ISSN: 0974-5823 Vol. 7 (Special Issue, Jan.-Mar. 2022)

International Journal of Mechanical Engineering

A Detailed Analogy between Estimated Pre-flood area using ISOdata Classification and K-means Classification on Sentinel 2A data in Cuddalore District, Tamil Nadu, India

M. Saikrishna[1], Vidhya Lakshmi Sivakumar[2]

[1]Research Scholar, Department of Civil Engineering,
Saveetha School of Engineering, Saveetha Institute of Medical And Technical Sciences,
Saveetha University, Chennai, Tamilnadu, India. Pincode: 602105.

[2]Project Guide, Corresponding Author, Department of Civil Engineering,
Saveetha School of Engineering, Saveetha Institute of Medical And Technical Sciences,
Saveetha University, Chennai, Tamilnadu, India. Pincode: 602105.

ABSTRACT

Aim: The aim of this study is to evaluate the area obtained for different Land use/Land cover (LULC) regions, specifically pre-flood areal extent using novel unsupervised classification techniques, namely, ISOdata and K-means classifier on Cuddalore district, Tamil Nadu. **Materials and Methods:** Sentinel 2A data was obtained from the USGS Earth Explorer satellite database for Cuddalore district, Tamil Nadu. A total of 22 samples have been taken, with 11 samples for ISOData and 11 for K-means classification technique. **Results**: An independent-samples-t-test performed on two groups reveals that there is no statistically significant difference $p=1.000$ ($p>0.05$) between ISOdata (Interactive Self Organization Data Analysis) and K-means classifiers. However, the K-means classifier performs better than the ISOdata classifier**. Conclusion:** Thus, within the limits of the study carried out, it is evident that the ISOdata and K-means classifier performed equally with no difference.

Keywords: ISOdata, K-means classifier, Novel Unsupervised classification, Remote Sensing, Sentinel 2A, Digital Image Processing, Image Classification

INTRODUCTION

Remote Sensing (RS) is a technology that includes the imaging of the Earth's surface and is a valuable source of knowledge for observing the same. In common parlance, remote sensing is the use of an aerial sensor technology for detecting and classifying phenomena at a distance on Earth's land, atmosphere, and oceans using propagated signals (Neuenschwander 2009). It is critical to determine which of many classification algorithms is better suited for the land use/land cover classification of Sentinel-2A info. Several experiments have been conducted to compare the classification accuracies of Landsat-8 and Sentinel-2A with SVM and MLC classification algorithms(Priyadarshini and Kumar 2018). Remote sensing satellite images have important applications in a variety of fields, including climate analyses, forest resource assessment, and marine environment research and clustering is a popular unsupervised data mining technique that can be used to mine a variety of data sets such as geoscientific data, biological data, multimedia data, and so on (Bandyopadhyay and Saha 2012) through Digital Image Processing.The only distinction between them is that the number of groups is described differently. In the K-means rule, the number of classes remains constant during iteration; however, the ISOdata Algorithm allows for a variable number of classes. If the same number of classes are defined using the same optimum iteration, all methods provide the same results(Pan, Xi, and Wang, n.d.).

The total number of flood mapping related studies rummaged in two research databases such as Researchgate and Google Scholar over the last five years (2016 - 2021) is 160 and 180, respectively. A number of publications have emphasised the significance of unsupervised classification algorithms such as ISOdata and K-means classifiers.Natural floods are common and unavoidable. Effective flood inundation mapping and flood risk assessment software, on the other hand, can be helpful for emergency response and crisis management(Uddin, Matin, and Meyer 2019). The following is a general drawback of the k-means algorithm (as well as the ISOdata algorithm): k-means functions well with photographs of spherical clusters of the same variation (Rani et al. 2015). Using an unsupervised and Digital image processing, the classifier obtains the spectral groups or clusters in the multi-band images without the analyst's involvement (Salih 2018). The aggregation of pixels in unsupervised classification is based on unlabeled results (Rosen 2000). Digital image processing and Image classification is known as the method of assigning pixels to raster data based on groups (Zhang and Kerekes 2011). When the two techniques were compared, k-means formed the clusters more efficiently than ISOdata. It was difficult to predict the LULC type for small clusters using ISOdata. Thus, K-means outperforms ISOdata in defining or predicting LULC type using high-resolution hyperspectral images (Giri 2016).

According to previous research, the availability of high spatial resolution data is uneconomical; therefore, free-of-charge medium resolution data combined with suitable classification techniques can expose possible flooded regions (Batra, Roy, and Panda 2020). Previous work by the team in a range of domains from drought monitoring, ground water mapping to soil texture mapping using remote sensing and GIS ((Sivakumar, Krishnappa, and Nallanathel 2021; "[No Title]" n.d.; Vidhya, Vinay, and Reddy 2019; Lakshmi et al. 2015). Another notable work carried out with wide experience in interdisciplinary projects (S. R. Samuel, Acharya, and Rao 2020; Nasim et al. 2010; DeSouza et al. 2014; Sekhar, Narayanan, and Baig 2001). The aim of this research is to compare unsupervised classifiers, ISOdata, and K-means for mapping flooded zones in the Cuddalore district, Tamil Nadu, India.

MATERIALS AND METHODS

The study was carried out in the Remote Sensing and Geographic Information System (GIS) laboratory, Department of Civil Engineering, Saveetha School of Engineering, Saveetha Institute of Medical And Technical Sciences (SIMATS), Tamil Nadu, Chennai. In this analysis, two classes of unsupervised classifiers were compared: group A - ISOdata classifier and group B - K-means classifier. The total number of samples in each category is 11 (N=11). Fallow land, deep water, shallow water, soil 1, soil 2, agricultural land, barren land, cloud, cloud shadow, coastal water, and forest are the eleven groups. The sample size was set at 11 after clinical.com measured a pre-test power of 80% and an alpha value of 0.05 in clinical.com with a mean of 0.0668±0.0125 for ISOdata and a mean of 0.0003 (Kane, Phar, and BCPS n.d.). The study planning for both groups A and B was one sample and eleven sample sizes of Region Of Interest (ROI) on subset data of Sentinel 2A data.

Study Area

Cuddalore district, located in the south Indian state of Tamilnadu lies between 11°11" and 12° 5"N and 78° 38" and 80° 00" E, covering an area of 3,564 km^2. The Bay of Bengal encompasses 52 kilometres of the district's eastern coastline.Floods of strong waves occurred on December 4, 2020, and began with mild rainfall as heavy rains(Ravikumar, Bhaskaran, and Others 2018).Sentinel 2A images from various months in 2020 were retrieved from the USGS Earth Explorer.However, the most recent geometric and radiometric corrections were added to the results.

Unsupervised Classification

In this type of image classification, training samples are not required *apriori*; however, the number of classes and the number of iterations for the algorithm must be given as input.

1. ISOdata algorithm – ISOData unsupervised sorting clusters uniformly spaced pixels and classes based on a user-defined threshold.

2. K– Means algorithm - identifies clusters depending on the cluster's centre pixel or assigns each data point to a cluster. The homogeneous pixels are grouped together to form an entity.

Sentinel 2A image from 7th October 2020 was retrieved from the USGS Earth Explorer. Few bands provide no details usable for spectral analysis. As a result, it is essential to recognise and exclude certain bad bands that do not contain valuable information that were not considered for the study. A layer stacked image using specific Green, Red and Near-Infrared wavelengths corresponding to bands 3, 4 and 8 of the Sentinel 2A sensor was produced. The same is the case for group 2 as well.

Fallow land, deep water, shallow water, soil1, soil2, agricultural land, barren land, cloud, cloud shadows, coastal water, and forest are the eleven groups considered for classification. All the Regions Of Interest (ROI) were defined using sample pixels or training sites from the FCC for each LULC. The selected ROIs are fed into the classifier, which generates the LULC map of the study region. Few bands provide no details usable for spectral analysis. As a result, it is essential to recognise and exclude certain bad bands that do not contain valuable information that were not considered for the study. Layer Stacking of all the bands of 3, 4 and 8 and the corresponding wavelengths (in nm) are 559, 664, and 832 nm.A subset of the study region is chosen and the classifiers are used to classify the image data The results are then examined and the distinction between ISOdata and K-means groups are studied.

A statistical analysis between the two groups of unsupervised classification is performed using SPSS version 25. An independent samples t-test is performed on the results obtained from this study. Dependent variable is Region of Interest and Independent variables are classified images ISOdata and K-means.

RESULTS

The hyperspectral imaging has a high resolution that can be used to analyze or classify various forms of land use and land cover. Figure 1 is the methodology of the proposed work. Fig. 2 shows the layer stacked image of Bands 1, 3, and 4 respectively as a false colour composite (FCC).

Figures 3 and 4 show the different types of LULC identified from the output of ISOdata and K-means are Class 1 (Red) Coastal water, Class 2 (Violet) Barren land, Class 3 (Blue) Soil1, Class 4 (Yellow) Soil2, Class 5 (Cyan blue) Shallow water, and Class 6 (Pink) Cloud, Class 7 (Brown) Cloud Shadow, Class 8 (Purple) Fallow land, Class 9 (Orange) Forest, Class 10 (Green) Deep water, Class 11(Electric blue) - Agricultural land.

Figure 5 Shows the comparison of ISOdata and K-mean technique (independent samples t-test means±1 SD). It shows that the ISOdata and K-means performed equally without any difference.

Tables 1 and 2 show the groups defined using the K-means and ISOdata techniques, as well as the corresponding LULC forms and percentage classification results for different LULC types. From the values of class 1 and class 5 with 4219.94 km^2 and 859.74 km^2 respectively, indi-cates more water in the selected area of study while class 10 and class 11 covers total area of 1033.71 $km^2$and 2938.45 km^2 for the vegetation class. Tables 3 and 4 exhibit the mean and standard error of two algorithms, ISOdata and K-means of 11 Samples. Mean of both the algorithms are the same (Mean =1096.00) and SD is same in both ISOdata and K-means (SD =1303.40) and independent t test shows an insignificant value of 1.000 is obtained for both the groups.

DISCUSSION

It is observed that the ISOdata and K-means classifier performed equally with no difference in this study.

The similar findings made by (Abbas et al. 2016), in which the authors have concluded that it has been determined that unsupervised classification of land patterns with K-Means and ISOdata by adjusting the parameter values for number of iterations, number of classes, and shift threshold yields a different degree of accuracy and each explain its success according to literature. Recent advancements in satellite sensor technologies have been matched by the emergence of new and novel approaches to RS data analysis and integration and The research has led to the development of new methods for mineral evaluation that are based on sustainable and environmentally friendly natural resource exploitation.

The opposing findings were made by (Sirat, Setiawan, and Ramdani 2018). The K-Means method yields a Silhouette Coefficient (SC) of 0.999997187, while the ISOdata method yields a Silhouette Coefficient of 0.999957161. In this case, the K-Means algorithm has a higher SC value than the Isodata algorithm in clustering the data of fire spots with a slight SC value gap.

High quality research in various disciplines with particular reference to evidence-based work is carried out in our institution (Vijayashree Priyadharsini 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Ramesh et al. 2018; Mathew et al. 2020). We hope this study adds to this rich legacy.

The limitations of the study are the classifier's spectral classification does not correspond to the knowledge groups of interest to the analyst, and the analyst has little control over the menu of classes. Relevant groups' spectral properties will evolve over time (relationships between information classes and spectral classes are not constant).

CONCLUSION

A different method of unsupervised classification has been applied and tested extensively for flood prone regions. From these it has been concluded that unsupervised classification of ISOdata and K-means classifiers performed equally and there is no significant difference between these classifiers.

DECLARATIONS

Conflict of interests

No conflict of interests in this manuscript

Authors Contributions

Author MSK was involved in data collection, data analysis, manuscript writing. Author SVL was involved in conceptualization, data validation, and critical review of the manuscript.

Acknowledgments

The authors would like to express their gratitude towards Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding: We would also like to thank the following organisations for providing financial assistance to complete the study.

1. Venkata Narasimhulu Farms, Andhra Pradesh
2. Saveetha University
3. Saveetha Institute of Medical And Technical Sciences
4. Saveetha School of Engineering

REFERENCES

1. Abbas, A. W., N. Minallh, N. Ahmad, S. A. R. Abid, and M. A. A. Khan. 2016. "K-Means and ISODATA Clustering Algorithms for Landcover Classification Using Remote Sensing." *Sindh University Research Journal - SURJ (Science Series)* 48 (2). https://sujo-old.usindh.edu.pk/index.php/SURJ/article/view/2358.
2. Bandyopadhyay, Sanghamitra, and Sriparna Saha. 2012. *Unsupervised Classification: Similarity Measures, Classical and Metaheuristic Approaches, and Applications*. Springer Science & Business Media.
3. Batra, Usha, Nihar Ranjan Roy, and Brajendra Panda. 2020. *Data Science and Analytics: 5th International Conference on Recent Developments in Science, Engineering and Technology, REDSET 2019, Gurugram, India, November 15–16, 2019, Revised Selected Papers, Part II*. Springer Nature.
4. DeSouza, Sherwin I., M. R. Rashmi, Agalya P. Vasanthi, Suchitha Maria Joseph, and Rashmi Rodrigues. 2014. "Mobile Phones: The next Step towards Healthcare Delivery in Rural India?" *PloS One* 9 (8): e104895.
5. Ezhilarasan, Devaraj, Velluru S. Apoorva, and Nandhigam Ashok Vardhan. 2019. "Syzygium Cumini Extract Induced Reactive Oxygen Species-Mediated Apoptosis in Human Oral Squamous Carcinoma Cells." *Journal of Oral Pathology & Medicine: Official Publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology* 48 (2): 115–21.
6. Giri, Chandra P. 2016. *Remote Sensing of Land Use and Land Cover: Principles and Applications*. CRC Press.
7. Jain, Ravindra Kumar, Sridhar Prem Kumar, and W. S. Manjula. 2014. "Comparison of Intrusion Effects on Maxillary Incisors among Mini Implant Anchorage, J-Hook Headgear and Utility Arch." *Journal of Clinical and Diagnostic Research: JCDR* 8 (7): ZC21–24.
8. Johnson, Jayapriya, Ganesh Lakshmanan, Biruntha M, Vidhyavathi R M, Kohila Kalimuthu, and Durairaj Sekar. 2020. "Computational Identification of MiRNA-7110 from Pulmonary Arterial Hypertension (PAH) ESTs: A New microRNA That Links Diabetes and PAH." *Hypertension Research: Official Journal of the Japanese Society of Hypertension* 43 (4): 360–62.
9. Kane, Sean P., Phar, and BCPS. n.d. "Sample Size Calculator." Accessed June 26, 2021. https://clincalc.com/stats/samplesize.aspx.
10. Keerthana, B., and M. S. Thenmozhi. 2016. "Occurrence of Foramen of Huschke and Its Clinical Significance." *Journal of Advanced Pharmaceutical Technology & Research* 9 (11): 1835.
11. Krishna, R. Nivesh, and K. Yuvaraj Babu. 2016. "Estimation of Stature from Physiognomic Facial Length and Morphological Facial Length." *Journal of Advanced Pharmaceutical Technology & Research* 9 (11): 2071.
12. Lakshmi, S. Vidhya, S. Vidhya Lakshmi, Jijo James, S. Soundariya, T. Vishalini, and P. Kasinatha Pandian. 2015. "A Comparison of Soil Texture Distribution and Soil Moisture Mapping of Chennai Coast Using Landsat ETM and IKONOS Data." *Aquatic Procedia*. https://doi.org/10.1016/j.aqpro.2015.02.188.
13. Mathew, M. G., S. R. Samuel, A. J. Soni, and K. B. Roopa. 2020. "Evaluation of Adhesion of Streptococcus Mutans, Plaque Accumulation on Zirconia and Stainless Steel Crowns, and Surrounding Gingival Inflammation in Primary …." *Clinical Oral Investigations*. https://link.springer.com/article/10.1007/s00784-020-03204-9.
14. Menon, Aniruddh, and M. S. Thenmozhi. 2016. "Correlation between Thyroid Function and Obesity."

Journal of Advanced Pharmaceutical Technology & Research 9 (10): 1568.

15. Nasim, Iffat, Prasanna Neelakantan, R. Sujeer, and C. V. Subbarao. 2010. "Color Stability of Microfilled, Microhybrid and Nanocomposite Resins--an in Vitro Study." *Journal of Dentistry* 38 Suppl 2 (June): e137–42.
16. Neuenschwander, Amy L. 2009. "Landcover Classification of Small-Footprint, Full-Waveform Lidar Data." *Journal of Applied Remote Sensing*. https://doi.org/10.1117/1.3229944.
17. "[No Title]." n.d. Accessed June 28, 2021. https://www.acadpubl.eu/hub/2018-119-17/4/304.pdf.
18. Pan, Feifei, Xiaohuan Xi, and Cheng Wang. n.d. "A Comparative Study of Water Indexes and Image Classification Algorithms for Mapping Inland Surface Water Bodies Using Landsat Imagery." https://doi.org/10.20944/preprints201911.0218.v1.
19. Priyadarshini, K. N., and M. Kumar. 2018. "A Comparative Study of Advanced Land Use/land Cover Classification Algorithms Using Sentinel-2 Data." *, Remote Sensing …*. https://pdfs.semanticscholar.org/a9f7/2c457239c22cd86f19e992247e91f9810e34.pdf.
20. Ramesh, Asha, Sheeja Varghese, Nadathur D. Jayakumar, and Sankari Malaiappan. 2018. "Comparative Estimation of Sulfiredoxin Levels between Chronic Periodontitis and Healthy Patients - A Case-Control Study." *Journal of Periodontology* 89 (10): 1241–48.
21. Rani, M. Mary Shanthi, M. Mary Shanthi Rani, Dept. of Computer Science and Applications, Gandhigram Rural University Gandhigram, Tamilnadu, and India. 2015. "A Genetic Algorithm Based K-Means Algorithm For Compressing Images." *International Journal Of Engineering And Computer Science*. https://doi.org/10.18535/ijecs/v4i9.50.
22. Ravikumar, P., G. Bhaskaran, and Others. 2018. "Assessment of Changes in the Land Use and Land Cover Pattern Using Matrix Union Method: A Case Study of Cuddalore District, Tamil Nadu, India." *International Journal for Research in Applied Science and Engineering Technology* 6 (4): 4828–32.
23. Rosen, David. 2000. "Methods for Correcting Topographically Induced Radiometric Distortion on Landsat Thematic Mapper Images for Land Cover Classification." https://doi.org/10.15760/geogmaster.12.
24. Salih, Abdelrahim. 2018. "Classification and Mapping of Land Cover Types and Attributes in Al-Ahsaa Oasis, Eastern Region, Saudi Arabia Using Landsat-7 Data." *Journal of Remote Sensing & GIS*. https://doi.org/10.4172/2469-4134.1000228.
25. Samuel, Melvin S., Jayanta Bhattacharya, Sankalp Raj, Needhidasan Santhanam, Hemant Singh, and N. D. Pradeep Singh. 2019. "Efficient Removal of Chromium(VI) from Aqueous Solution Using Chitosan Grafted Graphene Oxide (CS-GO) Nanocomposite." *International Journal of Biological Macromolecules* 121 (January): 285–92.
26. Samuel, Srinivasan Raj, Shashidhar Acharya, and Jeevika Chandrasekar Rao. 2020. "School Interventions-Based Prevention of Early-Childhood Caries among 3-5-Year-Old Children from Very Low Socioeconomic Status: Two-Year Randomized Trial." *Journal of Public Health Dentistry* 80 (1): 51–60.
27. Sekhar, C. H., V. Narayanan, and M. F. Baig. 2001. "Role of Antimicrobials in Third Molar Surgery: Prospective, Double Blind,randomized, Placebo-Controlled Clinical Study." *The British Journal of Oral & Maxillofacial Surgery* 39 (2): 134–37.
28. Sirat, Edo Fadila, Budi Darma Setiawan, and Fatwa Ramdani. 2018. "Comparative Analysis of K-Means and Isodata Algorithms for Clustering of Fire Point Data in Sumatra Region." *2018 4th International Symposium on Geoinformatics (ISyG)*. https://doi.org/10.1109/isyg.2018.8611879.
29. Sivakumar, Vidhya Lakshmi, Rakshith Radha Krishnappa, and Manoj Nallanathel. 2021. "Drought Vulnerability Assessment and Mapping Using Multi-Criteria Decision Making (MCDM) and Application of Analytic Hierarchy Process (AHP) for Namakkal District, Tamilnadu, India." *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2020.09.657.
30. Sriram, Nirisha, Thenmozhi, and Samrithi Yuvaraj. 2015. "Effects of Mobile Phone Radiation on Brain: A Questionnaire Based Study." *Journal of Advanced Pharmaceutical Technology & Research* 8 (7): 867.
31. Subashri, A., and M. S. Thenmozhi. 2016. "Occipital Emissary Foramina in Human Adult Skull and Their Clinical Implications." *Journal of Advanced Pharmaceutical Technology & Research* 9 (6): 716.
32. Thejeswar, E. P., and M. S. Thenmozhi. 2015. "Educational Research-iPad System vs Textbook System." *Journal of Advanced Pharmaceutical Technology & Research* 8 (8): 1158.
33. Uddin, Kabir, Mir A. Matin, and Franz J. Meyer. 2019. "Operational Flood Mapping Using Multi-

Temporal Sentinel-1 SAR Images: A Case Study from Bangladesh." *Remote Sensing* 11 (13): 1581.
34. Venu, Harish, Lingesan Subramani, and V. Dhana Raju. 2019. "Emission Reduction in a DI Diesel Engine Using Exhaust Gas Recirculation (EGR) of Palm Biodiesel Blended with TiO2 Nano Additives." *Renewable Energy* 140 (September): 245–63.
35. Vidhya, S., Lakshmi Y. Vinay, and Kumar Reddy. 2019. "MULTICRITERIA DECISION MAKING AHP BASED GROUNDWATER POTENTIAL MAPPING FOR GUMMIDIPOONDI DISTRICT." *International Journal of Pure and Applied Mathematics: IJPAM* 119 (17): 41.
36. Vijayashree Priyadharsini, Jayaseelan. 2019. "In Silico Validation of the Non-Antibiotic Drugs Acetaminophen and Ibuprofen as Antibacterial Agents against Red Complex Pathogens." *Journal of Periodontology* 90 (12): 1441–48.
37. Zhang, Jie, and John Kerekes. 2011. "Unsupervised Urban Land-Cover Classification Using WorldView-2 Data and Self-Organizing Maps." *2011 IEEE International Geoscience and Remote Sensing Symposium*. https://doi.org/10.1109/igarss.2011.6048920.

FIGURES AND TABLES

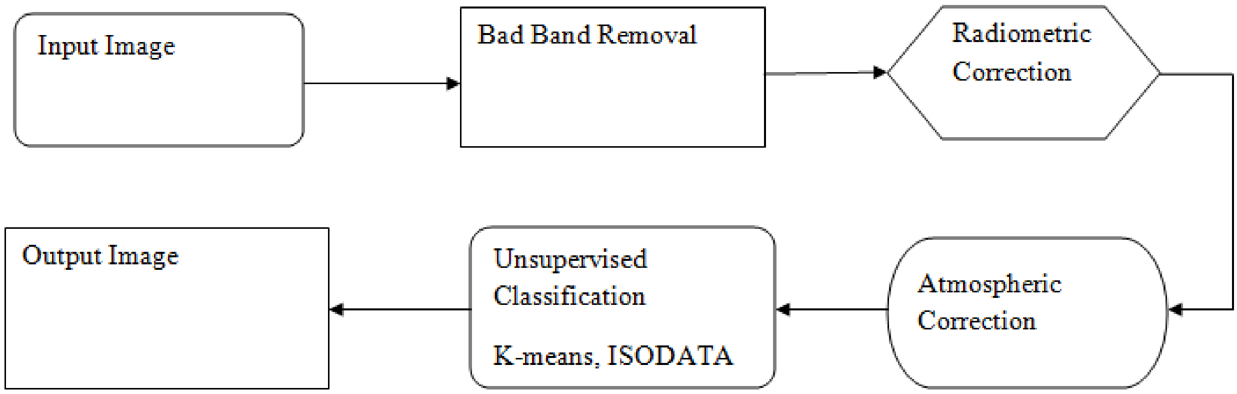

Fig. 1: A flowchart depicting the methodology adopted in this study

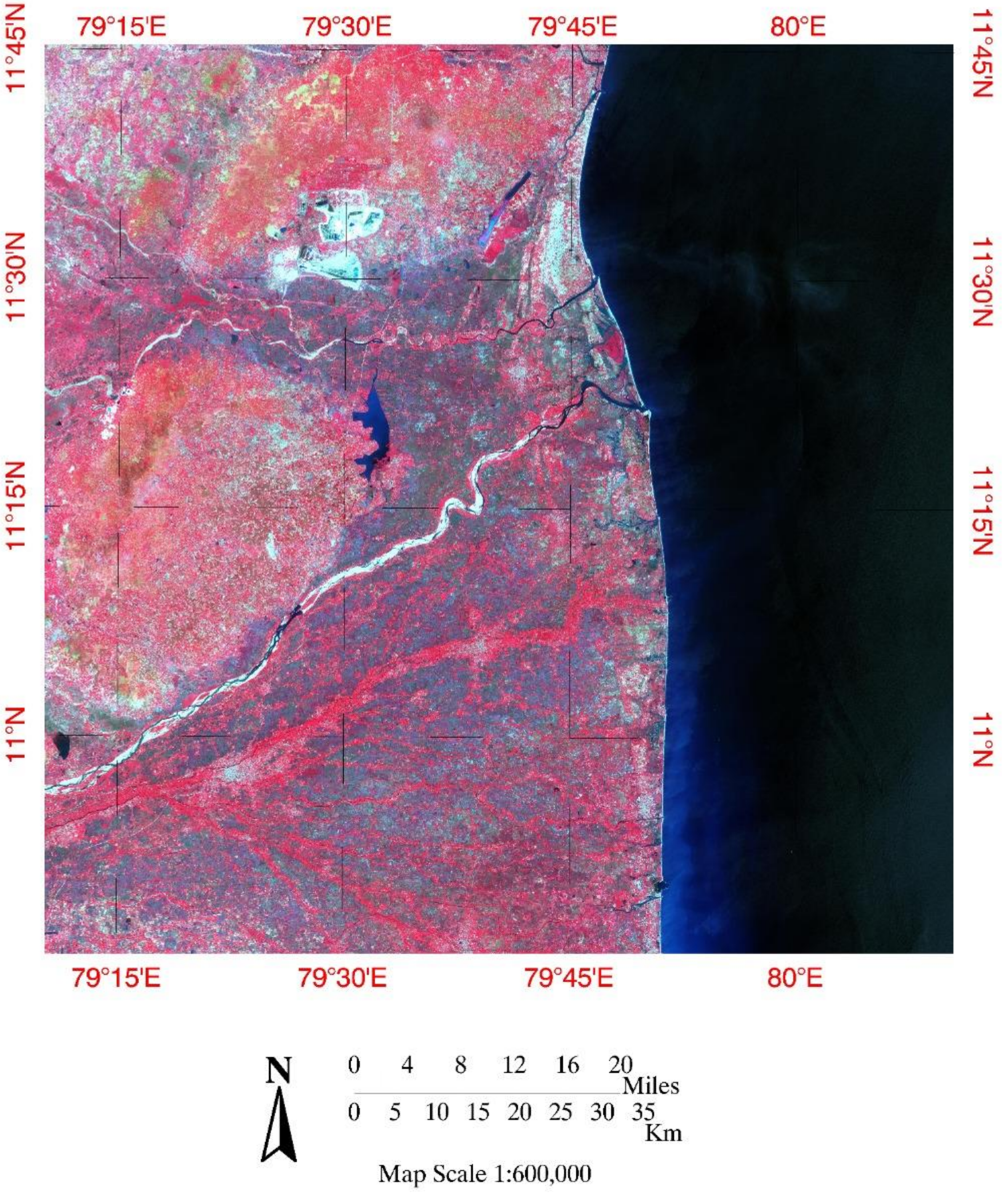

Fig. 2: A false colour composite image of the study region generated after layer stacking from Sentinel 2A captured in October 2021 (Source: U.S. Geological Survey)

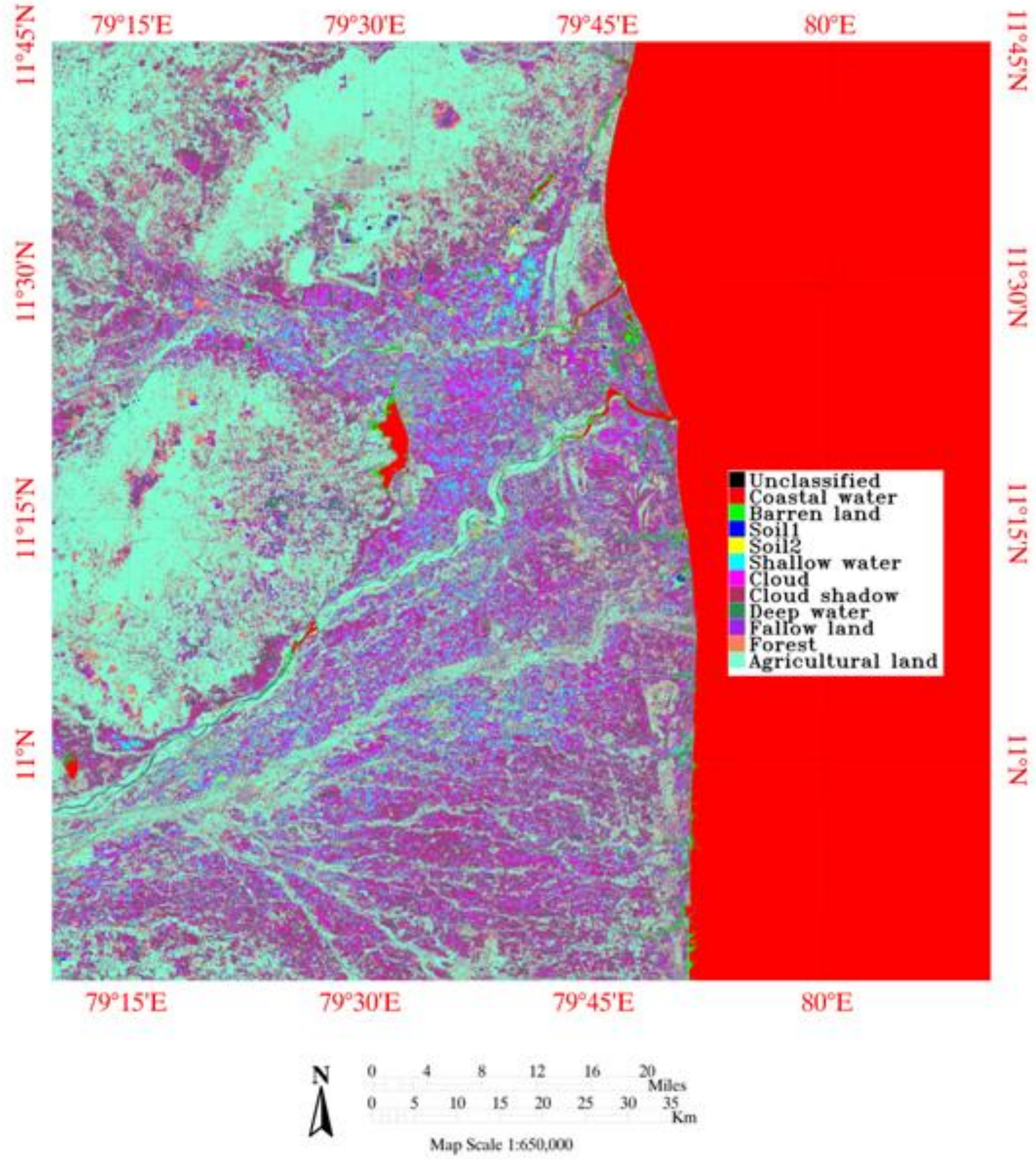

Fig. 3: Classified image of the study region using ISOdata unsupervised classification algorithm.

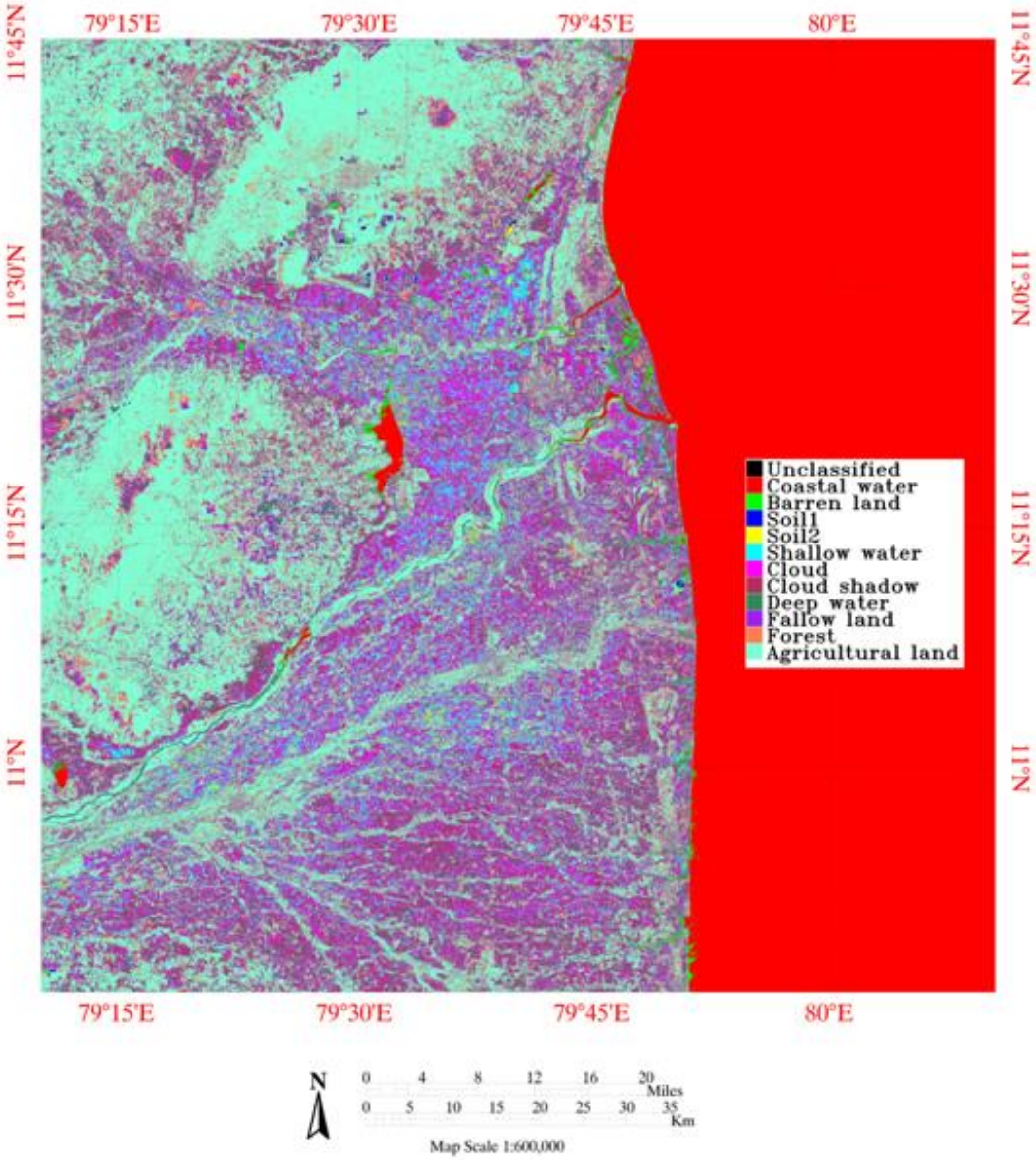

Fig. 4: Classified image of the study region using K-means unsupervised classification algorithm.

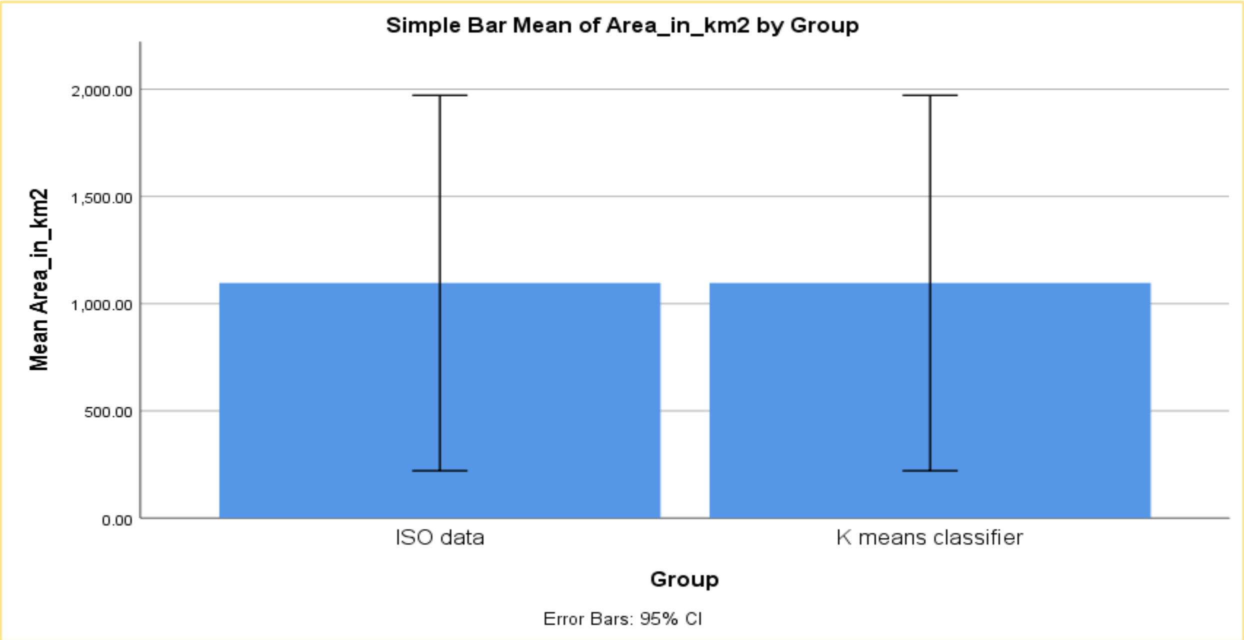

Fig. 5 Bar chart representing the comparison of ISOdata and K-mean techniques (independent samples t-test means = ±1 SD). It shows that the ISOdata and K-means performed equally without any difference. X-axis: represents ISOdata vs K-means Y-axis: represents Mean Area in km^2 ± 1 SD.

.

Table 1. The area occupied by the various LULC classes as calculated by ISOdata unsupervised classifier, along with the percentage of area occupied in the study area image

Class Summary	Pixel count	Percentage of area in the satellite image	Area in km^2
Unclassified	0	0	0
Coastal water	42199443	35.00	4219.94
Barren land	589968	0.48	58.99
Soil1	475274	0.39	47.52
Soil2	1494993	1.24	149.49
Shallow water	5548707	4.60	554.87
Cloud	8597448	7.13	859.74
Cloud shadow	7762819	6.43	776.28
Deep water	6400421	5.30	640.04
Fallow land	7768808	6.44	776.88
Forest	10337933	8.57	1033.79
Agricultural land	29384586	24.37	2938.45

Table 2. The area occupied by the various LULC classes as calculated by K-means unsupervised classifier,

along with the percentage of area occupied in the study area image

Class Summary	Pixel count	Percentage of area in the satellite image	Area in km^2
Unclassified	0	0	0
Coastal water	42199443	35.00	4219.94
Barren land	589968	0.48	58.99
Soil1	475274	0.39	47.52
Soil2	1494993	1.24	149.49
Shallow water	5548707	4.60	554.87
Cloud	8597448	7.13	859.74
Cloud shadow	7762819	6.43	776.28
Deep water	6400421	5.30	640.04
Fallow land	7768808	6.44	776.88
Forest	10337933	8.57	1033.79
Agricultural land	29384586	24.37	2938.45

Table 3. Statistics of the groups depicting the mean, standard deviation, and standard error mean values for the two groups studied, ISOdata and K-means, with 11 samples for each group. The confidence interval is set at 95%. The mean and standard deviation values for both the groups are identical.

Groups		N	Mean	Std.Deviation	Std.Error Mean
Area_ km^2	ISOdata	11	1096.00	1303.40	392.99
	K-means	11	1096.00	1303.40	392.99

Table 4. Independent samples T-test shows that there is no statistical significance ($p<0.05$) between ISOdata and K-means and it also shows that results from both the classifiers are identical.

		Leven's Test For Equality of Variances		**T-Test For Equality Of Means**						
				t	**df**	**Sig (2-tailed)**	**Mean difference**	**Std.Error Difference**	**95% Confidence Interval Of The Difference**	
		F	**Sig**						**Lower**	**Upper**
Area_ km^2	**Equal variances assumed**	0.00	1.00	0.00	20	1.00	0.00	555.77	-1159.32	1159.32
	Equal variances not assumed			0.00	20	1.00	0.00	555.77	-1159.32	1159.32