

**Spatial Temporal Analysis of Land Use Land Cover between 2000 to 2021 by
Applying Google Earth Engine - A Case Study of Preah Sihanouk province,
Cambodia**

International Workshop on Land Cover/Land Use Changes,
Forestry and Agriculture in South/Southeast Asia

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Presenter:

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Ministry of Environment

OUTLINE

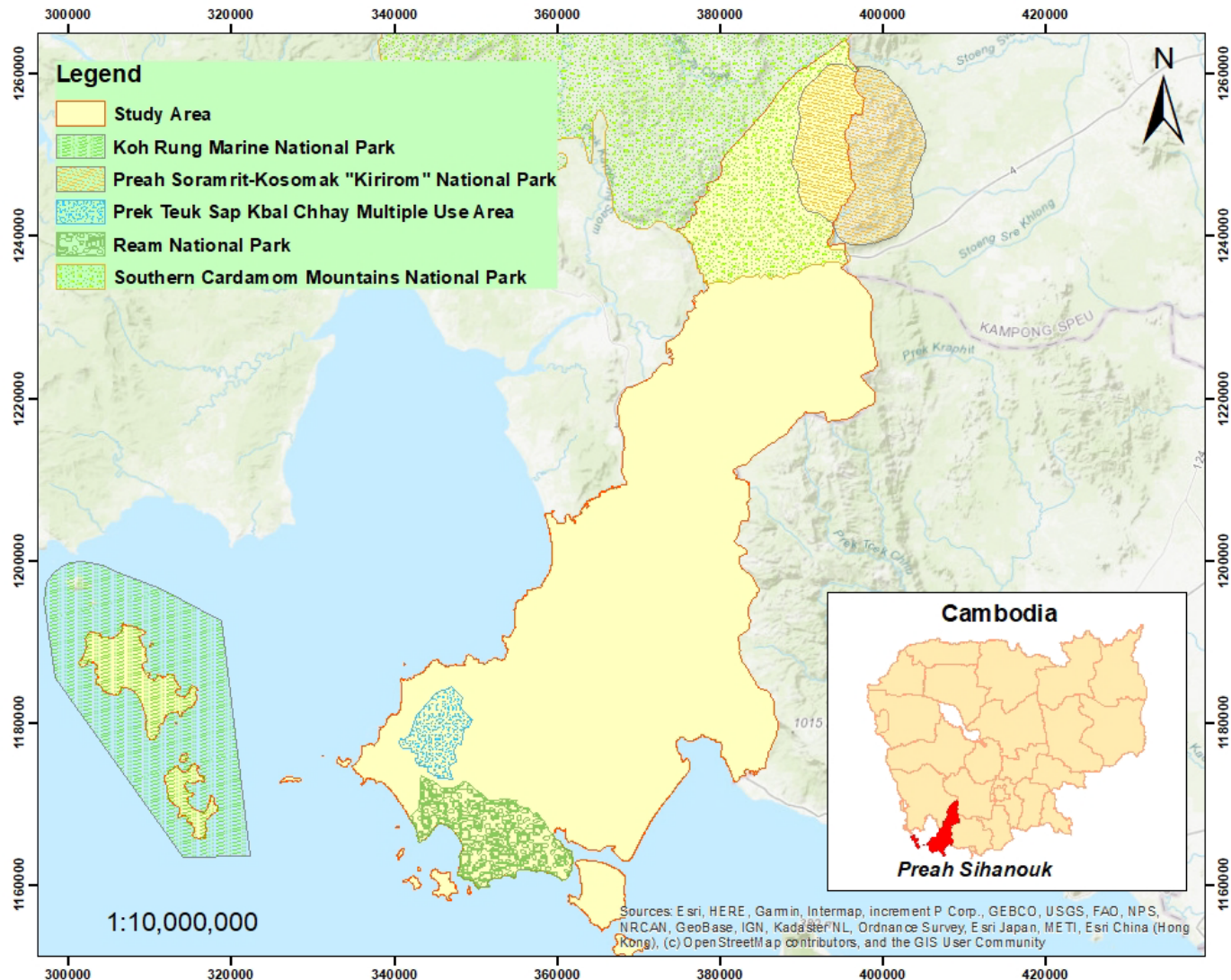
- ❖ Study Area
- ❖ Methodology
- ❖ Result and Discussion
- ❖ Conclusion

Objective

To determine the dynamic of Land Use Land Cover between 2000 to 2021

- 1. to classify and produce LULC map at a 3-year interval**
- 2. to determine the magnitude of change**

Study Area



Location: 230Km South-Western of Capital City

Topography: 2/3 are plateau and mountainous terrain, 1/3 plains and coastlines.

Climate: Tropical monsoon (rainy and dry season)

Temperature:26.4°C-32.1°C (avg. 30.9) (CDC,2014).

Area: 262, 260 ha

Population: 310,072 (2%) (NIS, 2020).

Livelihood: tourism sector, agriculture, fishery, and labor work in industrial and construction sector (Boswell et al., 2019 & JICA, 2008).

Study Area



Methodology

Satellite Data

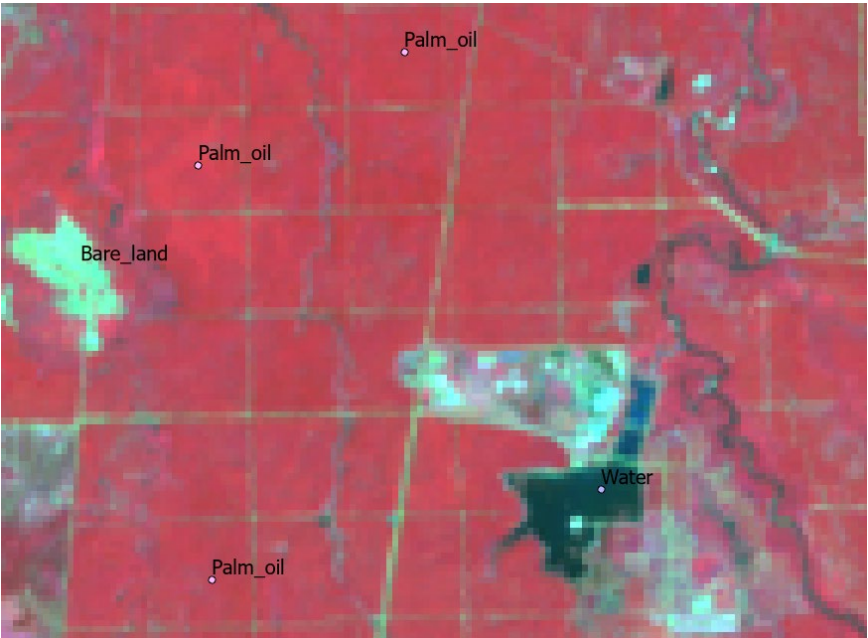
Year	Month	Spatial Resolution	Landsat Sensor	Spectral Bands	Spectral Indices
2000	July- Dec	30 M	TM-SR	BLUE, GREEN, RED, NIR, SWIR1, SWIR2 B(1-2-3-4-5-7)	NDVI, NDWI, NDBI, SAVI
2003					
2006					
2009					
2013			OLI-SR	BLUE, GREEN, RED, NIR, SWIR1, SWIR2 B(2-3-4-5-6-7)	
2015					
2018					
2021					

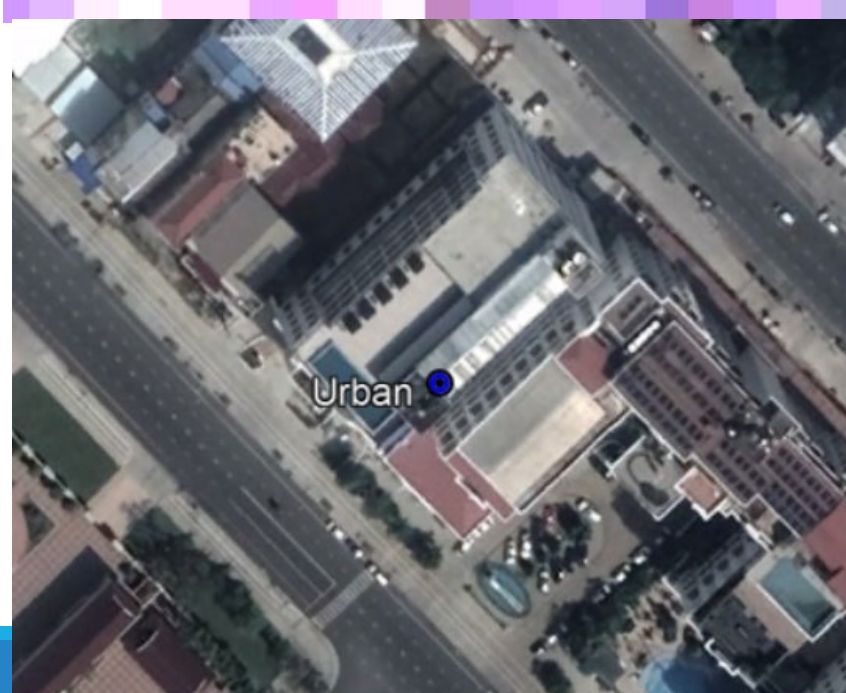
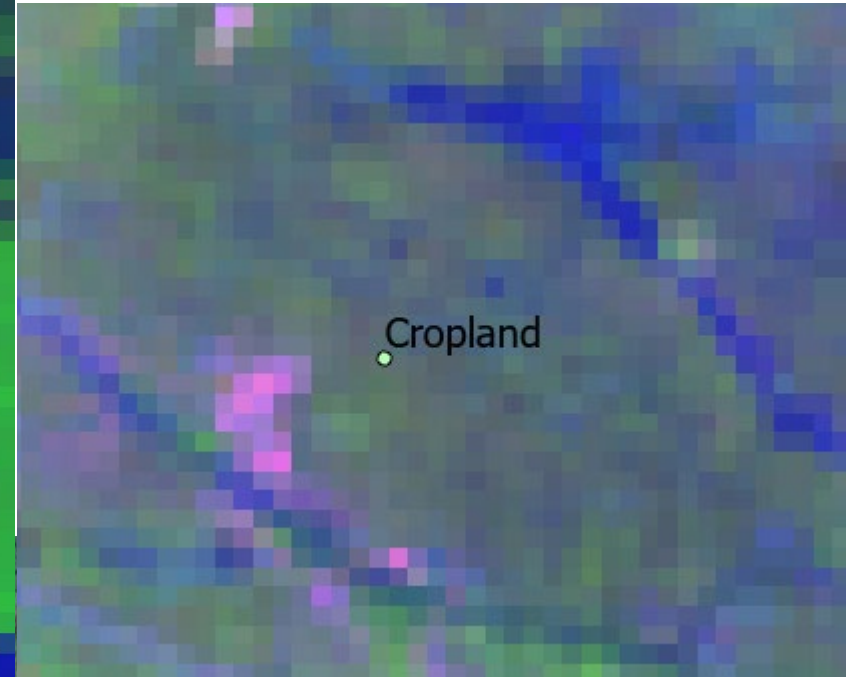
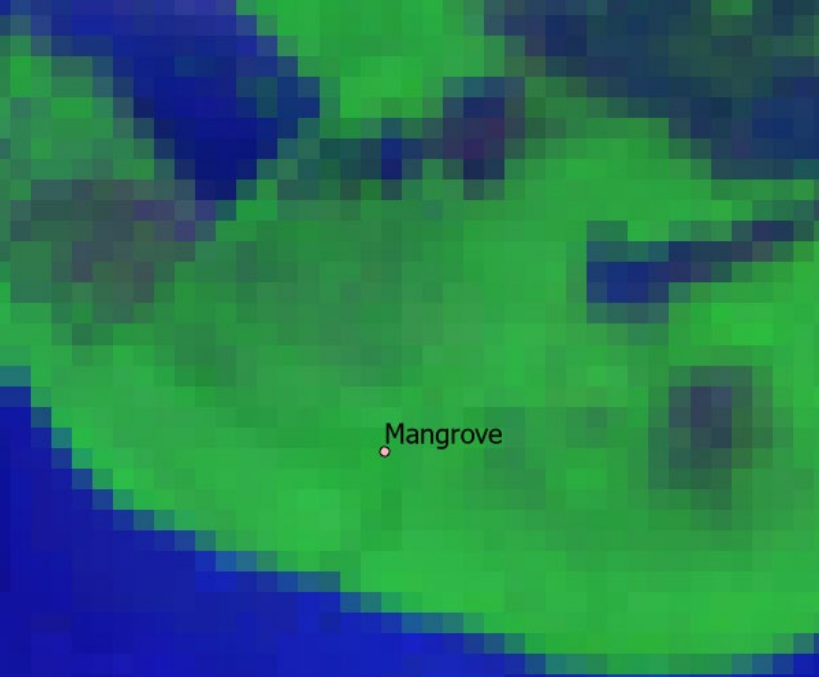
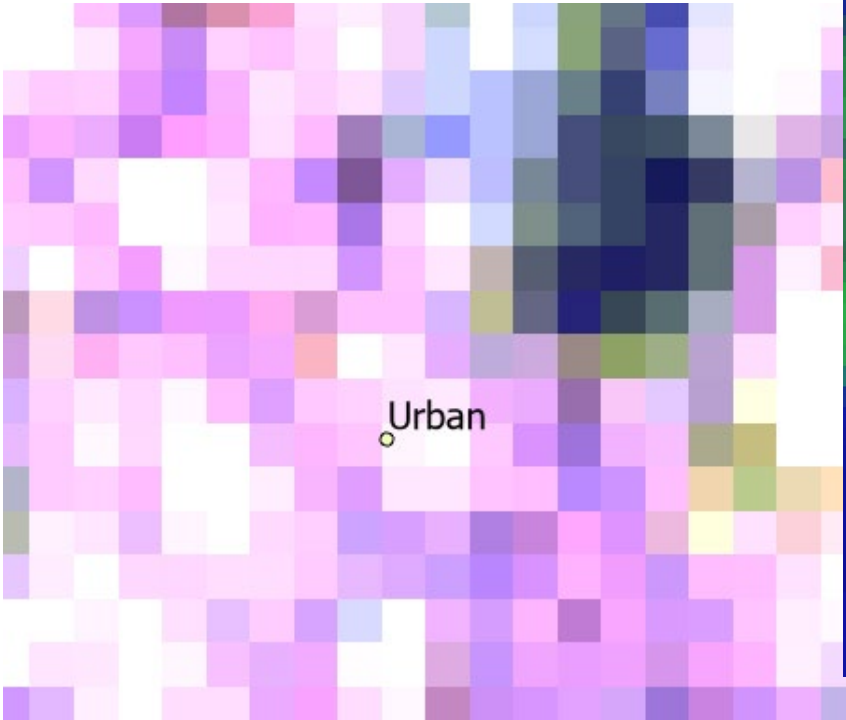
Methodology

Training Data

Year	Training Points	Training Classes	Sources
2000	316	7	1.Satellite Imageries 2.Google Earth 3.Reference Map
2003	378		
2006	316		
2009	291		
2013	334		
2015	334		
2018	349		
2021	347		

Total training points = 2665

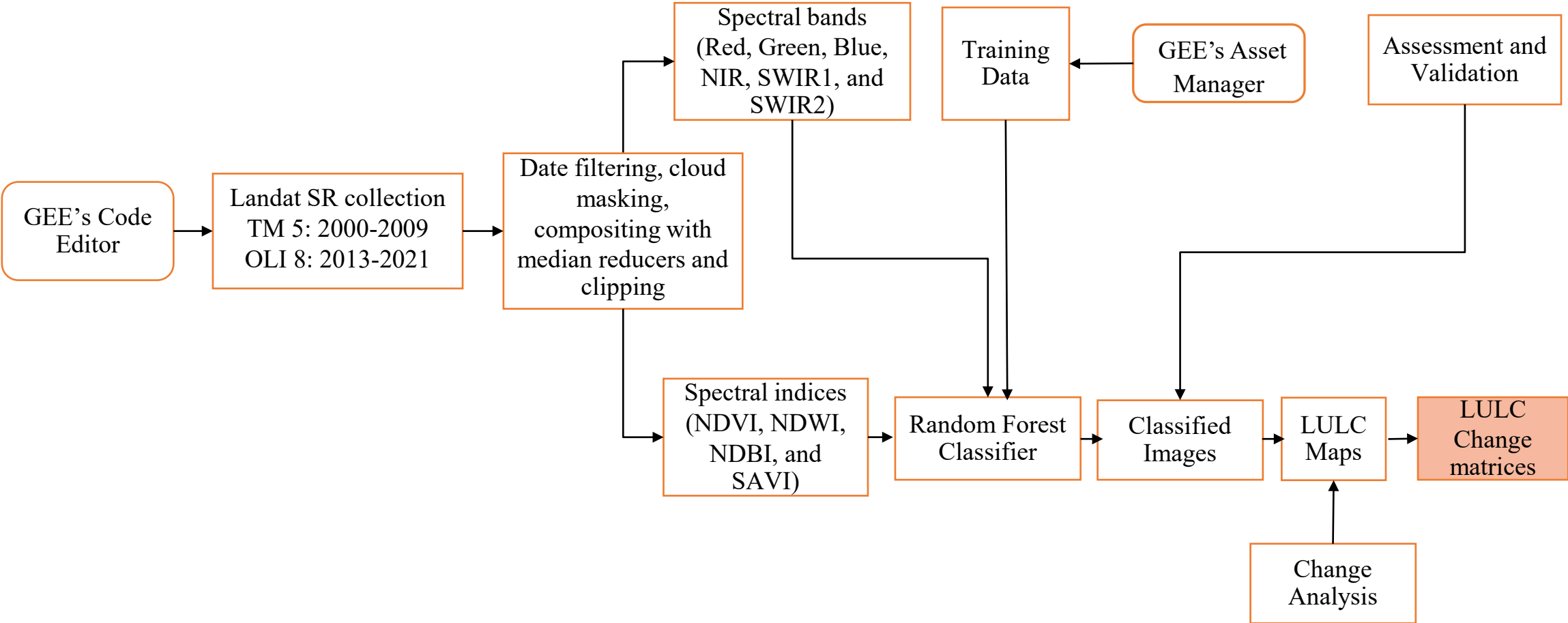




Imagery Date: 11/5/2021

Methodology

Research Framework



Methodology

LULC Categories

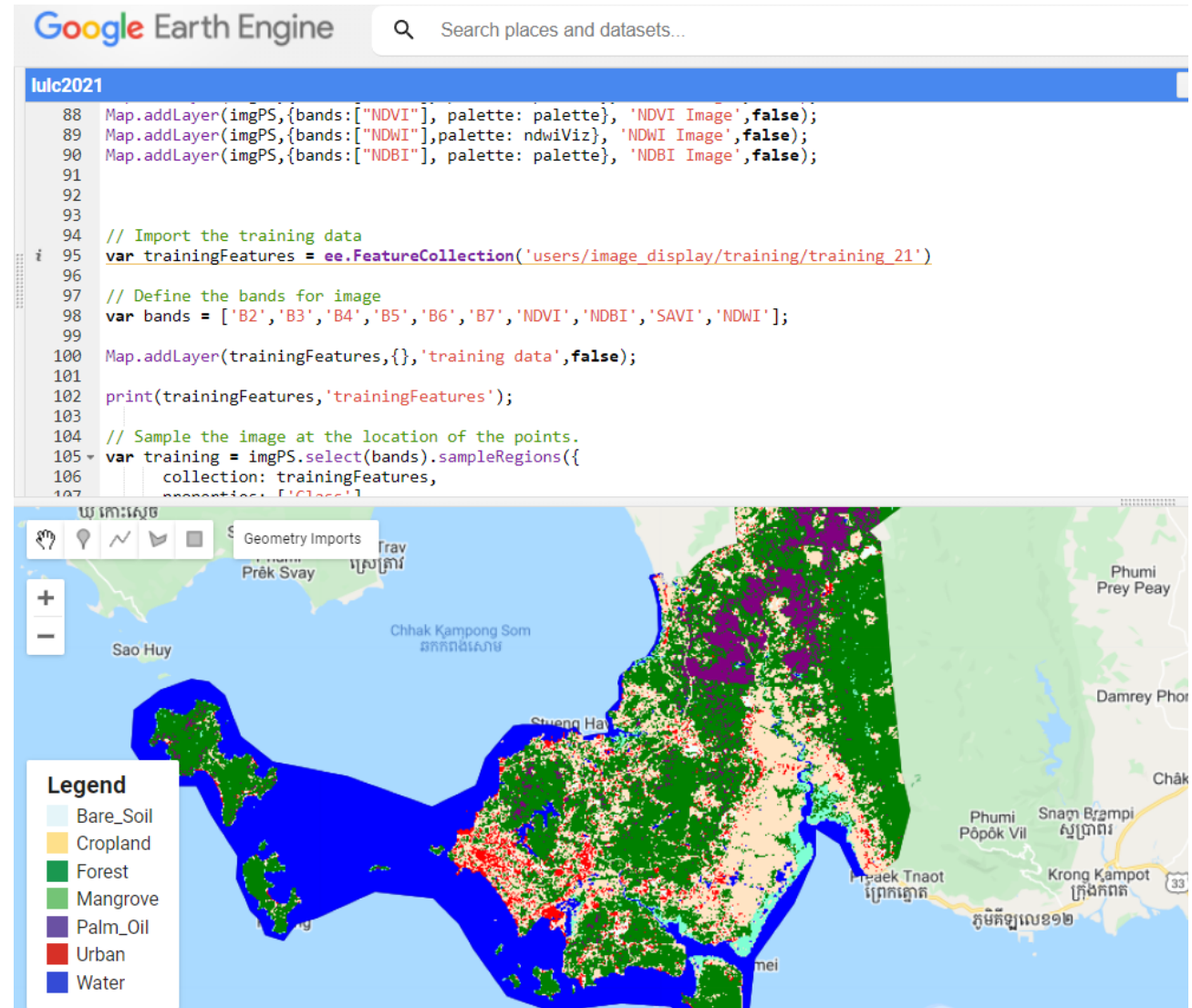
- This study will classify the LULC into 7 classes based on visual interpretation of imageries and reference maps.

No.	Classes	Description
1	Bare land	The area without vegetation cover such as sand, salt flats, beaches and sand dunes.
2	Built-up	The patch of land with building and construction
3	Cropland	Area with vegetation cover including paddy field, orchard, and pasture.
4	Forest	Area with all type of forest cover including evergreen, semi-evergreen, deciduous, wood shrub, pine tree and rubber plantation.
5	Mangrove	Areas dominated mangrove i.e. coastal salt-tolerant species
6	Palm	Areas dominated by palm oil trees.
7	Water	Area of fresh and seawater

Methodology

Classification Algorithm

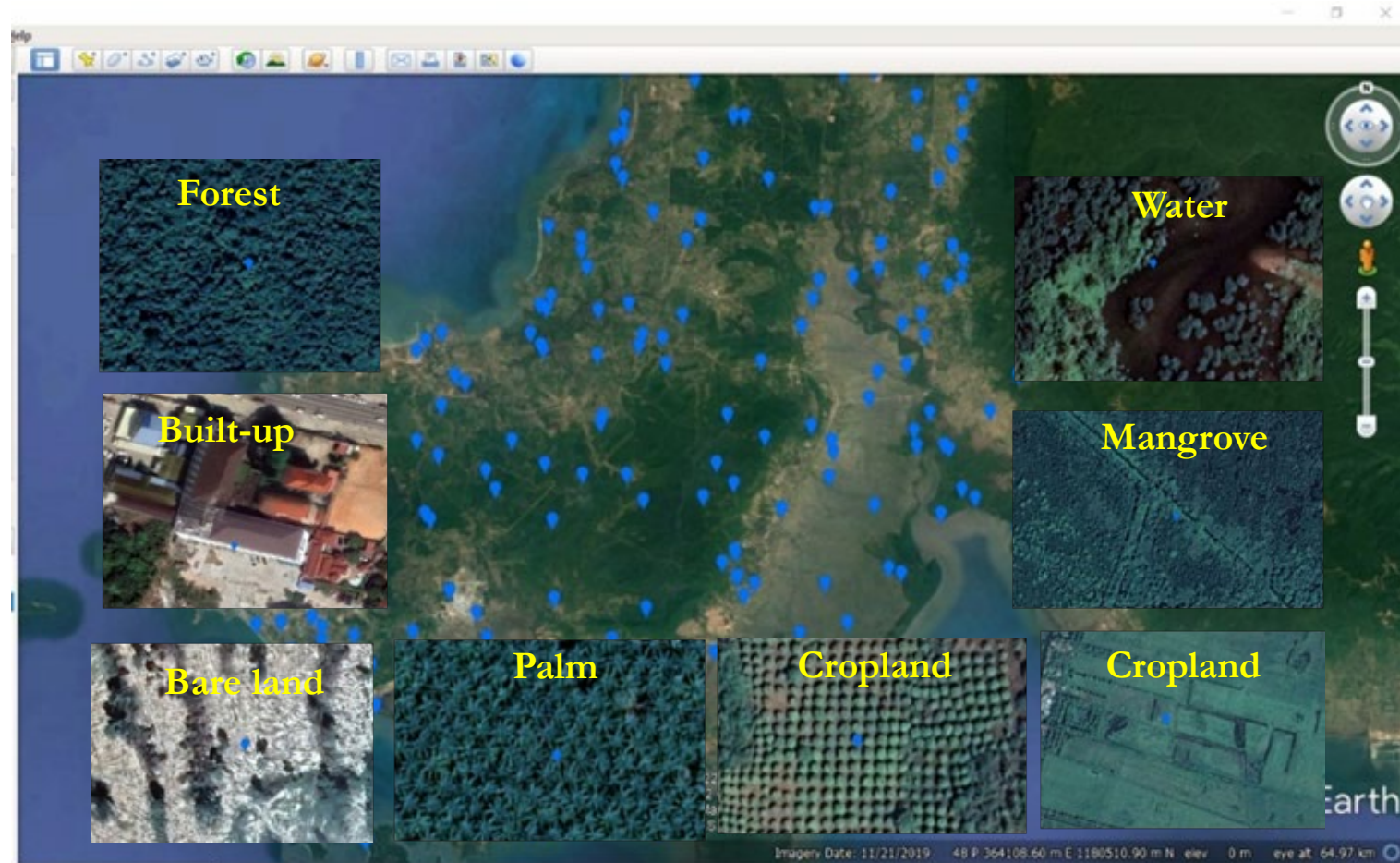
- GEE and Random Forest Classifier are the main platform and algorithm for LULC classification.
- The LULC classification is spontaneous in GEE by using JavaScript.
- NDVI, NDWI, NDBI and SAVI can improve the land cover mapping accuracy by aiding the classifier to distinguish the land cover types, for instance, NDVI help the classifier to differentiate vegetation types from the perspective of vegetation phenology.



Methodology

Accuracy Assessment

- Total of **3102** accuracy points were generated using the stratified random point method to assess the accuracy of the eight classified images.
- The accuracy points were manually assessed by visualizing the degree of agreement with Imageries and in Google Earth Pro, then recorded in Accuracy table.
- Confusion matrices were constructed to order to calculate UA, PA, OA and Kappa coefficient



Methodology

Accuracy Assessment

LULC 2021	Bareland	Built-up	Cropland	Forest	Mangrove	Palm	Water		Total	User Accuracy
Bareland	22	2	0	0	0	0	0		24	92%
Built-up	1	9	0	0	0	0	0		10	90%
Cropland	1	1	30	2	0	0	0		34	88%
Forest	0	0	2	108	1	3	0		114	95%
Mangrove	0	0	0	1	9	0	0		10	90%
Palm	0	0	1	1	0	13	0		15	87%
Water	0	0	0	0	1	0	9		10	90%
Total	24	12	33	112	11	16	9	200	217	
Producer.Ac	92%	75%	91%	96%	82%	81%	100%		OA	92%
Total Acc	0.92								217	
Random Acc	0.3190979									
Kappa Index	0.8849453									

Methodology

Kappa Index

$$\hat{K} = \frac{\text{Observed Accuracy} - \text{Chance Agreement}}{1 - \text{Chance Agreement}}$$

- $K > 0,8$ High accuracy
- $0,4 < K < 0,8$ moderate accuracy
- $K < 0,4$ low accuracy
- K negative very low accuracy

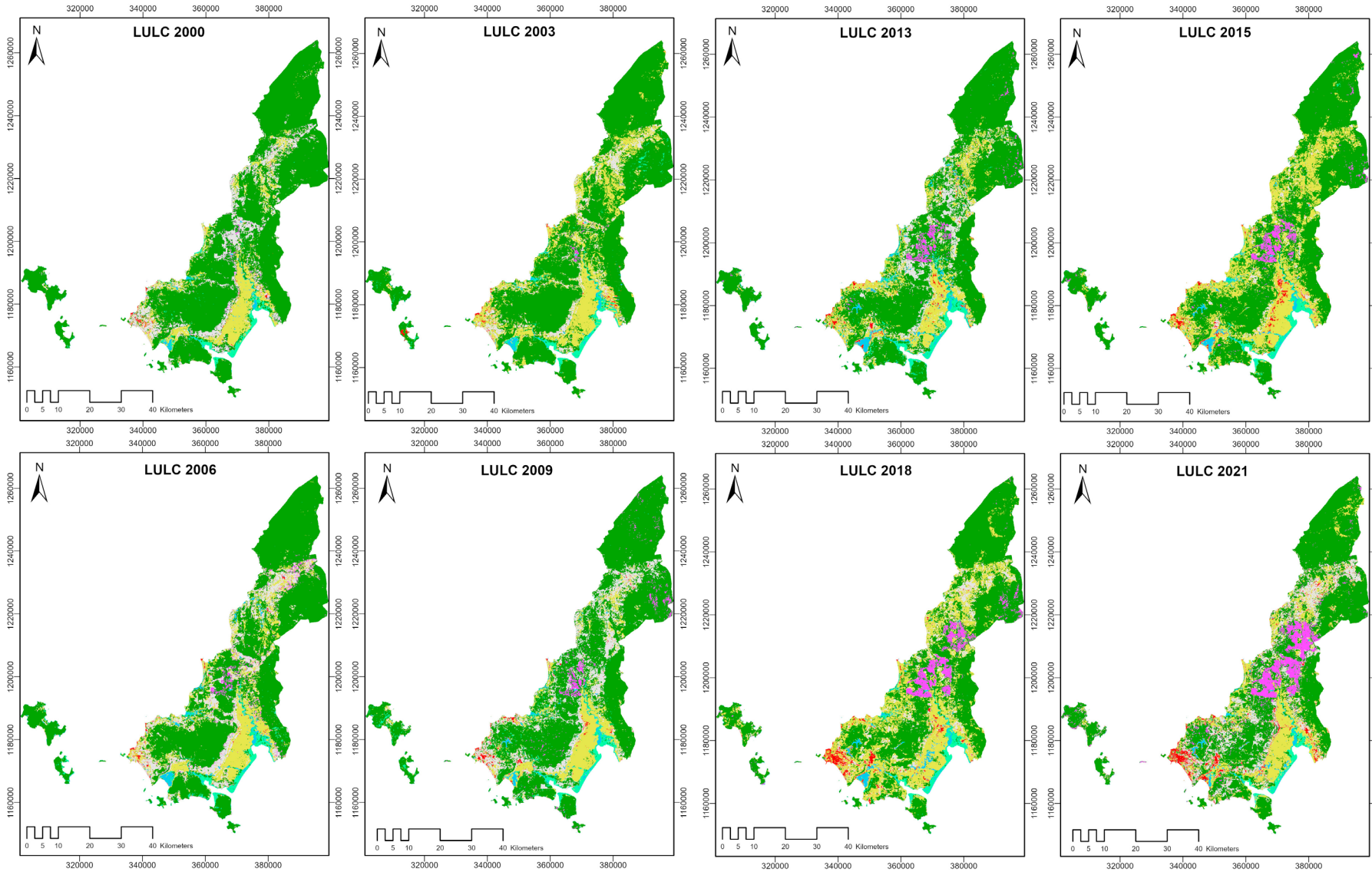
Result and Discussion

Accuracy Assessment

Year	Accuracy	LULC Types							Overall Accuracy	Kappa Inex
		Bare land	Built-up	Cropland	Forest	Mangrove	Palm	Water		
2000	Producer	69.2	100.0	62.1	97.1	60.0	100.0	90.9	87.3	0.78
	User	81.8	70.0	85.7	91.0	90.0	50.0	100.0		
2003	Producer	71.4	100.0	81.4	96.2	75.0	88.9	90.0	90.8	0.85
	User	83.3	90.0	92.1	92.1	90.0	80.0	90.0		
2006	Producer	85.2	100.0	73.7	97.5	81.8	100.0	100.0	91.5	0.87
	User	100.0	90.0	90.3	91.5	90.0	80.0	90.0		
2009	Producer	90.0	100.0	69.0	95.2	63.6	70.0	100.0	88.8	0.82
	User	100.0	90.0	83.3	90.2	70.0	70.0	90.0		
2013	Producer	66.7	100.0	73.5	98.3	69.2	72.7	83.3	88.1	0.81
	User	94.1	80.0	83.3	88.6	90.0	80.0	100.0		
2015	Producer	64.3	100.0	93.5	95.1	75.0	69.2	100.0	90.7	0.86
	User	90.0	90.0	81.1	94.4	90.0	90.0	100.0		
2018	Producer	69.2	100.0	93.6	95.4	75.0	66.7	75.0	90.6	0.86
	User	90.0	80.0	84.6	93.7	90.0	100.0	90.0		
2021	Producer	91.7	75.0	90.9	96.4	81.8	81.3	100.0	92.2	0.88
	User	91.7	90.0	88.2	94.7	90.0	86.7	90.0		

Result and Discussion

LULC Maps



Legend



Projection: WGS 84 UTM
Zone: 48 N

Result and Discussion

LULC Extent

LULC Class	Area (Ha)							
	2000	2003	2006	2009	2013	2015	2018	2021
Bare land	28,649	15,416	29,776	35,226	22,406	6,913	16,039	31,253
Built-up	1,763	1,825	1,817	2,913	3,289	4,687	5,869	9,136
Cropland	29,103	50,607	40,459	31,745	40,350	69,101	69,714	44,517
Forest	191,838	182,230	170,482	174,291	174,655	161,933	145,420	148,683
Mangrove	5,803	7,058	7,255	8,465	8,045	7,150	6,533	4,619
Palm	2,188	1,196	5,600	4,697	4,940	6,854	11,882	19,175
Water	2,663	3,657	6,588	4,655	8,311	5,361	6,431	4,612
Other	253	273	282	268	264	260	373	265
Total Area	262,260							

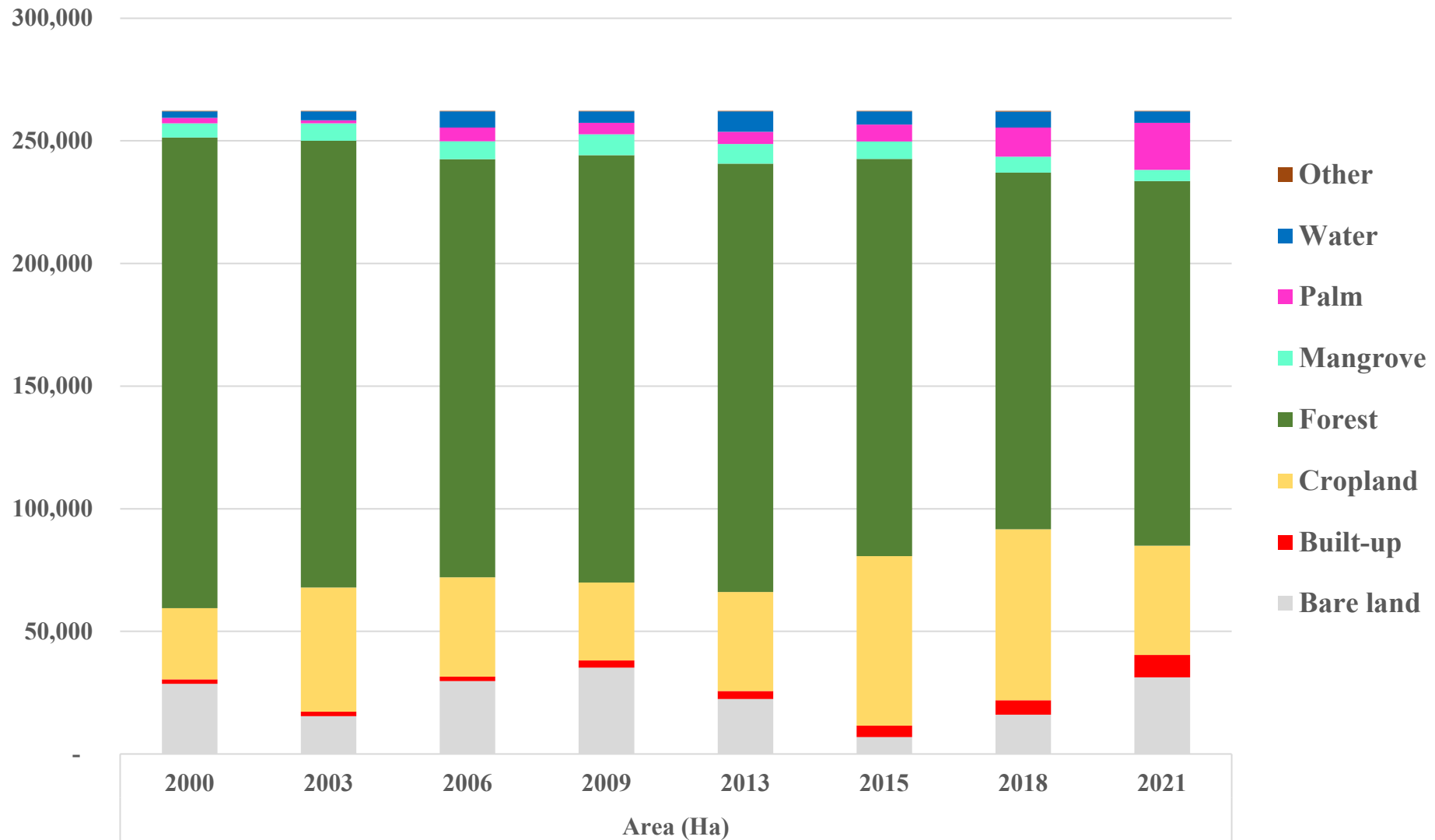
Result and Discussion

LULC Extent

LULC Class	Area (%)							
	2000	2003	2006	2009	2013	2015	2018	2021
Bare land	10.92	5.88	11.35	13.43	8.54	2.64	6.12	11.92
Built-up	0.67	0.70	0.69	1.11	1.25	1.79	2.24	3.48
Cropland	11.10	19.30	15.43	12.10	15.39	26.35	26.58	16.97
Forest	73.15	69.48	65.00	66.46	66.60	61.75	55.45	56.69
Mangrove	2.21	2.69	2.77	3.23	3.07	2.73	2.49	1.76
Palm	0.83	0.46	2.14	1.79	1.88	2.61	4.53	7.31
Water	1.02	1.39	2.51	1.78	3.17	2.04	2.45	1.76
Other	0.10	0.10	0.11	0.10	0.10	0.10	0.14	0.10

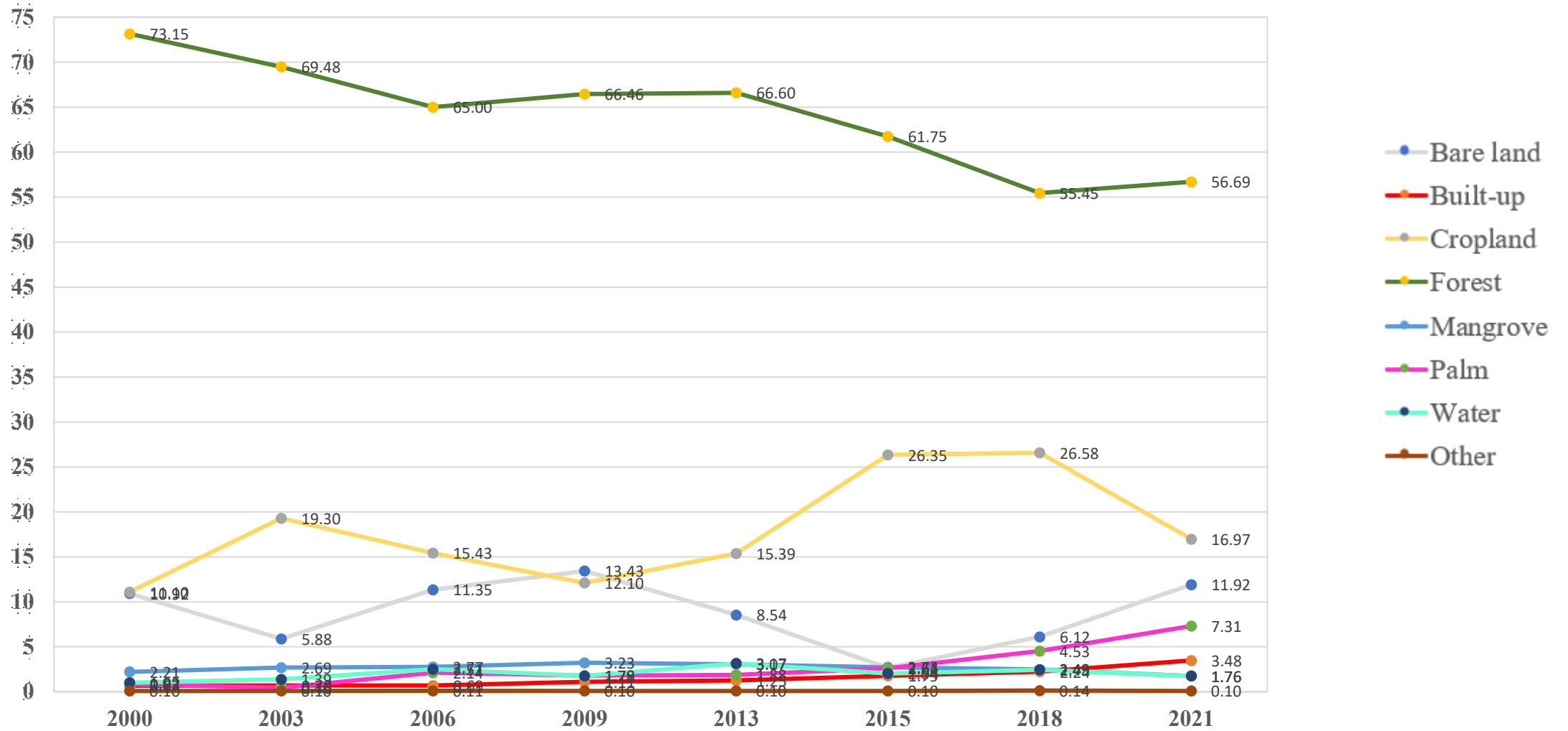
Result and Discussion

Classes Distribution of LULC



Result and Discussion

Evolution of LULC



Result and Discussion

LULC Change

LULC Class	Net Area Change (Hectares)							
	2000-2003	2003-2006	2006-2009	2009-2013	2013-2015	2015-2018	2018-2021	2000-2021
Bare land	-13234	14360	5449	-12820	-15492	9126	15214	2603
Built-up	62	-8	1095	377	1397	1182	3267	7373
Cropland	21504	-10148	-8714	8605	28750	613	-25197	15414
Forest	-9608	-11748	3810	363	-12721	-16514	3263	-43155
Mangrove	1255	198	1210	-420	-895	-618	-1913	-1184
Palm	-992	4404	-903	243	1915	5027	7293	16987
Water	994	2932	-1933	3656	-2951	1071	-1819	1949
Other	20	10	-15	-4	-3	112	-108	12

Result and Discussion

LULC Change

LULC Class	Net Area Change (%)							
	2000-2003	2003-2006	2006-2009	2009-2013	2013-2015	2015-2018	2018-2021	2000-2021
Bare land	-46.2	93.2	18.3	-36.4	-69.1	132.0	94.9	9.1
Built-up	3.5	-0.4	60.3	12.9	42.5	25.2	55.7	418.1
Cropland	73.9	-20.1	-21.5	27.1	71.3	0.9	-36.1	53.0
Forest	-5.0	-6.4	2.2	0.2	-7.3	-10.2	2.2	-22.5
Mangrove	21.6	2.8	16.7	-5.0	-11.1	-8.6	-29.3	-20.4
Palm	-45.3	368.2	-16.1	5.2	38.8	73.3	61.4	776.4
Water	37.3	80.2	-29.3	78.5	-35.5	20.0	-28.3	73.2
Other	7.8	3.6	-5.2	-1.5	-1.3	43.2	-28.9	4.9

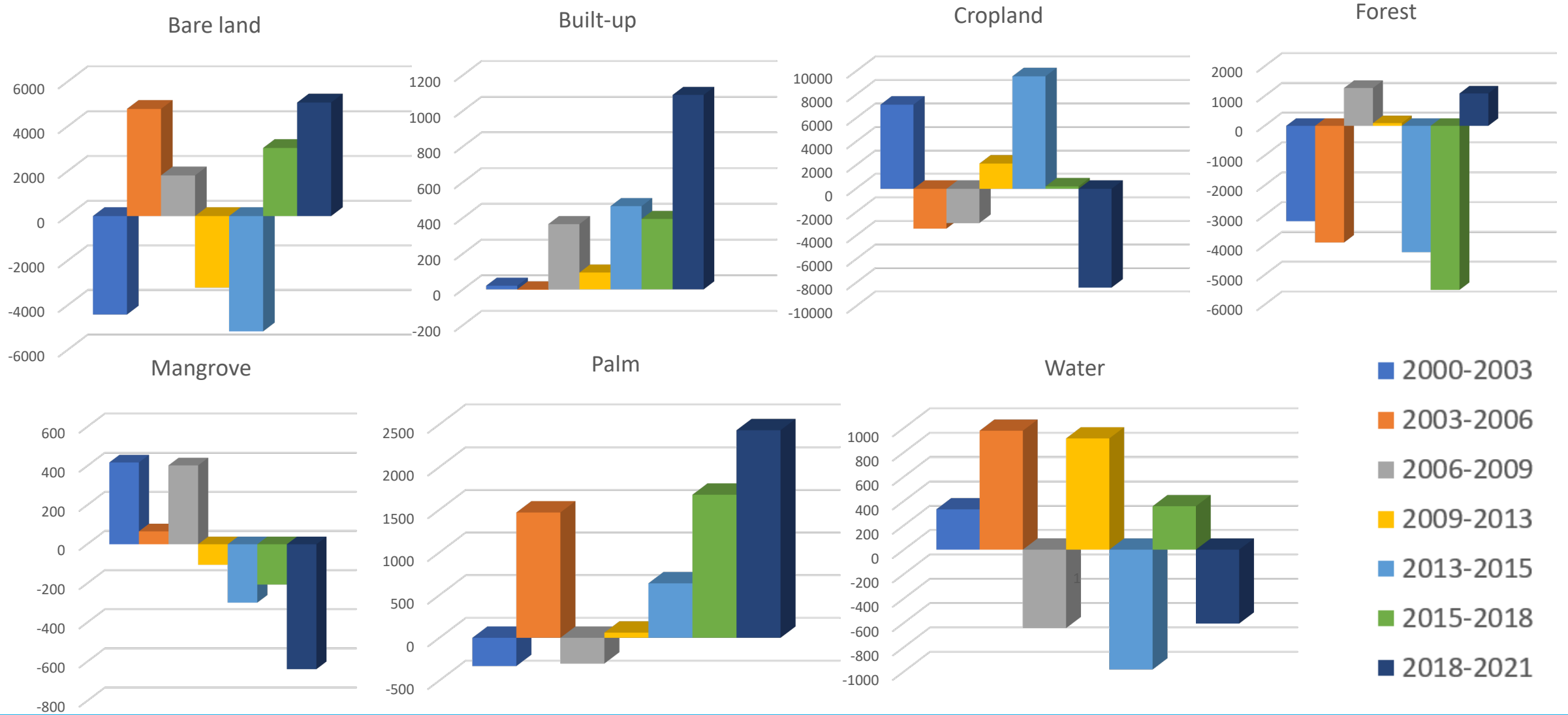
Result and Discussion

LULC Map Validation

	Classified Maps	Extent (ha)	Reference Maps	Extent (ha)	Sources	Difference	Diff %
Forest	LULC 2006	170,482	Forest Cover 2006	166,571	Forestry Adminsitration	3,911	2.3
	LULC 2009	174,291	Forest Cover 2010	169,446	Forestry Adminsitration	4,845	2.9
	LULC 2016	161,933	Cambodia Forest Cover 2016	156,579	MoE, 2018	5,354	3.4
	LULC 2018	145,420	Cambodia Forest Cover 2018	154,707	MoE, 2020	-9,287	-6.0

Result and Discussion

LULC Change Analysis



Conclusion

- Oil Palm is the most change class among other (**+776**), followed by Built-up.
- Forest class is still the dominant land cover in the entire period regardless of its changes. Forest cover is estimated to be around **56 %** of the total study area in 2021.
- Built-up area increased dramatically between 2018-2021 (**+55 %**) , and for the entire study period it increase around **418 %**.
- Bare land and Cropland magnitude is fluctuated during the study period.
- Historical satellite imageries (Google Earth) and GEE are robust tools for the study of LULC and widely used in researches.

Thank you!

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