Unsupervised Crop Classification Using Time Series Satellite Imagery

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INTRODUCTION

- Global population has reached 7.8 billion and is growing, presenting a challenge to food security
- Requirement of boosting agricultural production
- Smart agriculture enhances production and tackles environmental concerns
- Need of reliable and easily accessible data

INTRODUCTION (CONT.)

- Satellite provides data in form images which enables solution to diverse agricultural issues
  - Spatial resolution - 1 m, 3 m, 10 m, 30 m, 60 m, 250 m, etc.
  - Temporal resolution : 2 to 16 days
- Satellite provides multi-band data
- Vegetation Indices : NDVI, NDWI, NDMI, etc.
- Normalized Difference Vegetation Index (NDVI) = (NIR - RED) / (NIR + RED)

PROBLEM STATEMENT

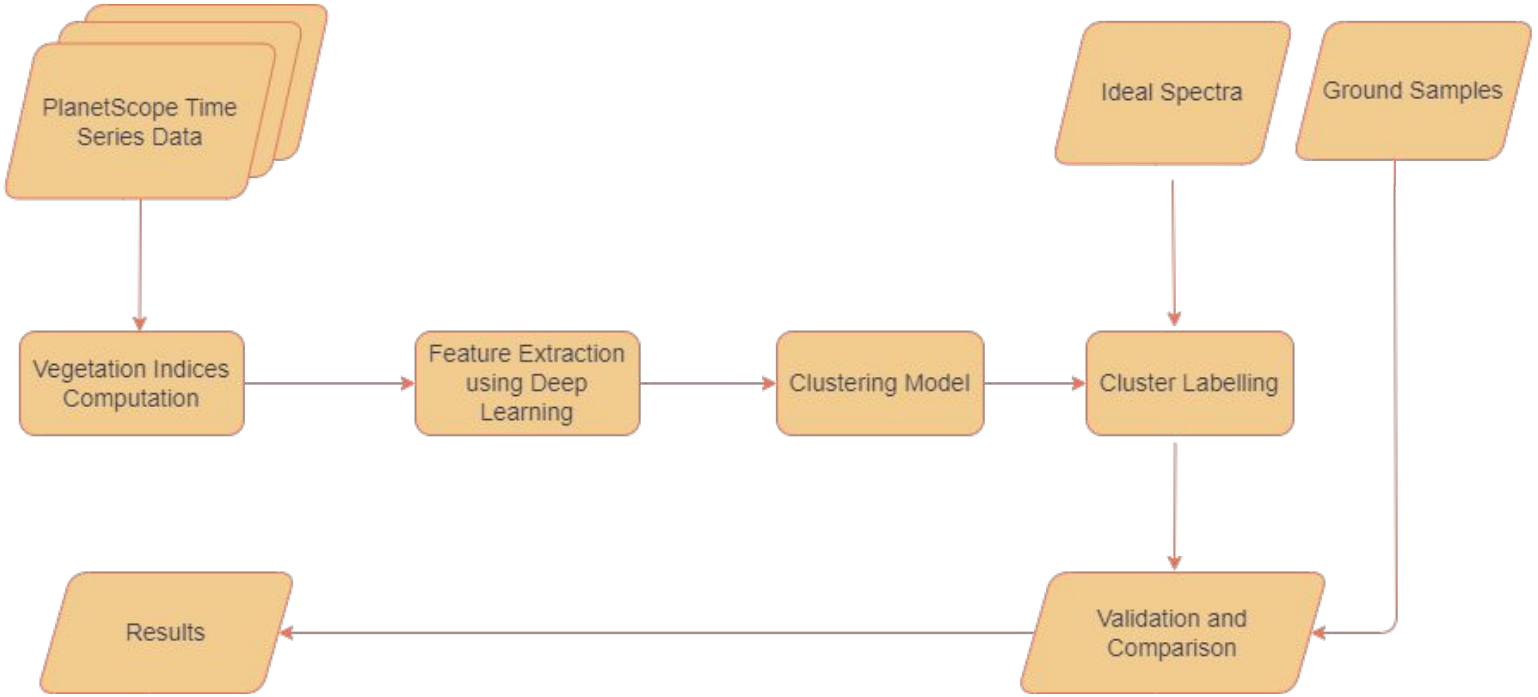
- **Can we use satellite images for crop type mapping ?**
- Potential applications
  - Crop growth monitoring
  - Production estimation
  - Supply chain planning
  - Land use planning
  - Water management

CHALLENGES & PROPOSED SOLUTION

- **Challenges**
  - Different sowing times of crops
  - Similarity between different crops
  - Variable crop varieties
  - Unlabeled areas

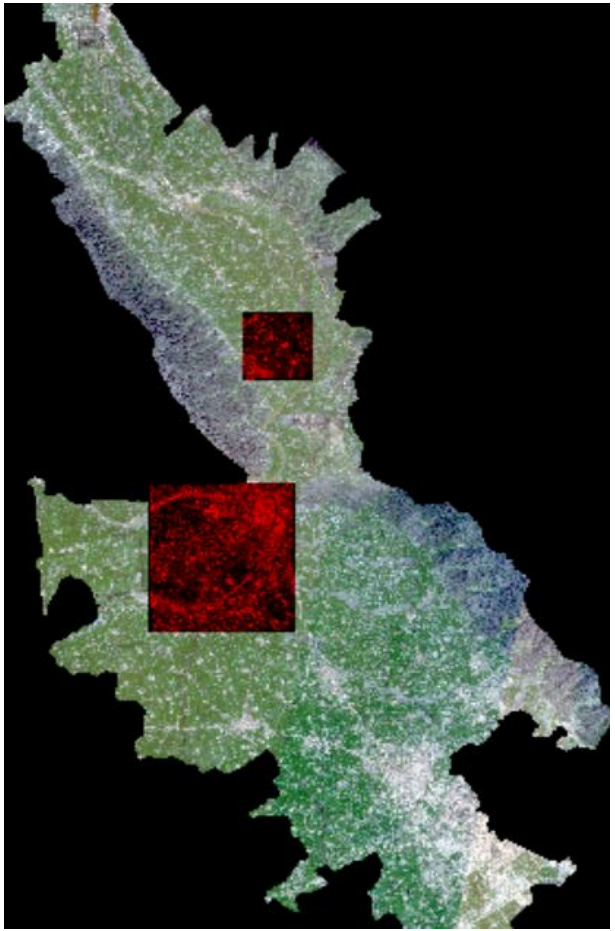
- **Proposed Solution**
  - Use of Time Series Dataset
  - Use of unsupervised ML algorithms
  - Spectral Matching

METHODOLOGY



TIME SERIES DATASET

- Upper part 38 km^2
- Lower part 178 km^2
- 32 satellite images in time series (June 2023 - Nov 2023)
- June (5 images), July (3 images), August (5 images), September (7 images), October (7 images), November (5 images)

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20221117.tif
20221121.tif
20221126.tif
20221129.tif
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20221204.tif
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20221209.tif
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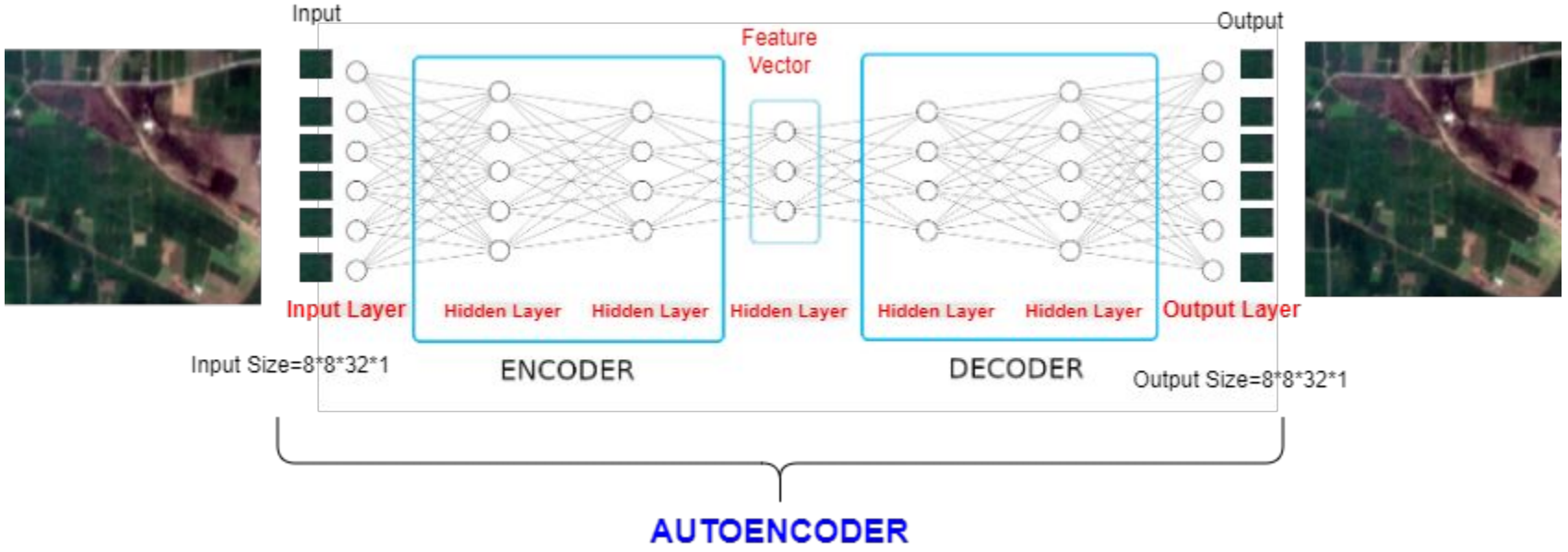
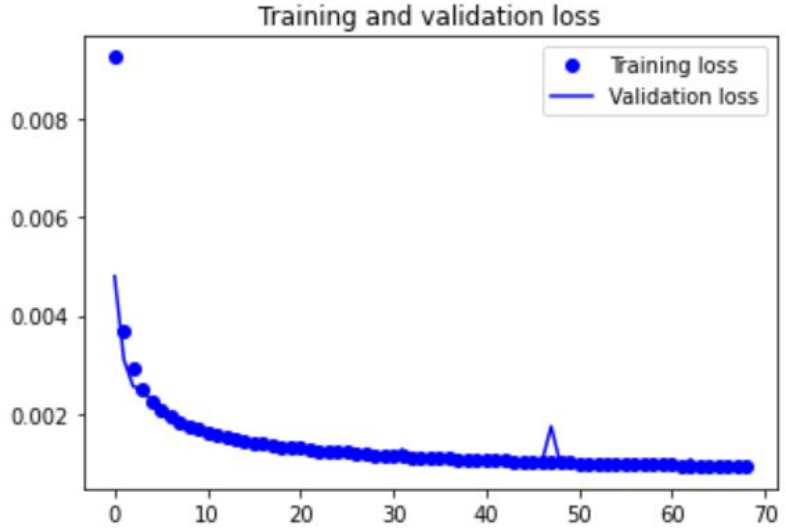
AUTOENCODER MODEL

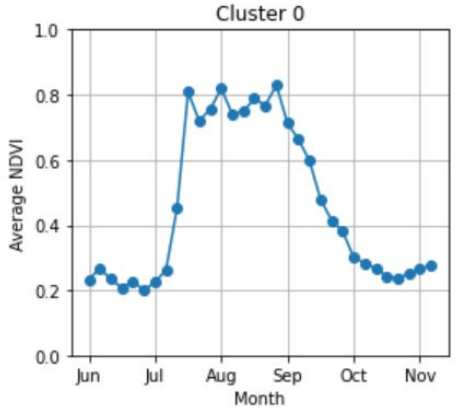


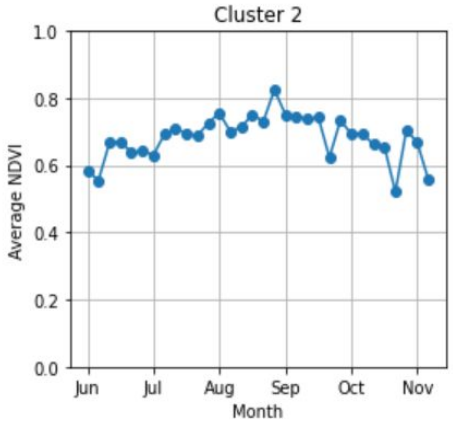
TRAINING AUTOENCODER

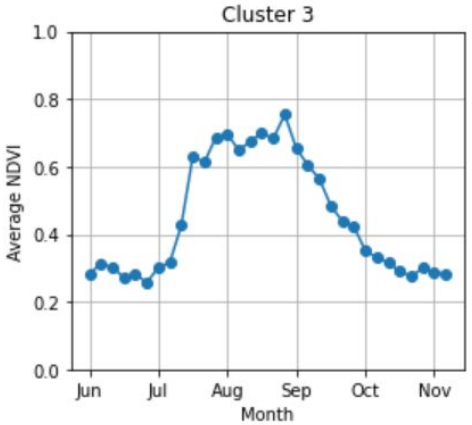
- Divided dataset into 80:20 ratio as training and validation data respectively
- Trained autoencoder for 70 epochs
- Saved only Encoder part
- Extracted feature vector

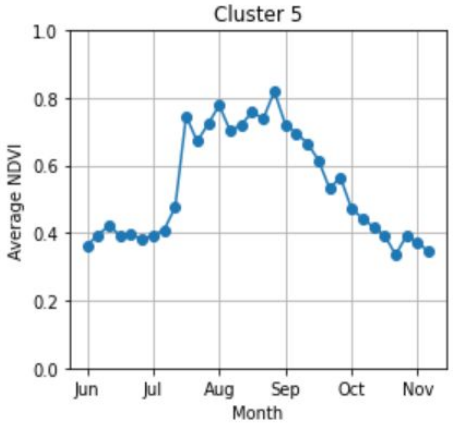


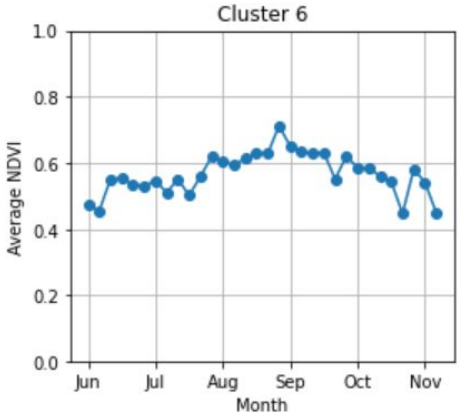
CLUSTERING USING K-MEANS

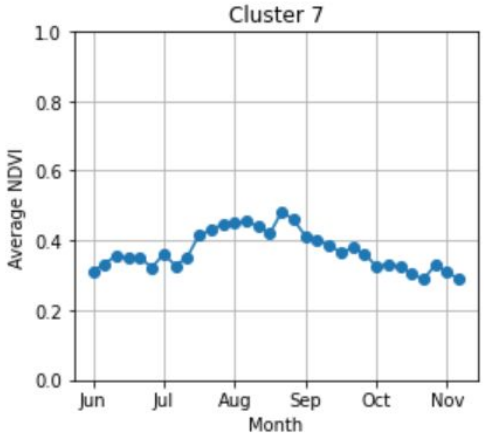


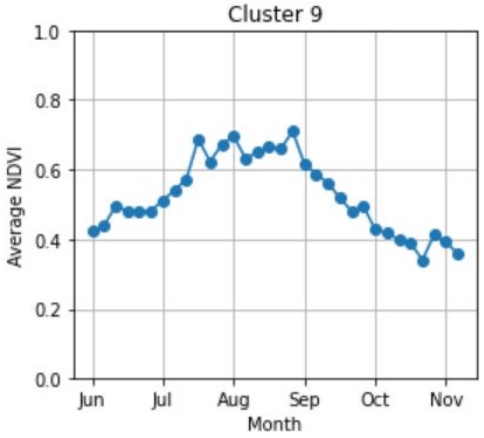









Cluster 7
Average NDVI
Month
Jun
Jul
Aug
Sep
Oct
Nov
0.0
0.2
0.4
0.6
0.8
1.0


Cluster 9
Average NDVI
Month
Jun
Jul
Aug
Sep
Oct
Nov
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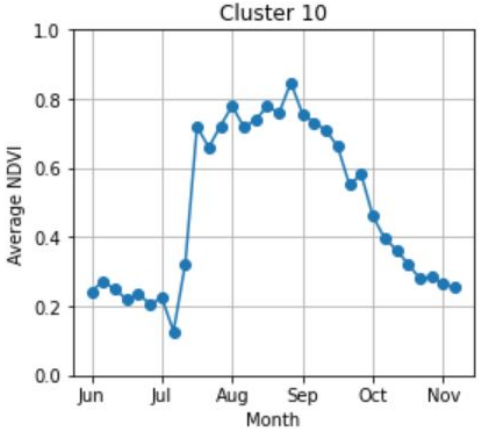
0.4
0.6
0.8
1.0


Cluster 10
Average NDVI
Month
Jun
Jul
Aug
Sep
Oct
Nov
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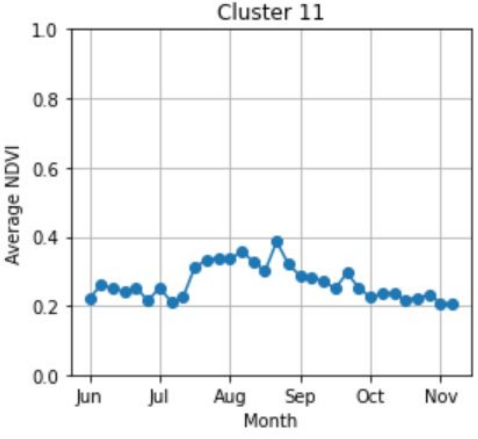
0.2
0.4
0.6
0.8
1.0


Cluster 11
Average NDVI
Month
Jun
Jul
Aug
Sep
Oct
Nov
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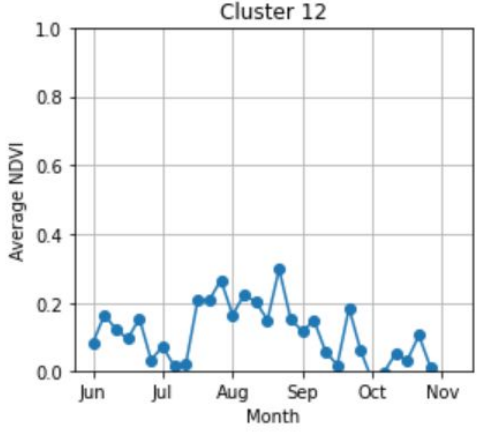
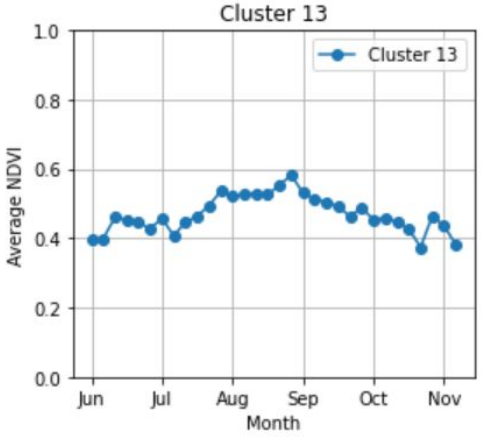
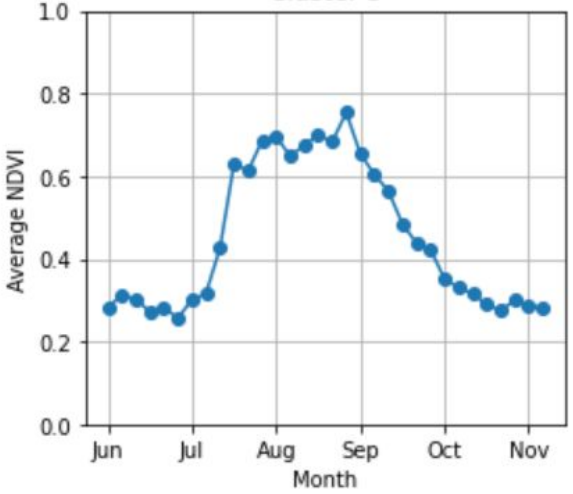
0.2
0.4
0.6
0.8
1.0

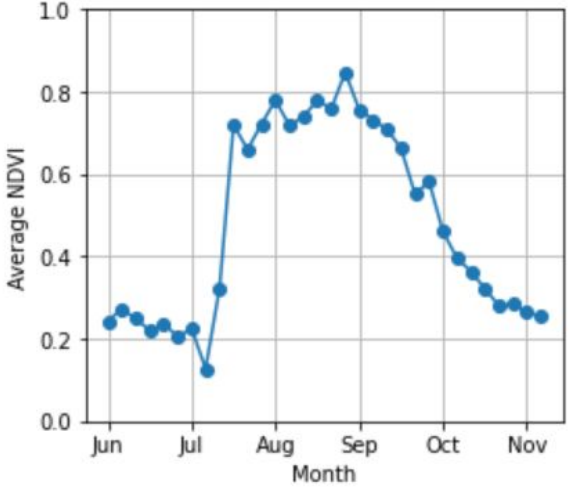

Cluster 12
Average NDVI
Month
Jun
Jul
Aug
Sep
Oct
Nov
0.0
0.2
0.4
0.6
0.8
1.0

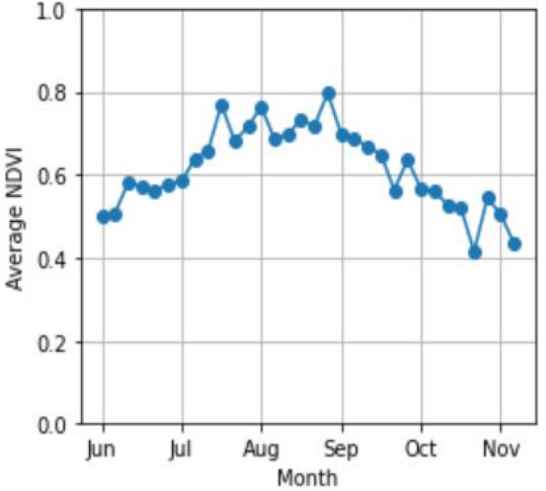

Cluster 13
Cluster 13
Average NDVI
Month
Jun
Jul
Aug
Sep
Oct
Nov
0.0
0.2
0.4
0.6
0.8
1.0

ASSIGNING CROP NAMES TO CLUSTERS

- Used ideal spectra + majority method
- Maize, paddy and sugarcane from left to right
- Finally assigned crop names to these clusters

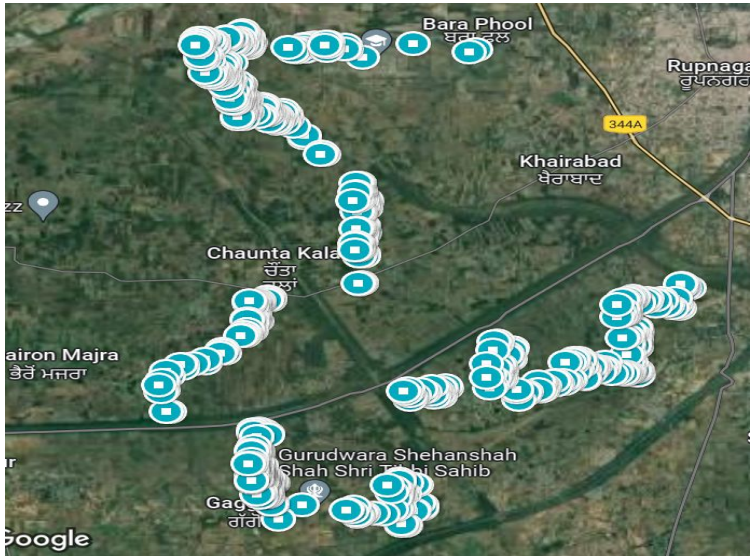


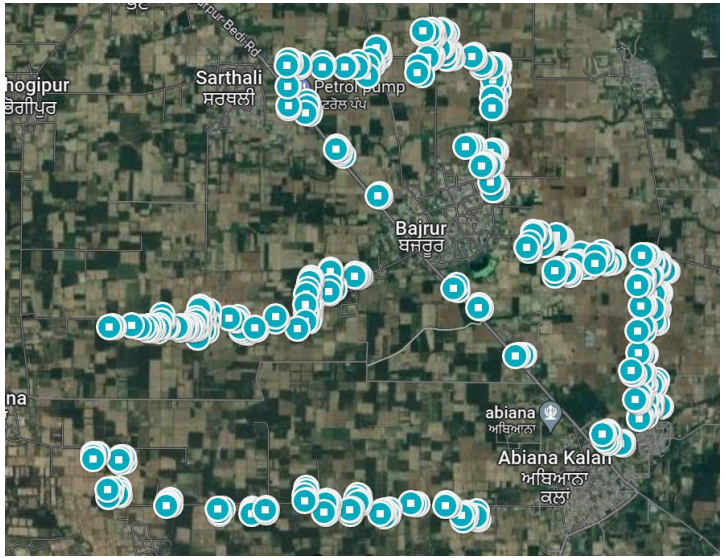




GROUND SAMPLES

- Visited 600+ crop fields in Rupnagar
- Collected around 3600 ground data points in the form of latitude & longitude
- Maize (800 points), Paddy (1940 points) and Sugarcane (830 points)





GROUND SAMPLES (CONT.)

Crop	Latitude	Longitude
Maize	31.093069	76.520368
Maize	31.09298	76.520357
Maize	31.092909	76.520322
Maize	31.09293	76.520411
Maize	31.092909	76.520352
Maize	31.093139	76.520336
Maize	31.093111	76.520408
Maize	31.092907	76.520419
Maize	31.092799	76.52032
Maize	31.092783	76.520387
Maize	31.092785	76.520347
Maize	31.093041	76.520584
Maize	31.093049	76.52068
Maize	31.092943	76.5206
Maize	31.092941	76.520533

Crop	Latitude	Longitude
Paddy	30.971968	76.468702
Paddy	30.971958	76.468776
Paddy	30.971934	76.468886
Paddy	30.971943	76.468593
Paddy	30.971334	76.468499
Paddy	30.971336	76.468947
Paddy	30.971591	76.469055
Paddy	30.971757	76.469068
Paddy	30.971766	76.468567
Paddy	30.971499	76.468526
Paddy	30.971897	76.46907
Paddy	30.971327	76.468745
Paddy	30.972413	76.466381
Paddy	30.97251	76.46621
Paddy	30.972542	76.465813

Crop	Latitude	Longitude
Sugarcane	30.971489	76.461421
Sugarcane	30.971461	76.461129
Sugarcane	30.971688	76.461446
Sugarcane	30.971644	76.461121
Sugarcane	30.971315	76.460979
Sugarcane	30.971145	76.460979
Sugarcane	30.970968	76.460864
Sugarcane	30.97086	76.461156
Sugarcane	30.970828	76.461379
Sugarcane	30.970798	76.461553
Sugarcane	30.970929	76.46162
Sugarcane	30.971111	76.461615
Sugarcane	30.971267	76.461645
Sugarcane	30.971515	76.461675
Sugarcane	30.971326	76.461399

EXPERIMENTS

- ArcMap and QGIS
- Python and Tensorflow
- Implemented four different methods
  - (Pixel based) + (K-Means) + (NDVI)
  - (Patch based) + (K-Means) + (NDVI)
  - (Autoencoder) + (Pixel based) + (K-Means) + (NDVI)
  - (Autoencoder) + (Patch based) + (K-Means) + (NDVI)

RESULTS

Method	Maize(Accuracy%)	Paddy(Accuracy%)	Sugarcane(Accuracy%)
Pixel Based	74.76	67.73	91.42
Patch Based	79.56	63.35	87.53
Autoencoder + Pixel Based	74.49	70.78	**94.50**
Autoencoder + Patch Based	**85.60**	**72.64**	83.78

CONCLUSION

- Proposed new method to map different crop types
- Used Autoencoder for feature extraction
- Future work may include working on more number of crops

QUESTIONS

THANK YOU