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# Accuracy Assessment of Classified Land Use and Land Cover Status using Algorithms Embedded in ARCGIS Software for Shimsha Catchment, Karnataka

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***Abstract*****: Surface runoff dynamics and volume of water stored in water bodies depend on terrain characteristics of catchment, climate parameters such as precipitation and temperature, besides land use and land cover of the catchment. Images obtained from remote sensing techniques were used to classify the land cover of various classes based on spectral characteristics of the pixel and same will be interpreted and recorded in the attribute table of shape file generated using ArcGIS software. Generated data with visual interpretation observed with error and hence assessment of accuracy for classifying image is required to enhance the quality of work carried and classification was compared by using ground control points which was obtained by physical verification in catchment area and interpreted the results for further studies. User and producer column data were used to create confusion matrix to study the difference between referenced data and classified data. The results from accuracy assessment showed using confusion matrix shows an overall accuracy obtained from the random sampling process for the image of 85.7 per cent. User's accuracy ranged from 62 to 100 per cent while producer's accuracy ranged from 25 to 100 per cent with kappa's coefficient of 0.80.**

**Keywords: runoff, remote sensing, classification, accuracy and confusion matrix**

## INTRODUCTION

Land use and land cover are important phenomena to hydrological and ecological changes happening in catchments, as they influence on interception losses, evapotranspiration, percolation etc., which are eventually a game changer with respect to surface hydrology and in particular, generation of surface runoff [8]. Generated surface runoff is so crucial among the water users of command area for adapting cropping pattern. Most of the surface runoff running through streams was collected in reservoirs, tanks, surface ponds etc. These water harvesting structures will be utilized by agriculture sector based on the availability of water, cropping pattern adopted by farmers and gross command area [1]. To understand the situation of catchment area, land use and land cover classification could be used with advanced remote sensing techniques. Image classification is the process adapted to obtain the information about land use and land cover, in which the idea behind is assigning land cover classes to pixels of raster data. There are three main types of image classification in remote sensing viz., unsupervised classification, supervised classification and object-based image analysis [3]. The classification provides clear idea about the runoff generation from the catchment. Several layers of remote sensed images are processed using Geographical Information System framework. Visual interpretation and the personnel classifying of image based on spectral observations stands in terms of the accuracy of classification. Accuracy assessment was not a part in image classification studies. However, chances of errors are normal during visual interpretation and hence accuracy assessment could be very effective using Ground truth points which will be compared with image classification [2]. It is not only assessing and judging the interpretation ability of the personnel but also allow to self evaluation of the work and also instill confidence about the work and provide greater confidence for future work[6]. Assessment provides the quantitative comparison about various methods, algorithms and analyst used. Finally, it gives good result of spatial information which can be used for decision making process. To assess the situation of Shimsha catchment area with respect to land use, classification was done using Support Vector Machine algorithms of supervised classification embedded with ArcGIS. Image was classified with details of dryland crop, urban area, plantation crop, water bodies and uncultivated land. The study also used to understand the usefulness of someone else's classification as a referenced data for accuracy of work carried out for land use and land classification by creating confusion matrix in ArcGIS and data was analysed using Kappa's co-efficient.

## MATERIALS AND METHODS

Shimsha Irrigation Project is an irrigation scheme operated in southern Karnataka where the reservoir is located at Marconahally, near Yediyur of Kunigal taluk comes under minor irrigation project of Karnataka. The reservoir has live storage capacity of 64 Million cubic metre and serves a cultural command area of 5942 ha out of 7203 ha of gross command area. The total catchment area for Marconahally reservoir is 4103 square kilometers [4]. ESRI(Environmental System Research Institute) and Impact Observatory Institute released 10 m spatial resolution dataset for free access to the public. Land use land cover data was downloaded from the website *livingatlas.arcgis.com/ landcover*. Downloaded data have different thematic bands for various application and are listed in table 1as provided by Indian Institute of Remote Sensing, Dehradun. This bands were used in ArcGIS software for further information extraction.

Table 1. Thematic bands of remote sensing images with their principle application

| Band | Name of the band | Wavelength (μm) | Characteristic and usage |
|---|---|---|---|
| 1 | Visible blue | 0.45-0.52 | Maximum water penetration |
| 2 | Visible green | 0.52-0.60 | Good for measuring plant vigour |
| 3 | Visible red | 0.63-0.69 | Vegetation discrimination |
| 4 | Near infrared | 0.70-0.90 | Biomass and soreline mapping |
| 5 | Middle infrared | 1.55-1.756 | Moisture content of soil |
| 6 | Middle infrared | 2.00-2.35 | Mineral mapping |
| 7 | Thermal infrared | 10.4-12.5 | Soil moisture and thermal mapping |

For supervised classification training samples of various land use were selected by drawing polygon over the pixel of image and name was provided based on spectral signature. Selected training sample was used for creating training samples for uncultivated land, plantation crop area, dryland crop area, settlement and water bodies. The classified image was shown in Figure 1. After visual evaluation of sixty three spots across catchment, the classification results were compared to observe errors during image classification. A confusion matrix was used to characterize the image classification accuracy. A table was created to analyze the comparison between classification pixel with ground truth points.

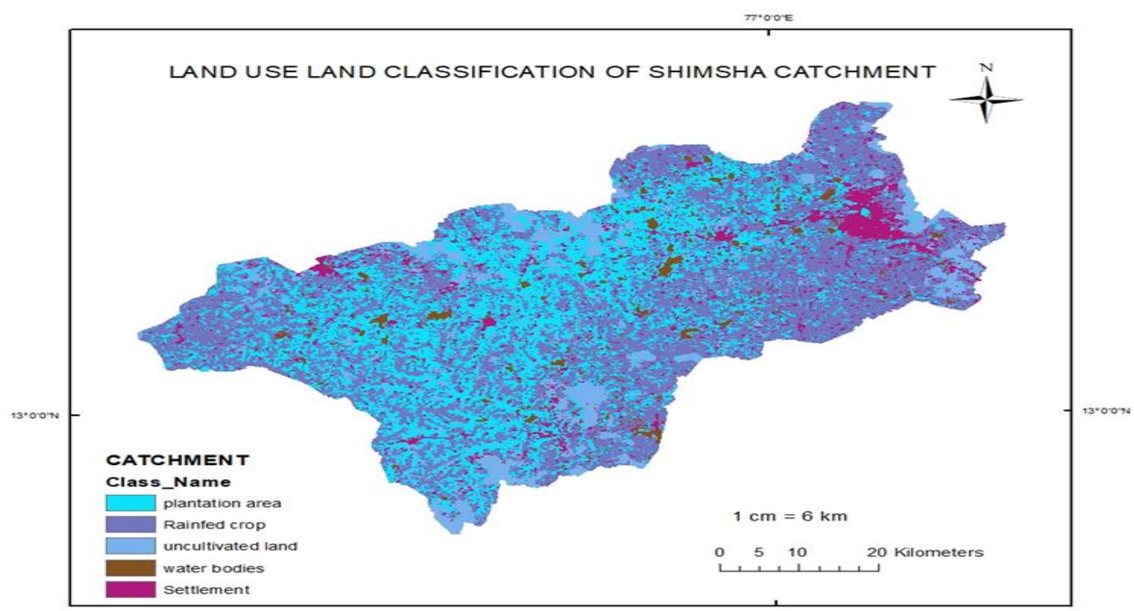


Fig.1: Land use land cover classifications of Shimsha catchment area

Point samples were created uniformly over the image using editing option in software. New value called user value was introduced by adding column in the attribute table of land classification shape file. The user value of each points depict the number given for the classified land details. Another new column with name of producer value was added to see the difference between classified land and reference map points. If any difference, that has to be replaced with true value based on referred data.

## INFORMATION EXTRACTION USING CONFUSION MATRIX

Producer's accuracy measures errors of omission, which is a measure of how well real-world land cover types can be classified. User's accuracy measures errors of commission, which represents the likelihood of a classified pixel matching the land cover type of its corresponding real-world location [7]. Attention was paid to the diagonal elements of the matrix. Diagonal cells contain the number of correctly identified pixels. Dividing the sum of these pixels by the total number of pixels classification's overall accuracy (OvAc) can be achieved.

$$Overall\ Accuracy = \frac{Total\ /\ number\ /\ of\ /\ correctly\ /\ classified\ /\ pixels}{Total\ /\ number\ /\ of\ /\ referenced\ /\ pixels} * 100 \quad ---(1)$$

$$User's\ Accuracy = \left[\left[\frac{Number\ /\ of\ /\ correctly\ /\ classified\ /\ pixels}{Total\ /\ number\ /\ of\ /\ classified\ /\ pixels\ /in\ /\ the\ /\ category} in\ /\ each\ /category\right]\right] * 100 \quad -----(2)$$

$$Producers\ Accuracy = \left[\left[\frac{Number\ /\ of\ /\ correctly\ /\ classified\ /\ pixels}{Total\ /\ number\ /\ of\ /\ classified\ /\ pixels\ /in\ /\ the\ /\ category} in\ /\ each\ /category\right]\right] * 100 \quad ----(3)$$

Another accuracy indicator was kappa coefficient. It is a measure of how the classification results compare to values assigned by chance. It can take values from 0 to 1. If kappa coefficient equals to 0, there is no agreement between the classified image and the reference image. If kappa coefficient equals to 1, then the classified image and the ground truth image are totally identical. So, the higher the kappa coefficient, the more accurate the classification[5].

$$\text{Kappa co-efficient } (\acute{K}) = \frac{N(\sum_{i=1}^{r} x_{ii}) - \sum_{i=1}^{r}(x_{i+} * x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} * x_{+i})} \quad (4)$$

Where r= number of rows in the error matrix

$x_{ii}$= number of observation in row i and column i ( on the major diagonal)

$x_{i+}$= total number of observations in row i (shown as marginal total to right of the matrix)

$x_{+i}$= total of observation in column i ( shown as marginal total at bottom of the matrix)

N= total number of observation included in matrix

## RESULTS AND DISCUSSION

Physical properties of soils within the catchment were determined by collecting the samples, further analyzed data were recorded in Table 2. Results from the table revealed that texture of soil is sandy loam, with infiltration rate of 22.5 mm per hour to 26 mm per hour. The image was classified with five distinguished classes: Plantation Crop, Dryland crop, Settlement, Uncultivated land and Water bodies. Table 3 shows the percentage of land use classes classified using vector machine algorithm within the Shimsha catchment. Although many spectral information obtained from the image, for the study purpose, only five classes were classified which were of prominent classes in the catchment.

Table 2. Physical properties of soils found in shimsha catchment

| | Land use | Bulk density ($g/cm^3$) | AWC( mm) $H_2O$/mm soil) | Organic carbon (%) | Saturated K (mm/hr) | Clay (%) | Silt (%) | Sand (%) | pH | Texture |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Dryland area | 1.725 | 0.124 | 0.56 | 50.34 | 10.7 | 6.71 | 65.01 | 6.18 | Sandy loam |
| 2 | Plantation area | 1.443 | 0.100 | 0.72 | 56.25 | 12.8 | 8.21 | 62.21 | 6.14 | Sandy loam |
| 3 | Settlement | 1.780 | 0.100 | 0.42 | 56.25 | 12.8 | 8.21 | 60.78 | 6.02 | Sandy loam |
| 4 | Uncultivated land | 1.640 | 0.120 | 0.50 | 54.78 | 10.80 | 9.54 | 64.89 | 6.24 | Sandy loam |

Table 3: Land use classification under Shimsha catchment using Support Vector Machine Algorithm, ArcGIS software

| Classified group | Area($Km^2$) | Area (%) |
|---|---|---|
| Dryland crop area | 1821.69 | 45% |
| Plantation crop area | 1309.92 | 32% |
| Settlement | 334.78 | 8% |
| Uncultivated area | 452.53 | 11% |
| Water bodies | 112.89 | 3% |
| Grand Total | 4031.80 | 100% |

The image was classified into five classes; Dryland crop area (1821.69 $km^2$), Plantation crop area(1309.92 $km^2$), Settlement (334.78 $km^2$), Uncultivated area(452.53 $km^2$) and Waterbodies (112.89 $km^2$), Agriculture was the dominant type of land-use classification which covers about seventy seven per cent of the total study area.

To calculate and interpret the confusion matrix manually, the values obtained were entered as per the observed and classified and later producers and user column were compared. The data generated were listed in error matrix for accuracy assessment.

Table 4. Error matrix resulting from classifying test pixels

| | Plantation area | Dryland area | Settlement | Uncultivated area | Water bodies | User (total) |
|---|---|---|---|---|---|---|
| Plantation area | 18 | 0 | 0 | 0 | 0 | 18 |
| Dryland area | 5 | 13 | 0 | 1 | 0 | 19 |
| Settlement | 1 | 0 | 5 | 2 | 0 | 8 |
| Uncultivated area | 0 | 0 | 0 | 1 | 0 | 1 |
| Water bodies | 0 | 0 | 0 | 0 | 17 | 17 |
| Producer( total) | 24 | 13 | 5 | 4 | 17 | 63 |

Table 4 represents matrix (error matrix) of a land use classification. The columns of the confusion matrix show to which classes the pixels is in the validation set belong (ground truth) and the rows show to which classes the image pixels have been assigned to in the image. The diagonal show the pixels that are classified correctly. Pixels that were not assigned to the proper class do not occur in the diagonal and give an indication of the confusion between the different land-cover classes in the class assignment. The results from accuracy assessment showed an overall accuracy obtained from the random sampling process for the image of 85.7 per cent. User's accuracy ranged from 62 to 100 per cent while producer's accuracy ranged from 25 to 100 per cent .

Table 5. Categorization of Kappa Statistic and its Rating Criteria for interpretation

| Sl.No. | Kappa Statistic | Strength of Agreement |
|---|---|---|
| 1 | <0.00 | Poor |
| 2 | 0.00-0.20 | Slight |
| 3 | 0.21-0.40 | Fair |
| 4 | 0.41-0.60 | Moderate |
| 5 | 0.61-0.80 | Substantial |
| 6 | 0.81-1.00 | Almost perfect |

The range of accuracy indicates a moderate confusion of dryland area with plantation crop area classes. Moreover, the measure of producer's accuracy (Sensitivity) reflects the accuracy of prediction of the particular category. The User's accuracy reflects the ability of personnel to classify the image and this accuracy is the more relevant measure of the classification's actual utility in the field. The commission error reflects the points which are included in the category while they really do not belong to that category. As per [7], categorization of Kappa statistic is widely referenced which is reproduced in Table 5 for rating of Kappa value for further interpretation. In this study an overall Kappa coefficient of 0.80 was obtained which is highly appreciable. Apart from overall classification accuracy, the above individualized parameters give a classifier a more detailed description of model performance of the particular class or category of field of interest or study.

## CONCLUSION

Physical property of soil indicated about the water holding capacity of soil but the response of surface runoff may be affected due to land use and land cover. Advanced remote sensing techniques and latest geographical Information Systems software are very much useful for studying natural resources management even at local scale. The objective of this paper was to classify the land use patterns in Shimsha catchment with high spatial resolution image and carried accuracy assessment in order to assess how well a classification worked with the help of manual observation considered to be ground truth data. Study was performed for accuracy assessment using confusion matrix. The study had an overall classification accuracy of 85per cent and kappa coefficient of 0.8. The kappa coefficient obtained from the study shows good result and hence the image classification can be used for Soil and Water Assessment Tool(SWAT) model for simulation of hydrological events, where land use land cover classification data is one among the required data for SWAT model to convert the catchment area into various hydrological response units.

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