2024 IEEE Conference on Computing, Applications and Systems (COMPAS)

A Semi-Supervised Approach For Detecting Agricultural Land Reduction In Bangladesh Using Satellite Images

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INTRODUCTION

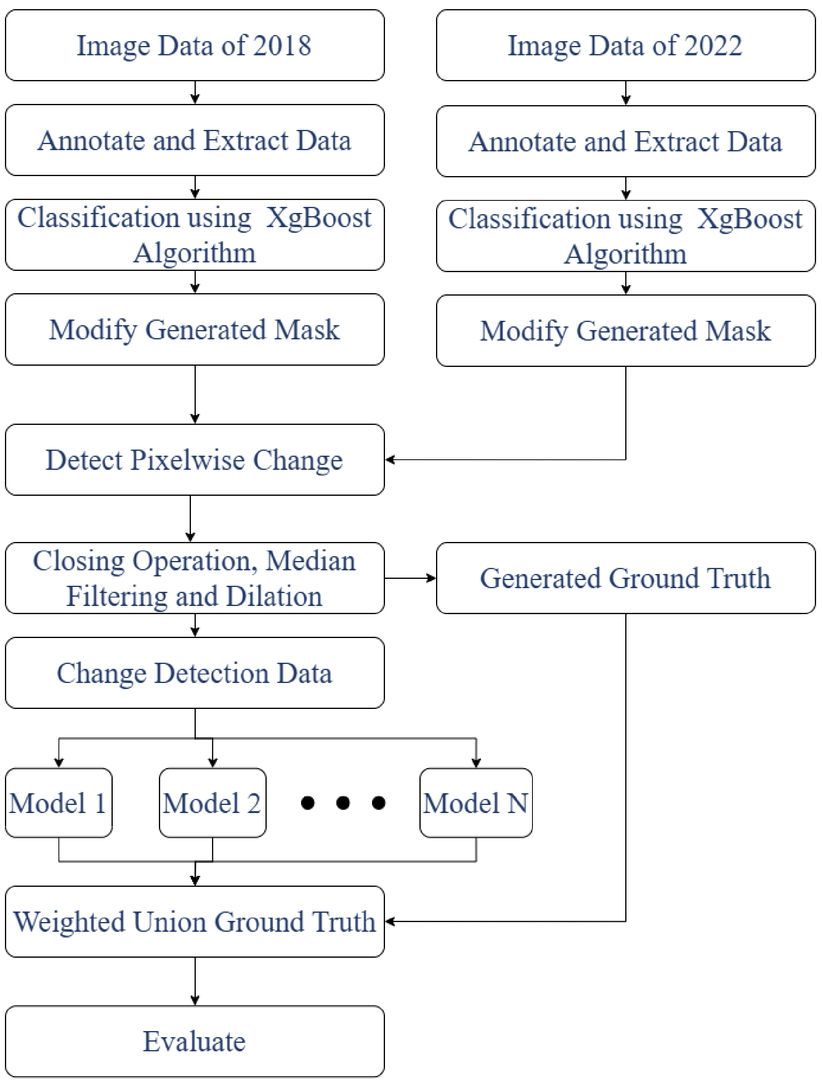
Agricultural land in Bangladesh is decreasing at alarming rate. Traditional land monitoring methods are often time consuming and expensive. Deep learning algorithms on change detection can be utilized, but these algorithm require high resolution image data, which are expensive, lack global coverage, and have a maximum of 4 channel. Sentinel satellite data, provided by Copernicus solve these issues, as they are free, provide global coverage, and consist of 12 bands. But deep learning algorithms including change detection algorithms require labeled data, which are limited. This data annotation task is difficult and time costly as these data are not high resolution image. To address the above challenge, a semi-supervised method was developed for change detection on medium-resolution satellite images. By employing this semi-supervised method, only a small amount of data needs to be annotated initially. Subsequently, changes in the data can be detected automatically with high precision, significantly reducing the time required for manual annotation and minimizing the potential for human error.

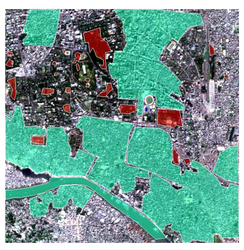
OBJECTIVES

- Develop a semi-supervised approach for change detection on pair of satellite images.
- Compare various deep learning methods on the data prepared from the proposed approach.
- Evaluate the suggested methodology with other deep learning methodologies in the areas of precision, recall and similarity.
- Calculate the amount of agricultural land reduced within the test data area.

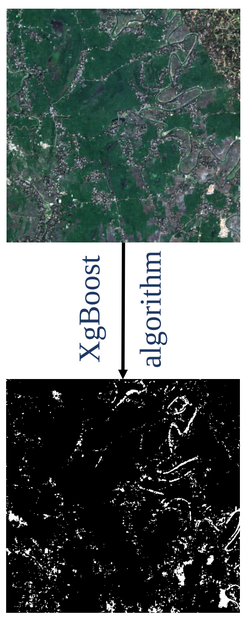
PROPOSED METHODOLOGY

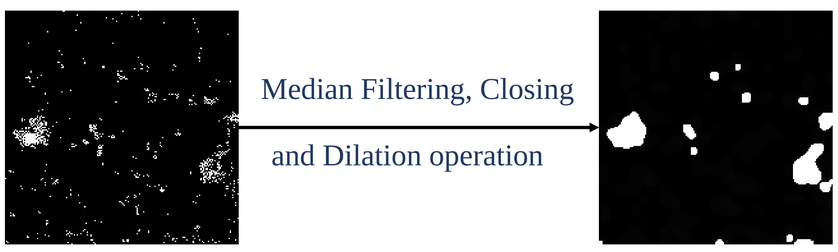
- The data, collected from Copernicus, Sentinel-2 satellite coverers specific area of Bangladesh.
- It consist of images of 2018 and 2022 with each having size (10980,10980) pixels and total of 12 channels. Channels having spatial resolutions of 10m and 20m were utilized resulting 9 channels.
- Annotation of images and then extraction of those pixels values was done using Sentinel Toolbox software named SNAP.
- The rest of the steps are explained in the following flowchart.



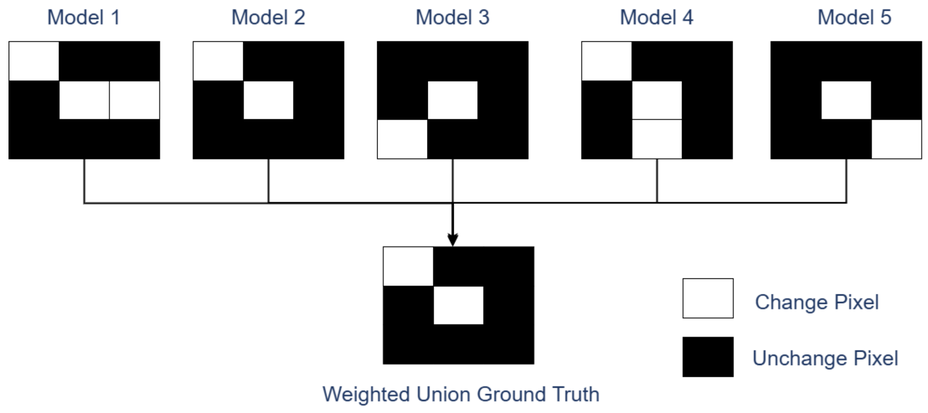


Annotation of Data





- Each image was split 60 by 60, resulting each image having a size of (183,183). Total 3600 pair of images were created.
- The final change mask generated by XgBoost algorithm can be used as a ground truth.
- After Training total of 8 deep learning models with the generated data, predicted data of each model can be blended using weighted union operations to prepare a new ground truth,.
- This new ground truth can be used to evaluate the proposed method.



RESULTS AND DISCUSSION

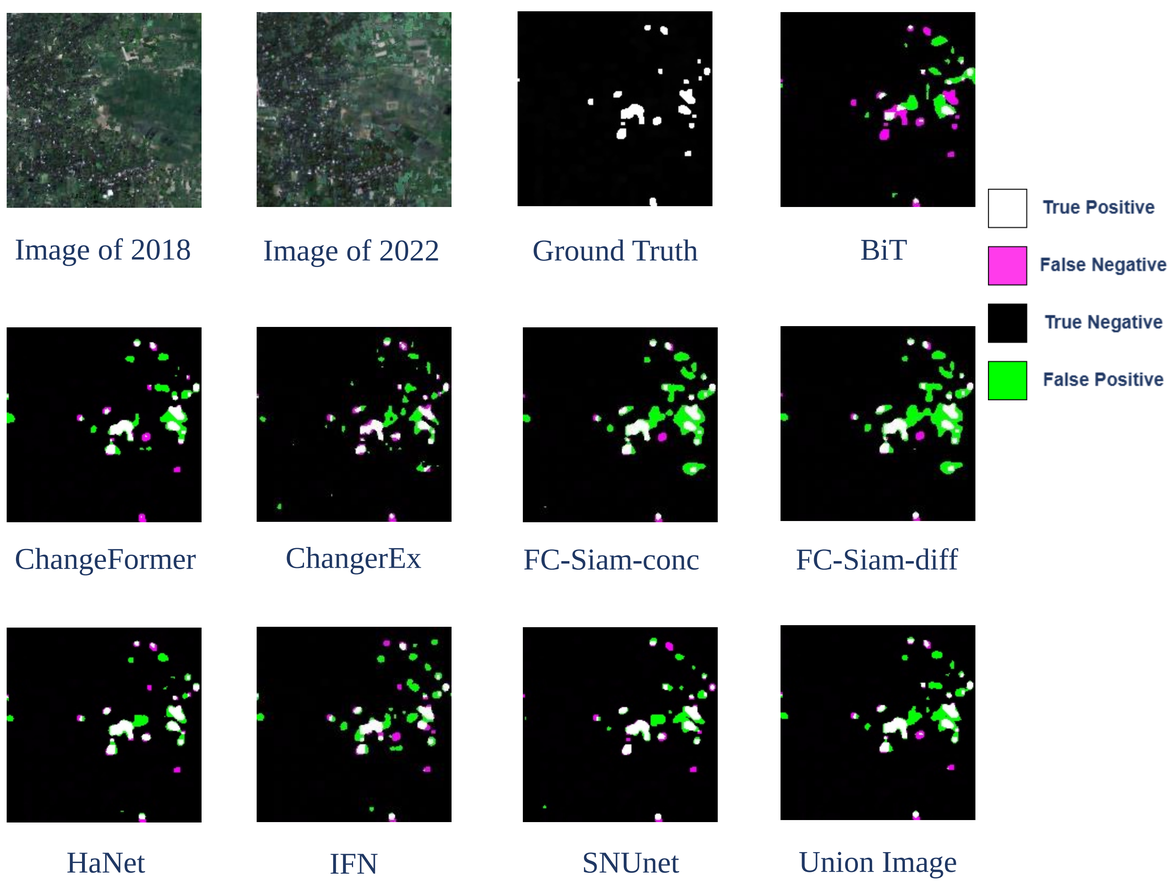
- As demonstrated on the table, the new ground truth generated from union of other deep learning models, exhibit significant similarity with the actual ground truth.
- As different deep learning methods extract distinct features and each method may have limitations in detecting changes in specific regions, so the results in not too high.
- Nevertheless, given the similarity exceeding the average, it can be said that the semi-supervised method efficiently identifies most of the changed areas, even without utilizing spatial features during training.

Model	Precision (%)	Recall (%)	F1 (%)	IOU (%)	Reduced(%)
FC-Siam-Diff	93.16	89.23	91.15	83.74	8.45
FC-Sium-Conc	93.16	89.39	91.24	83.89	8.50
IFN	92.29	90.15	91.41	84.18	9.14
BiT	92.27	88.61	90.4	82.48	8.53
SNUnet	**94.44**	89.55	**91.93**	**85.06**	8.17
ChangeFormer	93.29	89.21	91.2	83.82	8.41
Changer	90.88	**90.22**	90.55	82.73	9.49
HaNet	94.08	89.87	**91.93**	**85.06**	8.38
Proposed Method	80.87	76.11	78.02	64.80	8.35

Evaluation matrices of multiple models on test data

Approach	Total (km^2)	Reduced (km^2)	Reduced (%)
Proposed Approach	237.77	19.861	8.35
Deep Learning Models	237.77	17.156	7.21

Evaluation of agricultural land area changes



Prediction of different models and their union

CONCLUSION

The research successfully developed a semi-supervised method for change detection, compared various deep learning methodologies, and established a comprehensive set of evaluation metrics for the evaluation of various models. This approach will decrease time and effort spent finding outa change detection ground truth. It will also facilitate the assessment of the rate at which agricultural areas in urban regions of Bangladesh are declining.