Continuous Mapping and Monitoring Framework for Habitat Analysis in the United Arab Emirates

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Outline

- Introduction
- Habitat mapping in UAE
- Proposed Work
- Data and Results
- Future Work

Introduction

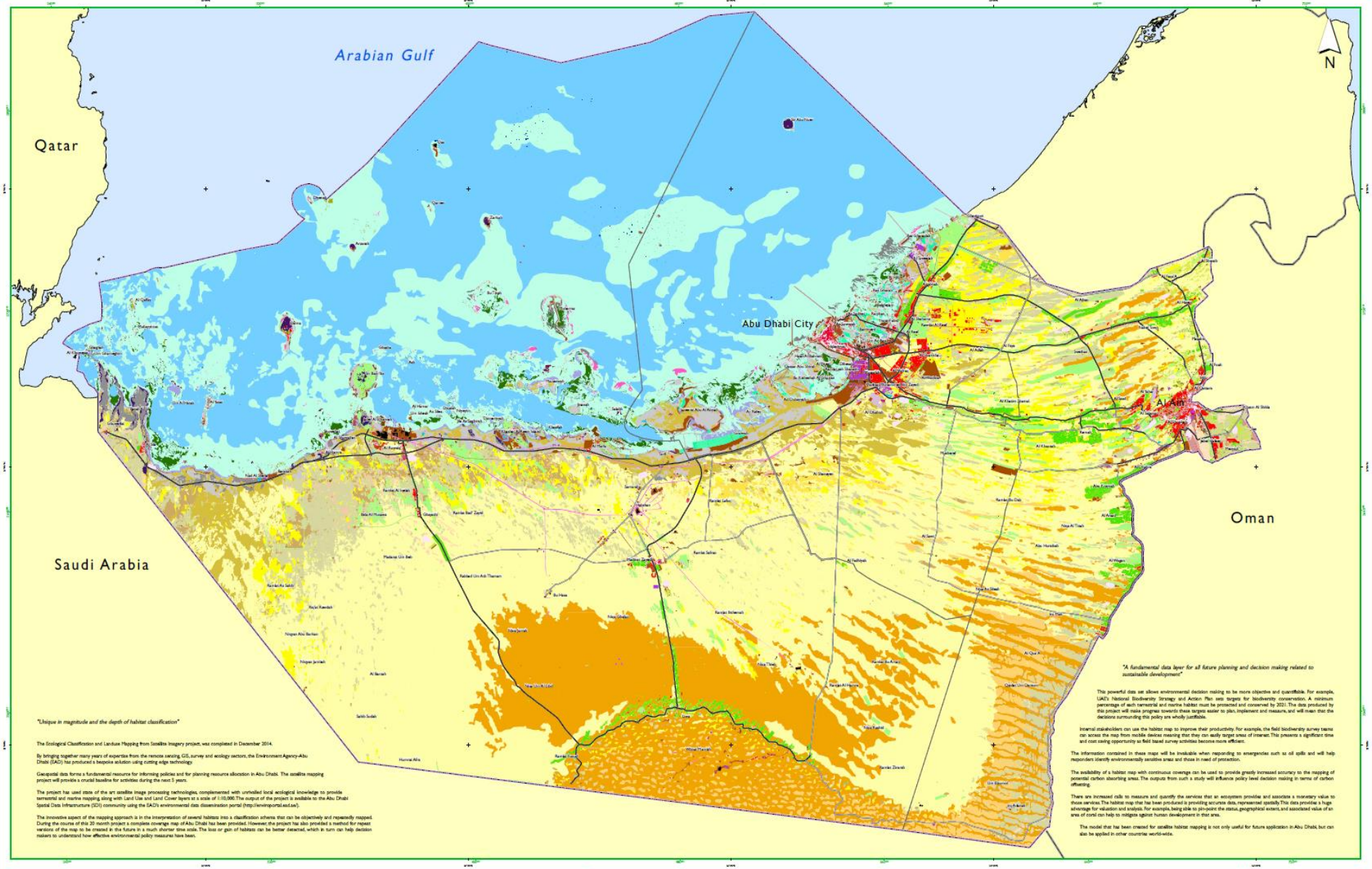
- United Arab Emirates (UAE) has seen a tremendous growth in the last decades developing advanced urban centers in the world e.g., Abu Dhabi and Dubai
- Rapid development can put the environment under significant stress
- Need for continuous monitoring of the landcover and landuse to make informed decisions
- Environment Agency- Abu Dhabi (EAD) has developed a detailed Habitat, Land Use, Land Cover Map based on very high resolution satellite imagery acquired between 2011 and 2013 for the Abu Dhabi Emirate.

Habitat mapping in the UAE

- First comprehensive mapping exercise: 2013
  - A total land area of 60,000 km^2 and a marine area of 30,000 km^2 has been mapped at 1:10,000 scale with an accuracy of around 87% on an average.
  - A total of 54 different natural and man-made mapping categories at a very fine level of detail, with 41 terrestrial and 13 marine habitat categories.
  - The map serves as a baseline to assess the state of fragile habitats in Abu Dhabi Emirate.
  - WorldView-2 and RapidEye satellite data were used for the generation of the maps.

https://www.ead.ae/Publications/Abu%20Dhabi%20Habitat%20Mapping%202016/Habitat%20Book%20English%20Web.pdf

Terrestrial and Marine Habitats



"Unique in magnitude and the depth of habitat classification"

The Ecological Classification and Landuse Mapping from Satellite Imagery project, was completed in December 2014.

By bringing together many years of expertise from the remote sensing, GIS, survey and ecology sectors, the Environment Agency-Abu Dhabi (EAD) has produced a bespoke solution using cutting edge technology.

Geospatial data forms a fundamental resource for informing policies and for planning resource allocation in Abu Dhabi. The satellite mapping project will provide a crucial baseline for activities during the next 5 years.

The project has used state of the art satellite image processing technologies, complemented with unrivalled local ecological knowledge to provide terrestrial and marine mapping, along with Land Use and Land Cover layers at a scale of 1:10,000. The output of the project is available to the Abu Dhabi Spatial Data Infrastructure (SDI) community using the EAD's environmental data dissemination portal (http://enviroportal.ead.ae/).

The innovative aspect of the mapping approach is in the interpretation of several habitats into a classification scheme that can be objectively and repeatedly mapped. During the course of this 20 month project a complete coverage map of Abu Dhabi has been provided. However, the project has also provided a method for repeat versions of the map to be created in the future in a much shorter time scale. The loss or gain of habitats can be better detected, which in turn can help decision makers to understand how effective environmental policy measures have been.

"A fundamental data layer for all future planning and decision making related to sustainable development"

This powerful data set allows environmental decision making to be more objective and quantifiable. For example, UAE's National Biodiversity Strategy and Action Plan sets targets for biodiversity conservation. A minimum percentage of each terrestrial and marine habitat must be protected and conserved by 2021. The data produced by this project will make progress towards these targets easier to plan, implement and measure, and will mean that the decisions surrounding this policy are wholly justifiable.

Internal stakeholders can use the habitat map to improve their productivity. For example, the field biodiversity survey teams can access the map from mobile devices meaning that they can easily target areas of interest. This presents a significant time and cost saving opportunity as field based survey activities become more efficient.

The information contained in these maps will be invaluable when responding to emergencies such as oil spills and will help responders identify environmentally sensitive areas and those in need of protection.

The availability of a habitat map with continuous coverage can be used to provide greatly increased accuracy to the mapping of potential carbon absorbing areas. The outputs from such a study will influence policy level decision making in terms of carbon offsetting.

There are increased calls to measure and quantify the services that an ecosystem provides and associate a monetary value to those services. The habitat map that has been produced is providing accurate data, represented spatially. This data provides a huge advantage for valuation and analysis. For example, being able to pin-point the status, geographical extent, and associated value of an area of coral can help to mitigate against human development in that area.

The model that has been created for satellite habitat mapping is not only useful for future application in Abu Dhabi, but can also be applied in other countries world-wide.

هـيـئـة الـبـيـئـة - أبـوظـبـي
Environment Agency - ABU DHABI

1:500,000

0 12.5 25 50 75 100 Kilometres

Abu Dhabi Emirate Terrestrial and Marine Habitats
Scale 1: 500,000

User defined projection:
Projection.....Transverse Mercator
Ellipsoid.....World Geodetic System 84
Horizontal Datum.....World Geodetic System 84
Longitude Origin.....Meridian 54° E of Greenwich
Latitude Origin.....Equator
False Coordinates of Origin.....500,000m E
0m N
Scale Factor at Central Meridian.....0.99965

Project Managed by:
Proteus FZC

Map created from satellite imagery classification and supporting field data.
Sources include:
- WorldView-2 satellite multi-spectral scenes from 2011, 2012 and 2013.
- RapidEye satellite scenes from 2012 and 2013
- Road network provided by Abu Dhabi SDI community
- Place names provided by Abu Dhabi SDI community

Note: This map is not an authority on international or inter-emirate boundaries.

Note: This map should be used in conjunction with the Habitat, Land Use and Land Cover Delineation Project 2014 Classification Manual.

LEGEND Note: Number refers to habitat code, text refers to habitat name

1010-Mudflats and sand exposed at low tide
1020-Sheltered tidal flats with cyanobacterial mats
1030-Saltmarsh
1040-Mangroves
1050-Storm beach ridges
1060-Sandy beaches
1070-Beach rock and gravelly beaches
2011-Coastal plains on well-drained sandy ground
2012-Coastal plains on well-drained rocky or gravelly terrain
2050-Coastal sand sheets and low dunes
3000-Coastal cliffs, headlands, rocky slopes and wadis in coastal situations
3100-Coastal wadis, including sabkha inland
4110-Sand sheets and dunes with tree cover
4120-Sand sheets and dunes with shrub cover
4130-Sand sheets and dunes with dwarf shrub cover
4140-Sand sheets and dunes with perennial herbs and graminoids
4200-Mega-dunes
5110-Gravel plains with distinct tree vegetation
5120-Gravel plains with dwarf shrub vegetation
5130-Gravel plains with sparse vegetation
5200-Inland wadis
6100-Mountain slopes, scree and associated wadis
6210-Jebels (including mesas and buttes)
6220-Escarpments, Miliffed sand dunes, rocky exposures
6320-Wadis in open terrain, and drainage channels
7100-Semi-artificial lakes
7200-Moist ground with Phragmites, Tamarix and grass mow
8100-Date plantations
8200-Farmland
8300-Livestock areas
8400-Forestry plantations
8500-Pipelines infrastructure
8600-Disturbed ground
9110-High density urban
9120-Low density urban
9210-Oil industry
9220-Airports and aerodromes
9230-Port areas
9240-Other industry
9500-Leisure areas
9600-Paved roads
10110-Fringing reef
10120-Fringing reef with macroalgae
11200-Patch reef
11210-Patch reef with macroalgae
12000-Seagrass bed
13000-Hardbottom
13010-Hardbottom with macroalgae
14000-Unconsolidated bottom
15100-Rock armouring / artificial reef
15200-Marine structure
16100-Dredged seabed
16200-Dredged area wall
17000-Deep sub-tidal seabed

BASE MAP LEGEND
Road - Dual Carriageway
Road - Single Carriageway
Municipality Boundary
Abu Dhabi Emirate Boundary
International Boundary

EAD Habitat Classification Codes

Type no.	Sub-type no.	Habitat type	MMUs (ha)
1000		Intertidal habitats	
	1010	Mudflats and sand exposed at low tide	5
	1020	Sheltered tidal flats with cyanobacterial mats	5
	1030	Saltmarsh	5
	1040	Mangroves	5
	1050	Storm beach ridges	5
	1060	Sandy beaches	5
	1070	Beach rock and gravelly beaches	5
2000		Coastal plains, sand sheets and low dunes	
	2011	Coastal plains on well-drained sandy ground	25
	2012	Coastal plains on well-drained rocky or gravelly terrain	25
	2020	Coastal sand sheets and low dunes	5
	2030	Coastal cliffs, headlands, rocky slopes and wadis in coastal situations	5
3000		Coastal sabkha, including Sabkha Matti	
	3100	Coastal sabkha, including Sabkha Matti	25
4000		Sand sheets and dunes	
	4110	Sand sheets and dunes with tree cover	25
	4120	Sand sheets and dunes with shrub cover	25
	4130	Sand sheets and dunes with dwarf shrub cover	25
	4140	Sand sheets and dunes with perennial herbs and graminoids	25
	4200	Mega-dunes	25
5000		Gravel plains (alluvial and interdunal)	
	5110	Gravel plains with distinct tree vegetation	25
	5120	Gravel plains with dwarf shrub vegetation	25
	5130	Gravel plains with sparse vegetation	25
	5200	Inland sabkha	25
6000		Mountains, rocky terrain and wadis	
	6100	Mountain slopes, screes and associated wadis	25
	6210	Jebels (including mesas and burqas)	5
	6220	Escarpments, lithified sand dunes, rocky exposures	5
	6320	Wadis in open terrain, and drainage channels	25
7000		Inland standing water habitats and habitats of moist ground	
	7100	Semi-artificial lakes	1
	7200	Moist ground with Phragmites, Tamarix and grass mats	5
8000		Oases, Farmland and Forestry	
	8100	Date plantations	1
	8200	Farmland	1
	8300	Livestock areas	1
	8400	Forestry plantations	1
9000		Urban habitat types	
	9110	High density urban	1
	9120	Low density urban	1
	9210	Oil industry	1
	9220	Airports and Aerodromes	1
	9230	Port Areas	1
	9240	Other industry	1
	9300	Leisure areas	1
	9400	Paved roads	1
	9500	Pipelines infrastructure	1
	9600	Disturbed ground	1
		Marine Habitat types	
11,000		Coral Reef	
		Fringing Reef	
	11,110	Fringing Reef with Macroalgae	
		Patch Reef	
	11,210	Patch Reef with Macroalgae	
12,000		Seagrass Bed	
13,000		Hard-Bottom	
	13,010	Hard-Bottom with Macroalgae	
14,000		Unconsolidated Bottom	
15,000		Marine Construction	
	15,100	Rock Armouring/Artificial Reef	
	15,200	Marine Structure	
16,000		Dredged Areas	
	16,100	Dredged Sea Bed	
	16,200	Dredged Area Wall	
17,000		Deep Seabed	

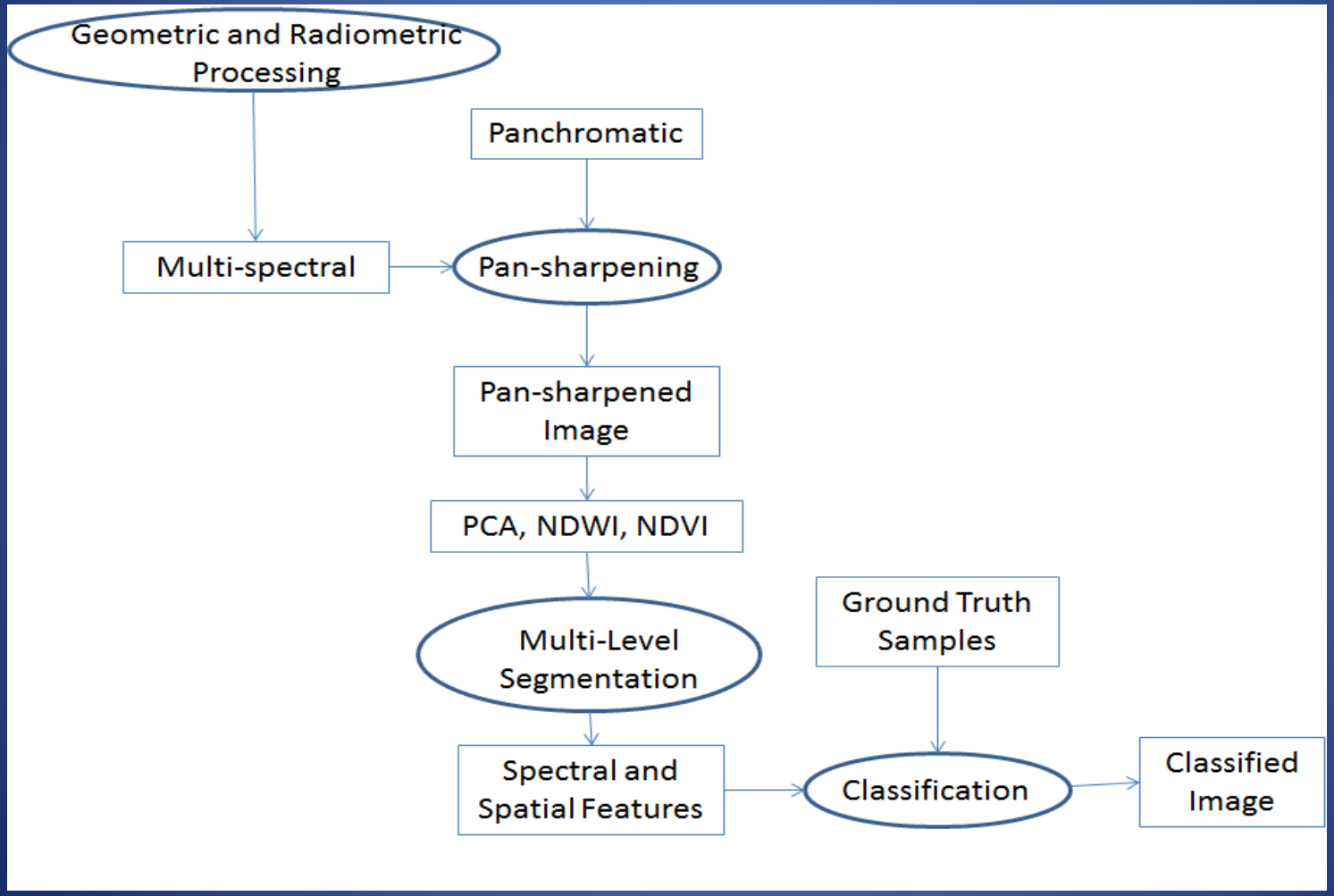
Habitat Mapping in the UAE

- Banking on the effort of the EAD, there is an ongoing effort to extend the process to cover the entire UAE with key stakeholders like UAE Space Agency and Ministry of Climate Change and Environment leading the initiative.
- The aim is to generate a highly detailed classification with over 55 classes and at a spatial resolution of less than 5 m for the entire country.
- The work also aims to develop a methodology to perform updates to the maps in short intervals of less than 2 years as against 5-6 years which is normally accepted globally.
- In the first phase, four areas are considered for the development and validation of the methods.

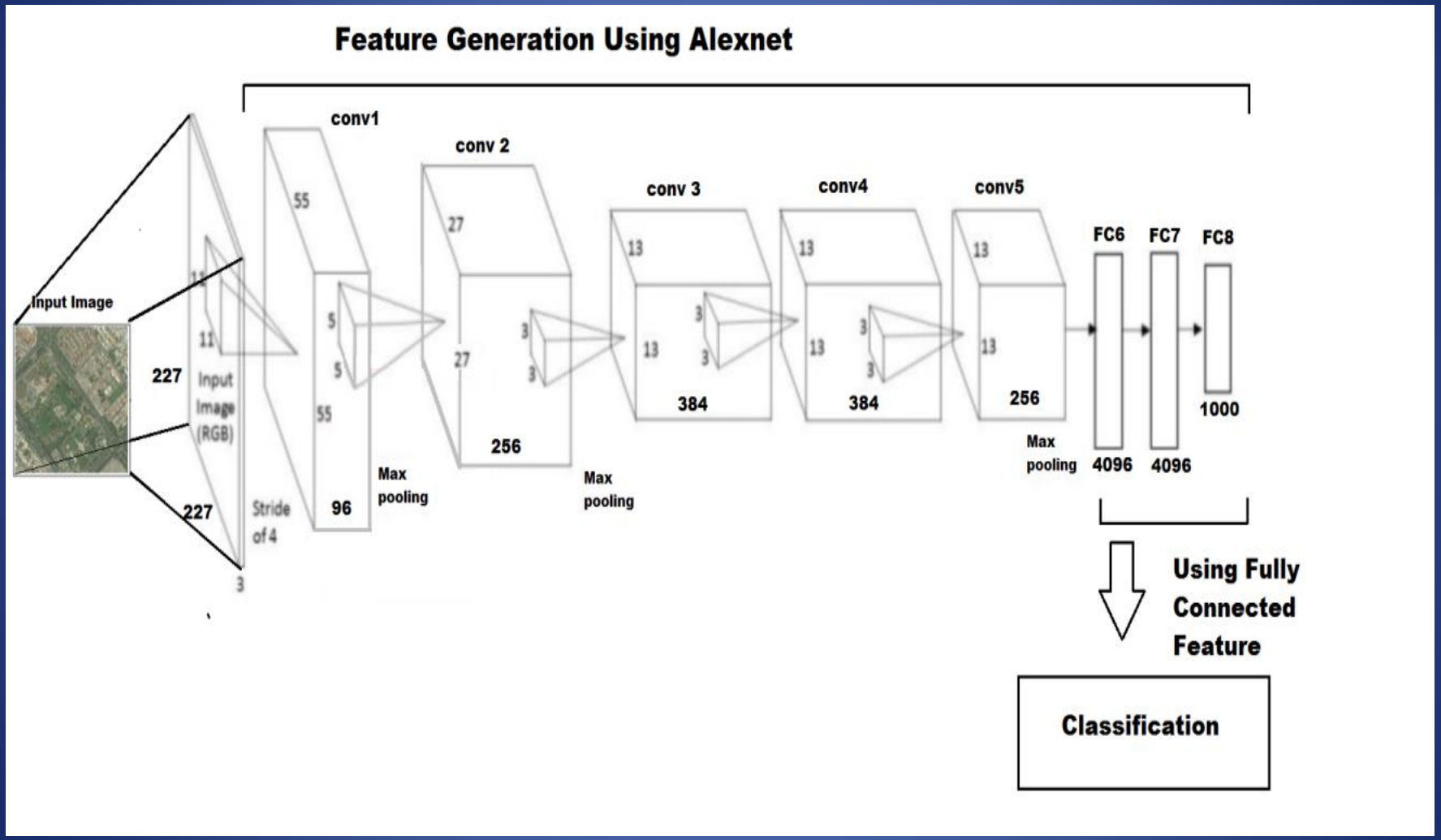
Proposed Work

- Two approaches are considered to generate the land use, land cover maps.
  - Segmentation-based classification
  - Convolutional Neural Network based advanced classification

Segmentation-based classification

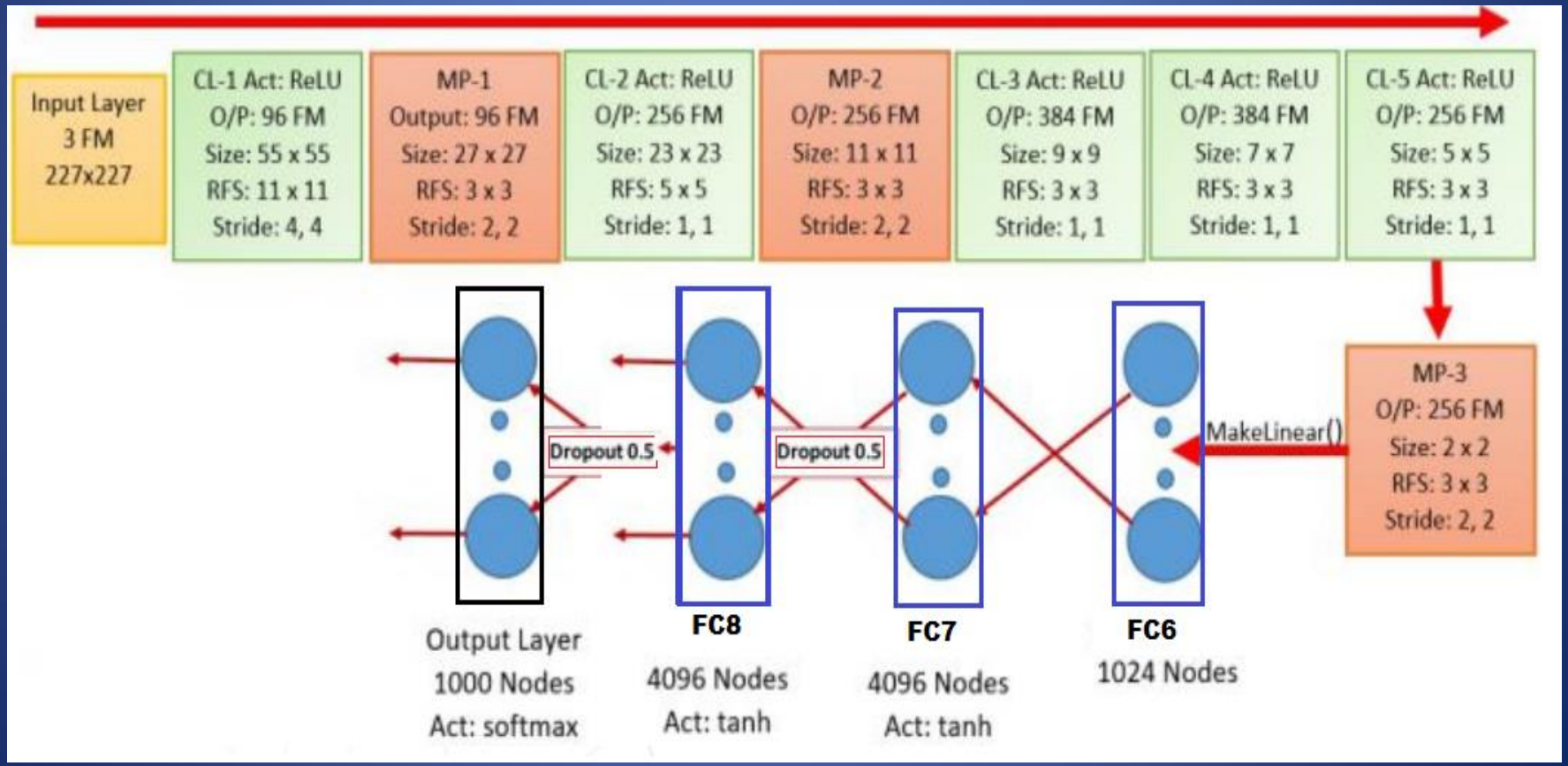


CNN-based classification



CNN-based classification

- AlexNet framework is used in this work.



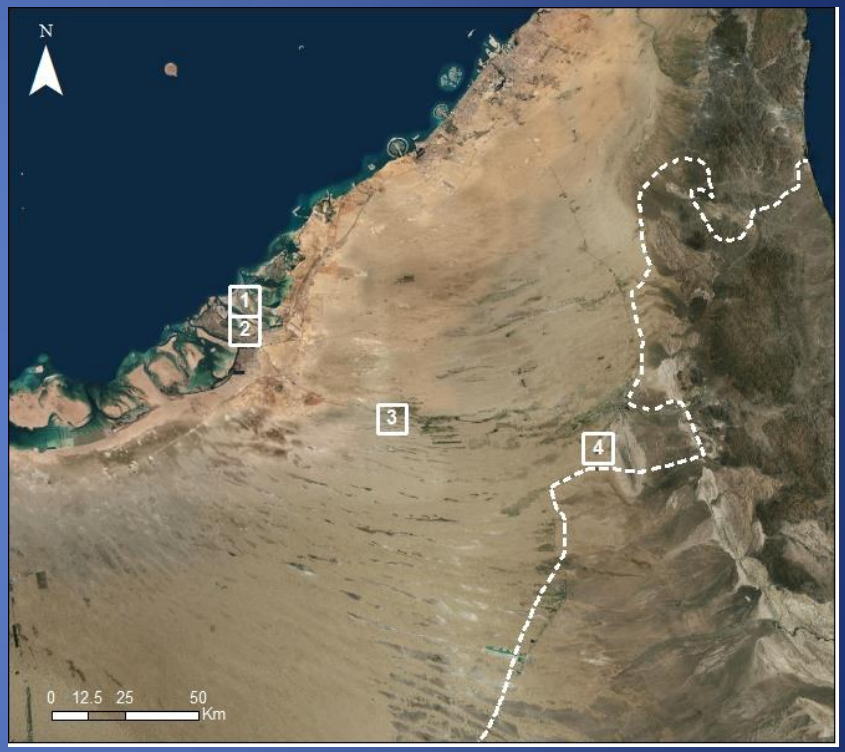
CNN-based classification

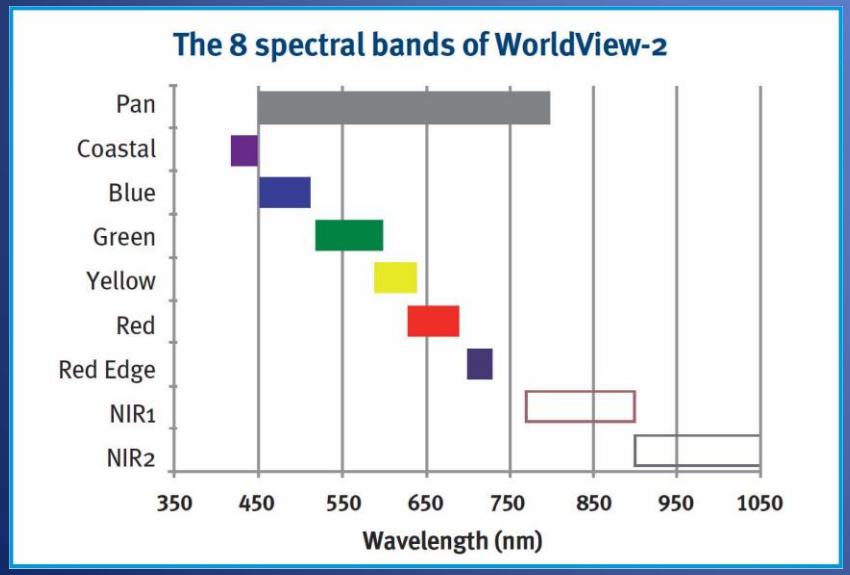
- We use an approach of **'Ensemble of Random Forests'** to classify the features (i.e. 4096 FC7 features) generated from AlexNet framework.

- Multiple Random Forests are employed to with around 20% sampling of the available training data and a majority voting is performed to decide the final class at every pixel.

Data

Images acquired by WorldView-2 satellite are used in this work at the four locations indicated in the figure. The final spatial resolution is 0.5 m after pan-sharpening

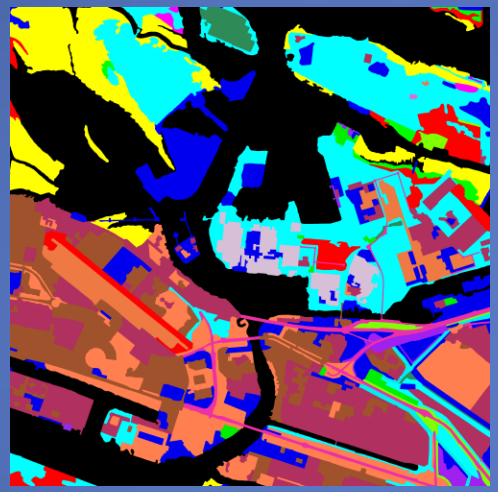




Results

- Segmentation based approach

Image



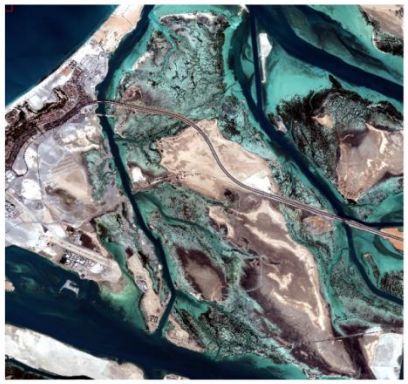
EAD Map

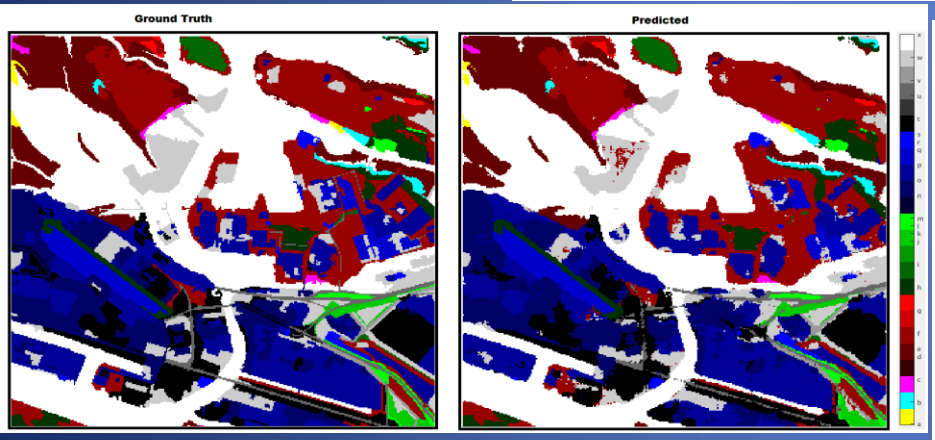
Proposed Method
Accuracy = 84%

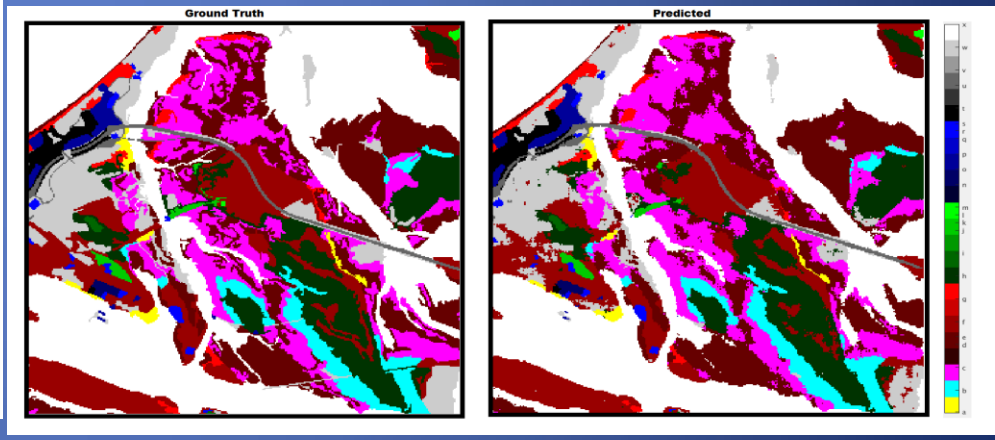
- Airports And Aerodromes
- Coastal Plains On Well-Drained Sandy Ground
- Coastal Sabkha, Including Sabkha Matti
- Coastal Sand Sheets And Low Dunes
- Date Plantations
- Disturbed Ground
- Forestry Plantations
- High Density Urban
- Leisure Areas
- Livestock Areas
- Low Density Urban
- Mangroves
- Mudflats And Sand Exposed At Low Tide
- Oil Industry
- Other Industry
- Paved Roads
- Pipelines Infrastructure
- Port Areas
- Saltmarsh
- Semi-Artificial Lakes
- Sheltered Tidal Flats With Cyanobacterial Mats
- Water

CNN Approach


Location 1


Location 2





Average accuracy > 92%

Conclusions

- Two methods are developed as an attempt to generate classification maps to replicate the earlier work in the emirate of Abu Dhabi at four randomly selected sites.

- The CNN-based approach has shown great potential in producing relatively high accuracy maps in comparison to the segmentation based approach.

- We are currently extending this work to cover entire Abu Dhabi emirate in the first phase which will be extended to the other emirates after updating the classification codes to integrate class definitions from other habitat classes