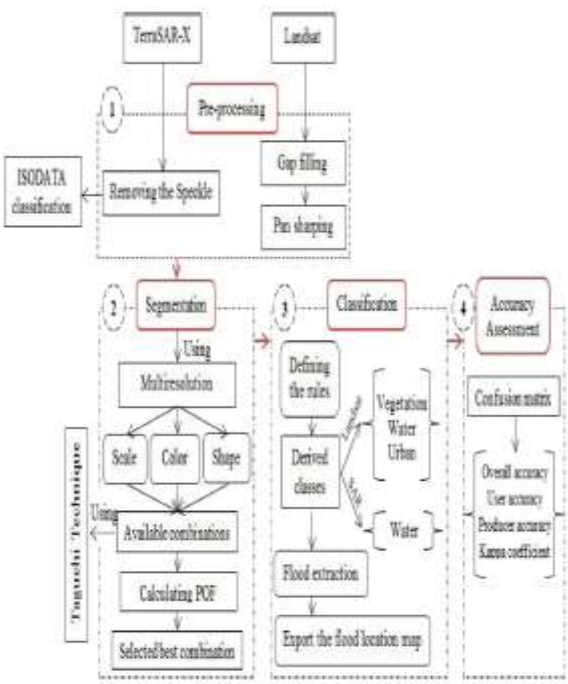

Fig 4. Rule based classification and taguchi optimization technique [7].

III. LITRATURE REVIEW

Meghan Halabisky et. al. [1] used spectral mixture analysis (SMA) to reconstruct surface water hydrograph for 750 weltands from time series of landsat satellite image. meaningful materials , known as spectral endmembers from mixed pixel is estimated by SMA techniques. This paper gives us overview about how to work with sub pixel in image analysis. Study area of this paper is Douglas County, Washington (WA), USA. 4 endmember has been developed through spectral mixture analysis model and sub-pixel wetland inundation is measured. From this paper following conclusion drawn work better when spatial resolution is less than 30 m for surface water measurement. Wetland scale is used to track changes. Seasonal and long-term is its temporal resolution. Application of this study is classification of wetland types by hydro periods and monitoring of wetland changes over time.

Corey Baker et. al.[2] used Landsat based satellite image from 1988 to 2001 to cover the changes in wetland ecosystem. Stochastic gradient boosting (SGB) and change vector analysis (CVA) is used to classify the image and to identify the location where wetland areas might have changed. This paper given information about the image classification and change detection over wetlands. The study area is 135,570-ha in lower basin of the Gallatin River, located in the Gallatin Valley of southwestern Montana, USA. The result of this study is Given 86% overall accuracy on detecting variety of wetlands. The application of the methodology present in this paper is easily Change detection of wetland ecosystem is observed.

Corey Baker et al.[3] map wetland and riparian areas using LANDSAT ETM+ satellite images and decision tree based model. The study area is 135,570-ha in lower basin of The Gallatin River, located in the Gallatin Valley of southwestern Montana, USA In this paper they use classification tree analysis (CTA) and stochastic gradient Boosting (SGB) and decision tree based classification algorithm. This algorithms are used to distinguish riparian areas and wetlands from the remaining landscaps. CTA used one step look ahead procedure and create classification tree with reduce variance. Classification error is used to refine tree development in SGB and multiple tree results be incorporated into a single best classification. CTA (73.1% overall accuracy) is less effective than SGB (86.0%).

Serge Olivier kotchi et al[4] used supervised classification of earth observatory(EO) image with maximum likelihood algorithm and estimate five key environmental determinants as agricultural land , water, forest, wetland, impervious surfaces from 78 beaches. The study area is watersheds of rivers L'Assomption, Yamaska, and Saint-François in southern Québec, Canada. The result of this analysis is an overall accuracy of 98.48% to distinguish the key components and a Kappa coefficient of 0.97. This paper demonstrates that EO images could monitor microbial contamination of recreational water.

J.N Serram et al[5] proposed in new mapping technique to estimate loss of small wetland on prairie landscape. An automated object based approach uses digital terrain objects derived from 130,157 wetland. They estimate wetland loss by % number & % area obtain by applying a frequency power low function verses wetland area. It can represent more accurate magnitude of wetland loss. Study area of this method is Prairie Pothole Region of North America. In this paper they estimate 2.6% loss of wetland area 16.2% historic loss of wetland number.

George Ovakghou et al[6] present a methodology for updating digital depth model of reservoirs and lake by using satellite remote sensing and measure wide intra and inter annual fluctuations of water level for mapping shorelines formed during annual water level change cycle they use a time series of terra MODIS satellite images. In-situ observations with connected shorelines of water levels were treated as elevation counter to produce DDM with spatial interpolation. This paper given detailed information about water level changed over annual cycle. The test site is Lake Kerkini (41◦13_N, 023◦08_E) reservoir northern Greece. This method can measure 171.1m maximum depth with possible accuracy. It is low cost and efficient method.

Biswajeet pradhan et. al.[7] proposed an efficient methodology to map and recognize the flooded areas using TerraSAR-X imagery. TerraSAR-X satellite image was captured during flood event and multispectral Landsat image was used to detect water bodies before flooding. In SAR images both water bodies and flooded areas appear black. To overcome this drawback Landsat image subtracted light detection from ranging data and identified from TerraSAR-X image and flooded location easily identified. Object oriented classification and Taguchi method applied on both images. From this technique wetland and non wetland easily identified. Test area was Kuala Terengganu area and this method ability to detect flooded area with Overall accuracy 93.04 and kappa coefficient 0.77.

L. C. CHEN et. al.[8] present a scheme to detect changes in shoreline using multi temporal satellite images and estimate the tide. The basic idea in this investigation is to reconstruct a reference digital terrain model (DTM) for tidal areas from a set of SPOT satellite images which is sampled over a short period. Study area was San-Tiau-Luen and Wai-San-Ting, on the western coast of Taiwan. The result of this investigation is area fallacy of the test sand barriers ranges between 7.6% and 12.5%.

Kate C. Fickas et. al.[9] proposed a Landsat based monitoring of annual wetland change, for this purpose Theil-Sen Slope estimate analysis is used. They interpret loss, gain and type conversion of wetland area. Tasseled cap Brightness, Greenness, and wetland indices were created for MSS data match TM/ETM+ Tasseled cap satellite images. They construct complete and consistent annual time series and entire Landsat archive were utilized. Test area was Willamette Valley of Oregon, USA. In the proposed method they achieved better accuracy(91%) than manual interpretation(80%).

IV. ANALYSIS ON WETLAND DETECTION TECNIQUE

References	**technique**	**Image source**	**Study area**	**Advantages/limitation**	**Application**
Meghan Halabisky et. al. [1]	Spectral mixing analysis(SMA)	Landsat TM Aerial photos	Douglas co. WA,USA	Spatial resolution of surface water measurement < 30 m	Classified wetland types by hydroperiod and monitored wetland change over time.
Corey Baker et al[2]	Change vector Analysis(CVA)	Landsat	Gallatin Valley of southwest Montana	Given 86% overall accuracy on detecting variety of wetlands	Change detection of wetland ecosystem
Corey Baker et al[3]	Classification tree analysis	Landsat ETM+	Gallatin Valley of southwest Montana	Given 73.16% overall accuracy on detecting variety of wetlands	Mapping wetlands and riparian areas
Serge Olivier kotchi et al[4]	Supervised classification with maximum likelihood algorithms	WorldView-2 and GeoEye-1	watersheds of rivers L'Assomption, Yamaska, and Saint-François in southern	an overall accuracy of 98.48% and a Kappa coefficient of 0.97	better estimation of environmental determinants with a better spatial resolution.

			Québec, Canada		
J.N Serram et al[5]	Automated object based approach	Aerial imagery	Prairie Pothole Region of North America	estimate 2.6% loss of wetland area, 16.2% historic loss of wetland number	New mapping techniques to estimate the preferential loss of small wetlands
George Ovakghou et al [6]	Digital depth model	Terra MODIS Landsat ETM+	Lake Kerkini (41◦13_N, 023◦08_E) reservoir northern Greece	171.1m maximum possible accuracy. Low cost and efficient.	detailed lake morphometry : Application to basins with large water level fluctuations
Biswajeet pradhan et. al.[7]	Object oriented classification and taguchi method	TerraSAR-X and Landset	Kuala Terengganu area Malaysia	Overall accuracy 93.04 and kappa coefficient 0.77	Detected flooded areas precisely and rapidly
L. C. CHEN et. al.[8]	Digital terrain model(DTM)	SPOT satellite image	San-Tiau-Luen and Wai-San-Ting, on the western coast of Taiwan	area error of the test sand barriers ranges between 7.6% and 12.5%.	Detection of shoreline changes for tideland areas
Kate C. Fickas et. al.[9]	Theil-Sen Slope estimate analysis	Landsat MSS and TM/ETM+	Willamette Valley of Oregon, USA	Better accuracy than manual interpretation M.I.=80%, This method=91%	monitoring of annual wetland change

V. CONCLUSION

This paper presents analysis and survey on wetland detection branchmark techniques on the basis of five parameter namely technique used, image source, study area, advantage or limitations and applications of particular techniques. From the above study conclusion be drawn that SMA technique is used to detect wetland less than 30 meters, it cover smallest surface area. Mixed pixel is subjected to work in this technique. CVA gives good change detection results in wetlands with 86% overall accuracy. CTA is another technique used to detect wetlands change and its accuracy 73.16% overall. Supervised classification with maximum likelihood algorithm applied to estimate environment determinants like water, forest, wetland, agriculture land and impervious surface with overall accuracy 98.48% with kappa coefficient 0.97. Automated object based approach is a method to represent more accurate magnitude to wetland loss using Arial imagery. Digital depth model estimate the water level in Lake Morphometry with 171.1m maximum accuracy. Object oriented classification and taguchi method is a flood detection technique with overall accuracy 93.04% and kappa coefficient 0.77. Detection of shoreline changes has been estimated through digital terrain modal (DTM). Theil sen slope technique given 91.1% accuracy in annual wetland change. Supervised classification with maximum likelihood algorithm given maximum accuracy 98.48% in determining environmental determinant. These analyses motivate to propose a technique which is able to detect and analyze the changes in small wetlands.

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