AGRICULTURE & FORESTRY LAND COVER

VIENTIANE CAPITAL

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CONTENT OF PRESENTATION

- Background
- Problems: Macro and Technical levels
- Assumption to solve the problem
- Study area Vientiane Capital
- Process of producing the Land cover (existing)
- New technology
- Conclusion
- Future work

BACKGROUND

- LAO PDR land locked country
- The country was Monarchy, long time Civil war and we have declared LAO People's Democratic Republic on 2 Dec 1975
- Country governed by one political party
- First Constitution 1991
- ASEAN member in 1997
- The GOL has approved 132 Mega and Medium Hydropower projects (in Operation 39, 18 Hydropower will operate by 2020, 90% Export), for the mining 229 Mega and Medium mining projects, accounted about 83,759 Km2
- Population approximately 7.5 Million (actual)
- GDP growth 6.9%

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PROBLEMS

- Macro Level
  - Land exploitation increased due to Development
  - Agriculture land has been decreasing
  - Local & Foreigner investors used and exploited the land without the fulfill Medium Strategy and impacted to the environment
  - Revenue collection in cadaster was not adequate
  - Regulation on the land management not up to date
  - Unplanned the used and exploitation land
  - Lacked of quantity and quality of human resources

PROBLEM (CONT.)

- Technical level
  - Data collection was not consistency
  - No data integration between the government agencies
  - Land title revenue was not contributed as the main National revenue
  - Technology was in low standard, low accuracy, time consuming impact to the planning
  - Long procedure, required a number of man power and more budget
  - Un-sufficient of quality and quantity of human resources

ASSUMPTION TO SOLVE THE PROBLEM

- Improvement of problem concerned to the technical level
- Proposed the way to increase the quality of the map, improve the standard and the accuracy of the data
- Focus into Vientiane Capital for the study as a pilot project
- Applied the Spatial information technology for the study
- After successfully applied the technology and applications, the relevant agencies will extend to the rest of the whole country
- Collection information from the Agriculture Land Management and Development Department, Ministry of Agriculture and Forestry (MAF).

STUDY AREA (VIENTIANE CAPITAL)

- Vientiane Capital is a prefecture of the country, has total area of 3.920 Km2
- Vientiane Capital was built in 16 century under the King Satsetthathirath
- Vientiane Capital has bordered with Vientiane, Bolikhamxay, Xiengkhouang Provinces and Nongkhay (Thailand)
- Protected areas Phou Khao Khouay National Protected area, Phou Phanang National protected area and Houay Ngang Forest reserve
- Vientiane Capital has 9 districts.

Vientiane Capital

ADMINISTRATION

District	Villages	Subdistricts	Area (ha)	Coordinates
Chanthabouly	30	5	2.249	17º 57’ 14”N - 18º 02’ 08”N, 102º 34’ 54” E - 102º 37’ 48”E
Sikhotabong	60	7	15.669	17º 57’ 31,90”N - 18º 02’ 50,33”N, 102º 21’ 37,87” E - 102º 34’ 26,65”E
Xaysettha	48	7	14.503	17º 54’ 35”N - 18º 02’ 37”N, 102º 37’ 03” E - 102º 47’ 04”E
Sisatanak	37	5	3.099	17º 54’ 37” N - 17º 57’ 40” N, 102º 36’ 56” E - 102º 36’ 56” E
Naxaythong	54	7	90.800	18º 01’ 20”N - 18º 20’ 50”N, 102º 15’ 30” E - 102º 37’ 10”E
Xaythany	104	11	71.787	17º 59’ 23.07”N - 18º 18’ 41.52”N, 102º 33’ 32,60” E - 102º 53’ 38,17”E
Hatsayfong	60	7	25.800	17º 49’ 32”N - 1-7º 59’ 42”N, 102º 36’ 56” E - 102º 53’ 12”E
Sangthong	37	5	80.000	18°3’20’’N - 18°29’20’’N, 102°00’50’’E - 102°20’20’’E
Pakngeum	63	6	56.000	17º 55’ 40”N - 18º 14’ 20”N, 102º 53’ 00” E - 102º 50 È 30”E
Total	493	53	359.907	

BOUNDARY

District	Boundary
Chanthabouly	North: Naxaythong and Xaythany Dist., South: Mekong River (Thailand), East: Saysettha and Sisatanak Dist., West: Sikhotabong Dist.
Sikhotabong	North: Naxaythong and Santhong Dist., South: Mekong River (Thailand), East: Chanthabouly and Xaythany Dist., West: Mekong River (Thailand)
Xaysettha	North: Xaythany Dist., South: Hatsayfong Dist., East: Xaythany and Hatsayfong Dist., West: Chanthabouly and Sisatanak Dist.
Sisatanak	North: Chanthabouly Dist., South: Hatsayfong Dist., East: Saysettha Dist., West: Mekong River (Thailand)
Naxaythong	North: Phonhong Dist. Vientiane Prov, South: Sikhotabong and Chanthabouly Dist., East: Thoulakhom Dist. Vientiane Prov. And Xaythany Dist., West: Sangthong Dist.
Xaythany	North: Thoulakhom Dist. Vientiane Prov., South: Xaysettha and Hatsayfong Dist., East: Pakngeum Dist., West: Naxaythong and Chanthabouly Dist.
Hatsayfong	North: Sisatanak, Xaysettha and Xaythany Dist., South: Mekong River (Thailand), East: Pakngeum Dist., West: Mekong River (Thailand)
Sangthong	North: Sanakham and Feuang Dist. Vientiane Prov., South: Sikhotabong Dist., East: Naxaythong, Phonhong and Hin Heub Dist. Vientiane Prov., West: Mekong River (Thailand)
Pakngeum	North: Thaphabad Dist. Bolikhamxa Prov., South: Mekong River (Thailand), East: Mekong River (Thailand), West: Xaythany and Hatsayfong Dist.

SOIL TYPE

District	ALISOLS	ACRISOLS	FLUVISOLS	GLEYSOLS	LUVISOLS	CANBISOLS	LIXISOLS	REGOSOLS	LEPTOSOSLS
Chanthabouly	X								
Sikhotabong	X	X	X	X	X			X	
Xaysettha	X	X		X	X	X			
Sisatanak	X	X		X	X				
Naxaythong	X	X	X	X		X	X	X	
Xaythany	X	X	X	X	X	X			
Hatsayfong	X	X	X	X	X	X			
Sangthong	X	X	X		X			X	X
Pakngeum	X	X	X	X	X	X	X		X

SOIL LAYERS

District	Sandy Loam (ha)	Loam (ha)	Loamy Sand (ha)	Heavy Clay (ha)	Clay Loam (ha)	Sand (ha)	Clay (ha)	Light Clay (ha)	Others (ha)
Chanthabouly	742	14							
Sikhotabong	1.841		8.423		2.146	320			2.938
Xaysettha	7.010	3.884	1.913	1.460			235		
Sisatanak	800	549	915	204	429				
Naxaythong	18.552	14.251	20.762	2.661	4.539	27.971			
Xaythany	31.198	23.999	4.608	7.756	14.782			69	
Hatsayfong	5.706	4.678	5.473	2.930	3.052				3.961
Sangthong	23.315	123	16.236	949	38.547			830	
Pakngeum	1.525	524	29.346	456	12.509	1.957	222	8.274	
Total	90.689	48.022	87.676	16.416	76.004	30.248	457	9.173	6.899

TOPOLOGY

District	Relief	Alt. Max (m)	Alt. Min (m)
Chanthabouly	Plain	186	154
Sikhotabong	Mountainous	683	160
Xaysettha	Plain	187	155
Sisatanak	Plain	236	70
Naxaythong	Mountainous	683	155
Xaythany	Mountainous	950	160
Hatsayfong	Plain	254	77
Sangthong	Mountainous	818	121
Pakngeum	Mountainous	400	160

CLIMATE

District	Rain (month)	Dry (month)	Max. Temp	Min. Temp	Avg. Temp	Rainfall	Huminity	Evaporation
Chanthabouly	4-10	11-3	41	22	25	1300-2100 mm	72%	750-1100 mm
Sikhotabong	4-10	11-3	41	22	25	1300-2100 mm	72%	750-1100 mm
Xaysettha	4-10	11-3	41	22	25	1300-2100 mm	72%	750-1100 mm
Sisatanak	4-10	11-3	41	22	25	1300-2100 mm	72%	750-1100 mm
Naxaythong	4-10	11-3	41	22	25	1300-2100 mm	72%	750-1100 mm
Xaythany	4-10	11-3	31.9	16	24.1	1748 mm		
Hatsayfong	4-10	11-3	41	22	25	1300-2100 mm	72%	750-1100 mm
Sangthong	4-10	11-3	41	22	25	1300-2100 mm	72%	750-1100 mm
Pakngeum	4-10	11-3	41	22	25	1300-2100 mm	72%	750-1100 mm

WATER RESOURCES

District	Rivers
Chanthabouly	Swamp, Lake, Mekong River
Sikhotabong	Nam Moun, Nam Dane, Lake
Xaysettha	Swamp That luang, Swamp Makhiev, Lake
Sisatanak	Swamp, Lake, Mekong River
Naxaythong	Swamp, Lake, Nam Souang, Nam Houm River, Ngeum River
Xaythany	Nam Ngeum River, Lake
Hatsayfong	Swamp, Lake, Mekong River
Sangthong	Mekong River, Nam Sang, Nam Tone
Pakngeum	Mekong River, Nam Ngeum River, Swamp, Lake

SOCIO-ECONOMIC

	2014			2020		
District	GDP Growth%	Per Capita (USD/Per)	Population	GDP Growth%	Per Capita (USD/Per)	Population
Chanthabouly	14	2.500	62.305	10	Not Avail.	73.000
Sikhotabong	13,5	1.700	103.073	15	2.000	118.398
Xaysettha	11	1.937	98.585	13	2.500	113.243
Sisatanak	13,25	1.689	75.143	14	2.500	88.042
Naxaythong	9,5	1.187	67.643	12	1.500	79.255
Xaythany	10,46	1.117	84.695	12	2.200	231.018
Hatsayfong	8,5	1.248	86.094	13	1.800	100.861
Sangthong	9	214	26.035	8	Not Avail.	34.986
Pakngeum	Not Avail.	Not Avail.	44.776	Not Avail.	2.500	59.084
			648.349			897.887

EDUCATION

District	Schools	Classes	Teachers Total	Students Total
Chanthabouly	90	745	1.069	23.088
Sikhotabong	154	560	1.057	17.659
Xaysettha	130		1.228	22.618
Sisatanak	97	562	1.367	15.432
Naxaythong	71	392	514	11.171
Xaythany	163	1.215	1.851	39.946
Hatsayfong	105	488	685	15.652
Sangthong	41		438	6.045
Pakngeum	67		450	9.139
Total	**918**	**3.962**	**8.659**	**160.750**

PUBLIC HEALTH

District	Hospital	Health care	Total Doctors	Pharmacy
Chanthabouly	1	30	44	81
Sikhotabong	1	3	61	80
Xaysettha	1		47	76
Sisatanak	1		49	70
Naxaythong	1	4	57	38
Xaythany	1	10	99	90
Hatsayfong	1	6	60	45
Sangthong	1	5	38	26
Pakngeum	1			
Total	**9**	**58**	**455**	**506**

INFRASTRUCTURE

District	Road (Km)	Electricity	Irrigation (ha)	Manufactury	Handicraft
Chanthabouly	132,99	100%			
Sikhotabong	299,10	100%		26	
Xaysettha	214,61	100%		239	
Sisatanak	58.098,00	100%	150	30	
Naxaythong	212,67	100%			154
Xaythany	904,15	100%	5.194	479	25
Hatsayfong	190,47	100%	3.895	148	13
Sangthong	162,00	100%	475		
Pakngeum					
Total	**60.213,99**	**100%**	**9.714**	**922**	**192**

INFRASTRUCTURE (CONT.)

District	Big Market	Medium Market	Small Market	Enterprises	Gross Sale
Chanthabouly	8	2		2.452	584
Sikhotabong	8		4	4.256	
Xaysettha				2.857	
Sisatanak	1	3		3.112	
Naxaythong	4		4	2.102	
Xaythany		7	15	2.430	
Hatsayfong			10	1.033	
Sangthong					
Pakngeum					
Total	**21**	**12**	**33**	**18.242**	**584**

THE PROCESS IN CREATING THE LANDCOVER MAP FOR THE AGRICULTURAL AND FORESTRY COMPOSES OF 6 STEPS AS FOLLOWING

3. Survey: Field trip for data collection on the topography and Socio-economic information for Vientiane Capital.

4. Compilation: Prioritized and allocated the suitable lancover for agriculture and forestry for Vientiane Capital.

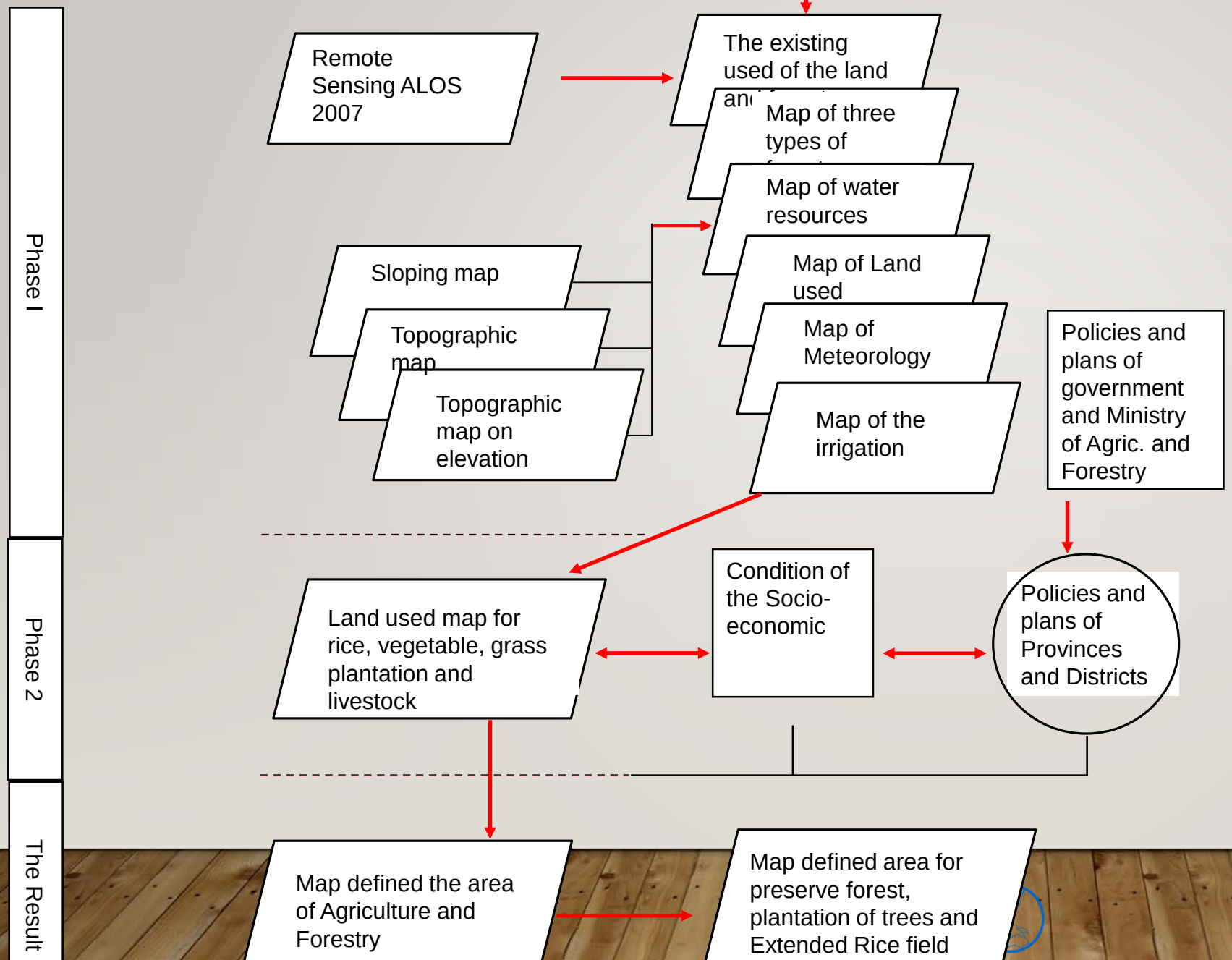
2. Analysis: Preliminary defined the landcover for the agriculture and forestry for Vientiane Capital.

5. Process: Analysing data collection and defined the land cover for the agriculture and forestry for Vientiane Capital.

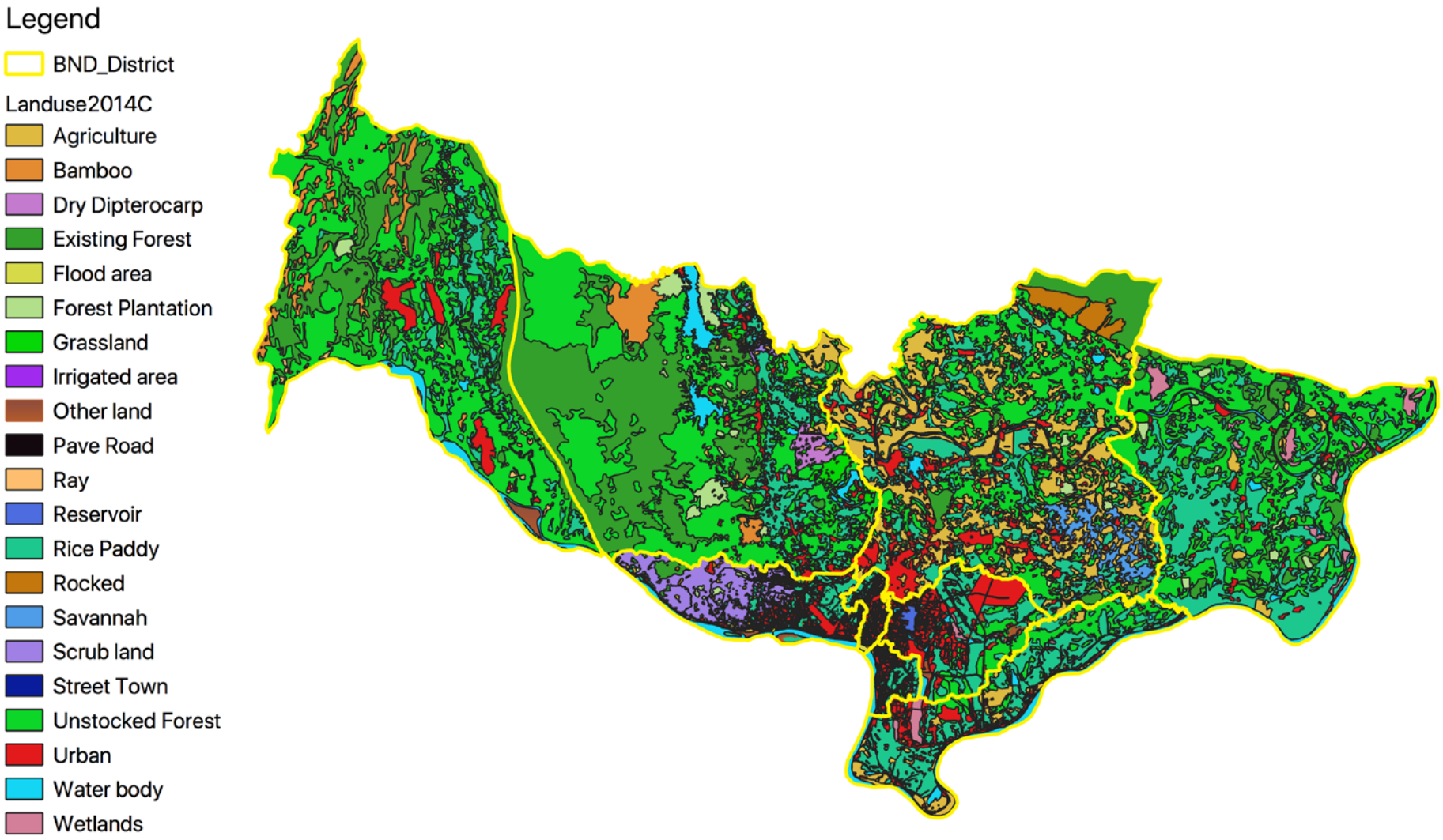
1. The preparation: Summary and the gathering for the agriculture and forest land for Vientiane Capital.

6. Map Development: Creation of the landcover map for the agriculture and forestry, produced the report, presentation of the finding and handover to the District for used.

The steps in defining area of Agriculture and Forestry



Land Classification of Vientiane Capital 2014 by Districts



Land Classification 2014 by Districts

Code	Sub District	Agriculture	Bamboo	Dry Dipterocarp	Existing Forest	Flood area	Forest Plantation	Grass land
2010100	Chanthabouly	0.698	0.000	0.000	45.064	59.539	0.000	0.000
2010200	Sikhotabong	566.998	0.000	0.000	689.639	0.411	502.674	0.025
2010300	Saysettha	6.691	0.000	0.000	0.351	0.000	0.000	0.000
2010400	Sisatanak	52.836	0.000	0.000	0.000	0.025	0.000	0.000
2010500	Naxaythong	2,562.944	3,000.465	1,139.957	27,950.332	0.000	3,259.885	2,089.216
2010600	Xaythany	25,788.557	0.000	0.000	5,672.765	0.000	710.880	2.132
2010700	Hatsayfong	2,923.654	0.000	0.000	74.748	0.000	0.000	0.000
2010800	Sangthong	0.000	4,823.414	0.000	20,133.510	0.000	274.249	0.000
2010900	Pakngeum	996.087	0.000	0.000	6,057.239	0.000	1,083.779	529.957
2010000	Vientiane Capital	32,898.465	7,823.879	1,139.957	60,623.648	59.975	5,831.467	2,621.330

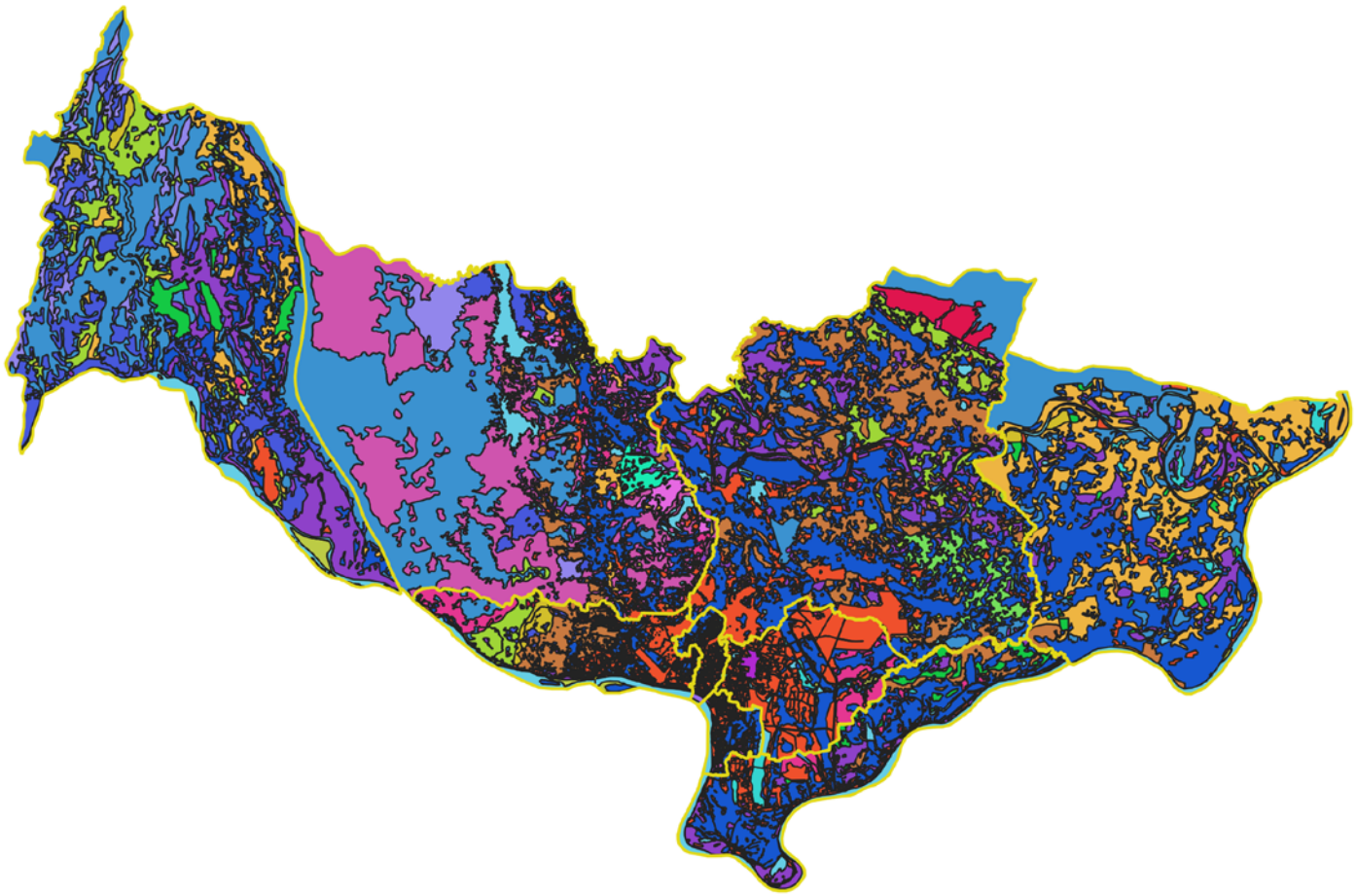
Land Classification 2014 by Districts (Cont.)

Code	Sub District	Irrigated area	Other land	Paved Road	Ray	Reser voir	Rice Paddy	Rocked
2010100	Chanthabouly	0.000	148.648	150.410	0.000	0.000	487.015	0.000
2010200	Sikhotabong	0.000	230.450	337.284	0.000	0.000	2,299.813	112.754
2010300	Saysettha	16.800	384.795	331.563	0.000	284.180	4,286.603	0.000
2010400	Sisatanak	18.254	12.884	112.303	0.000	0.000	795.877	0.000
2010500	Naxaythong	28.343	37.053	0.035	0.000	0.000	8,013.840	0.039
2010600	Xaythany	0.000	0.026	0.306	0.000	0.000	14,413.373	2,234.750
2010700	Hatsayfong	71.491	1.959	28.706	0.000	0.000	9,100.370	0.000
2010800	Sangthong	0.000	644.022	0.000	1,063.598	0.000	8,132.348	0.000
2010900	Pakngeum	0.000	32.795	0.000	0.000	0.000	18,995.478	0.000
2010000	Vientiane Capital	134.888	1,492.632	960.607	1,063.598	284.180	66,524.717	2,347.543

Land Classification 2014 by Districts (Cont.)

Code	Sub District	Savan nah	Scrub land	Street Town	Unstocked Forest	Urban	Water body	Wetland
2010100	Chanthabouly	0.000	0.000	0.000	0.000	1,182.919	153.512	23.129
2010200	Sikhotabong	0.000	6,162.442	0.000	104.666	2,910.424	1,584.162	68.692
2010300	Saysettha	0.000	0.000	0.000	2,833.521	5,599.302	486.780	335.912
2010400	Sisatanak	0.000	0.000	0.000	146.472	1,166.176	525.458	0.000
2010500	Naxaythong	0.000	301.180	0.000	34,230.743	2,046.335	3,746.051	126.608
2010600	Xaythany	2,880.404	0.000	0.000	23,298.023	6,933.669	2,266.583	0.156
2010700	Hatsayfong	0.000	0.000	32.913	3,196.156	3,010.228	2,013.379	580.592
2010800	Sangthong	0.000	0.000	0.000	36,296.164	2,726.686	2,075.997	0.000
2010900	Pakngeum	0.000	0.000	0.000	26,745.825	1,393.576	2,718.902	1,905.354
2010000	Vientiane Capital	2,880.404	6,463.622	32.913	126,851.570	26,969.315	15,570.824	3,040.443

Land Classification of Vientiane Capital 2020 by Districts



Legend

BND_District

Landuse2020C

- Agriculture
- Bamboo
- Dry Dipterocarp
- Existing Forest
- Expension for Rice Paddy
- Flood area
- Forest Plantation
- Grassland
- Irrigated area
- Other land
- Pasture
- Pave Road
- Potential for Annual Crop
- Potential for Forest plantation
- Potential for Perennial Crop
- Potential for Reforestation
- Reservoir
- Rice Paddy
- Rocked
- Savannah
- Scrub land
- Unstocked Forest
- Urban
- Water body
- Wetlands

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Land Classification 2020 by Districts

Code	Sub District	Agriculture	Bamboo	Expension Rice	Dry Diptero carp	Existing Forest	Flood area	Forest Plantation
2010100	Chanthabouly	0.490	0.000	0.000	0.000	38.059	58.426	0.000
2010200	Sikhotabong	266.075	0.000	0.000	0.000	696.011	0.443	335.965
2010300	Saysettha	0.000	0.000	0.000	0.000	0.159	0.000	0.000
2010400	Sisatanak	51.364	0.000	0.000	0.000	0.000	0.000	0.000
2010500	Naxaythong	2,636.538	2,846.342	1,242.388	1,116.943	27,930.774	0.000	3,216.796
2010600	Xaythany	10,485.525	0.000	9.785	0.000	5,662.008	0.000	687.257
2010700	Hatsayfong	2,227.603	0.000	0.000	0.000	72.900	0.000	3.698
2010800	Sangthong	10,280.960	4,553.679	5,492.571	0.000	23,281.957	0.000	11,961.504
2010900	Pakngeum	4,168.327	0.000	19,263.077	0.000	9,164.995	0.000	171.891
2010000	Vientiane Capital	30,116.882	7,400.021	26,007.821	1,116.943	66,846.863	58.869	16,377.111

Land Classification 2020 by Districts (Cont.)

Code	Sub District	Grass land	Irrigated area	Other land	Pasture	Pave Road	Potential Annual Crop	Potential Perennial Crop
2010100	Chanthabouly	0.000	0.000	158.088	0.000	151.094	0.000	0.000
2010200	Sikhotabong	0.000	0.000	238.950	736.563	337.284	2,999.424	1,502.349
2010300	Saysettha	0.000	16.800	128.692	0.000	331.262	2.171	0.000
2010400	Sisatanak	0.000	18.254	18.217	0.000	113.208	0.000	0.000
2010500	Naxaythong	2,117.086	28.343	43.432	2.395	0.035	1,836.555	465.702
2010600	Xaythany	2.836	0.000	0.000	0.000	0.367	17,535.994	5,156.519
2010700	Hatsayfong	0.000	71.491	1.672	0.000	63.150	1,405.789	0.000
2010800	Sangthong	0.000	0.000	623.872	681.205	0.000	0.000	6,211.561
2010900	Pakngeum	0.000	0.000	578.414	608.696	0.000	410.581	1.271
2010000	Vientiane Capital	2,119.922	134.888	1,791.337	2,028.859	996.400	24,190.514	13,337.402

Land Classification 2020 by Districts (Cont.)

Code	Sub District	Potential Forestation	Potential Reforestation	Reservoir	Rice Paddy	Rocked	Savannah
2010100	Chanthabouly	0.000	0.000	0.000	479.909	0.000	0.000
2010200	Sikhotabong	0.000	1,352.865	0.000	1,525.098	123.075	0.000
2010300	Saysettha	1.162	1,518.062	283.096	3,372.391	0.000	0.000
2010400	Sisatanak	0.000	0.000	0.000	780.155	0.000	0.000
2010500	Naxaythong	605.280	1,877.690	0.000	7,996.585	0.008	0.000
2010600	Xaythany	2.523	187.791	0.000	28,908.331	2,235.046	2,872.439
2010700	Hatsayfong	718.970	826.237	0.000	8,986.689	0.000	0.000
2010800	Sangthong	1,903.211	112.293	0.000	8,099.470	0.000	0.000
2010900	Pakngeum	779.663	0.000	0.000	16,109.711	0.000	0.000
2010000	Vientiane Capital	4,010.809	5,874.938	283.096	76,258.339	2,358.129	2,872.439

Land Classification 2020 by Districts (Cont.)

Code	Sub District	Scrub land	Street Town	Unstocked Forest	Urban	Water body	Wetland
2010100	Chanthabouly	0.000	0.000	0.000	1,198.146	147.342	19.345
2010200	Sikhotabong	0.000	0.000	2.820	3,864.187	1,578.426	9.837
2010300	Saysettha	0.000	0.000	0.011	8,098.997	478.043	338.539
2010400	Sisatanak	0.000	0.000	177.968	1,153.560	517.045	0.000
2010500	Naxaythong	208.456	0.000	28,402.281	2,064.058	3,697.371	104.034
2010600	Xaythany	0.000	0.000	2.847	8,032.614	2,237.474	0.360
2010700	Hatsayfong	0.000	0.000	0.244	3,074.200	2,560.185	579.063
2010800	Sangthong	0.000	0.000	0.000	827.670	2,115.466	0.000
2010900	Pakngeum	0.000	0.000	0.000	1,083.126	2,793.442	1,416.684
2010000	Vientiane Capital	208.456	0.000	28,586.171	29,396.558	16,124.794	2,467.862

NEW TECHNOLOGY FOR THE REGION

- Satellite-based mapping
  - Fast and efficient
  - Required less budget
  - International Standard, high quality and accuracy
  - Required human resources skill, less human resources

RELATED WORKS

- Land-cover classification using optical satellite images is widely researched for decades
- Optical images
  - Pros: record reflectance/emission of Earth's surface in wavelengths of 0.4-12.5 micrometer (visible, near infrared, shortwave infrared,…), many satellite images are free of charge (MODIS, Landsat 5/7/8, Sentinel 2A,…)
  - Cons: highly influenced by clouds, data is considered lost when Earth's surface is covered by clouds
- Land-cover classification in cloud-prone areas
  - Vientiane Capital is frequently covered by cloud (Whitcraft et al. 2015)
  - It is a challenge to derive land-cover maps in cloud-prone areas using medium/high spatial resolution images due to its low temporal frequency (Landsat: 30m, 16 days)

PROBLEM STATEMENT

- Propose a land-cover classification method for Vientiane Capital using medium/high spatial resolution optical images
- Produce an land cover map in 2017 for Vientiane Capital

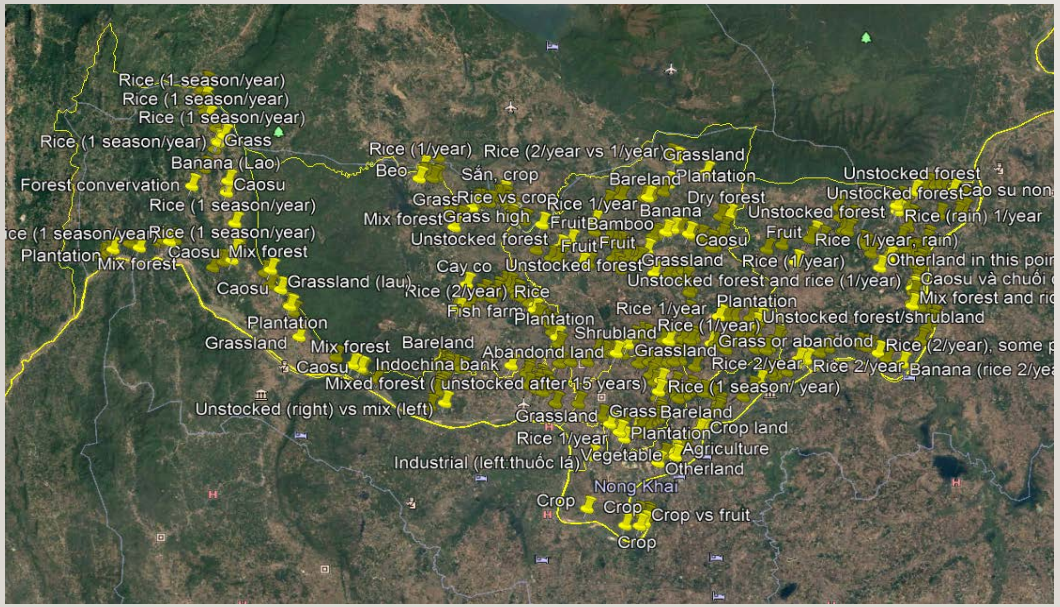
SATELLITE IMAGE

- Landsat 8 surface reflectance (SR) images: launch date 11/2/2013 (NASA)
  - 7 spectral bands: coastal, blue, green, red, nir, swir1, swir2
  - Spatial resolution: 30m
  - Temporal resolution: 16 days
- Images period: 2015-2017

Year	Number of images
2015	71
2016	70
2017	61
Total	202

GROUND TRUTH DATA

- Field visits to 9 districts of Vientiane Capital
- 547 points collected



Distribution of ground samples

Number of samples by class

Class	Number of points
Agriculture	71
Forest	151
Grass/Shrub	96
Bareland & Rock	14
Industrial	9
Built up	49
Rice	141
Water	16
Total	**547**

TRAINING DATA

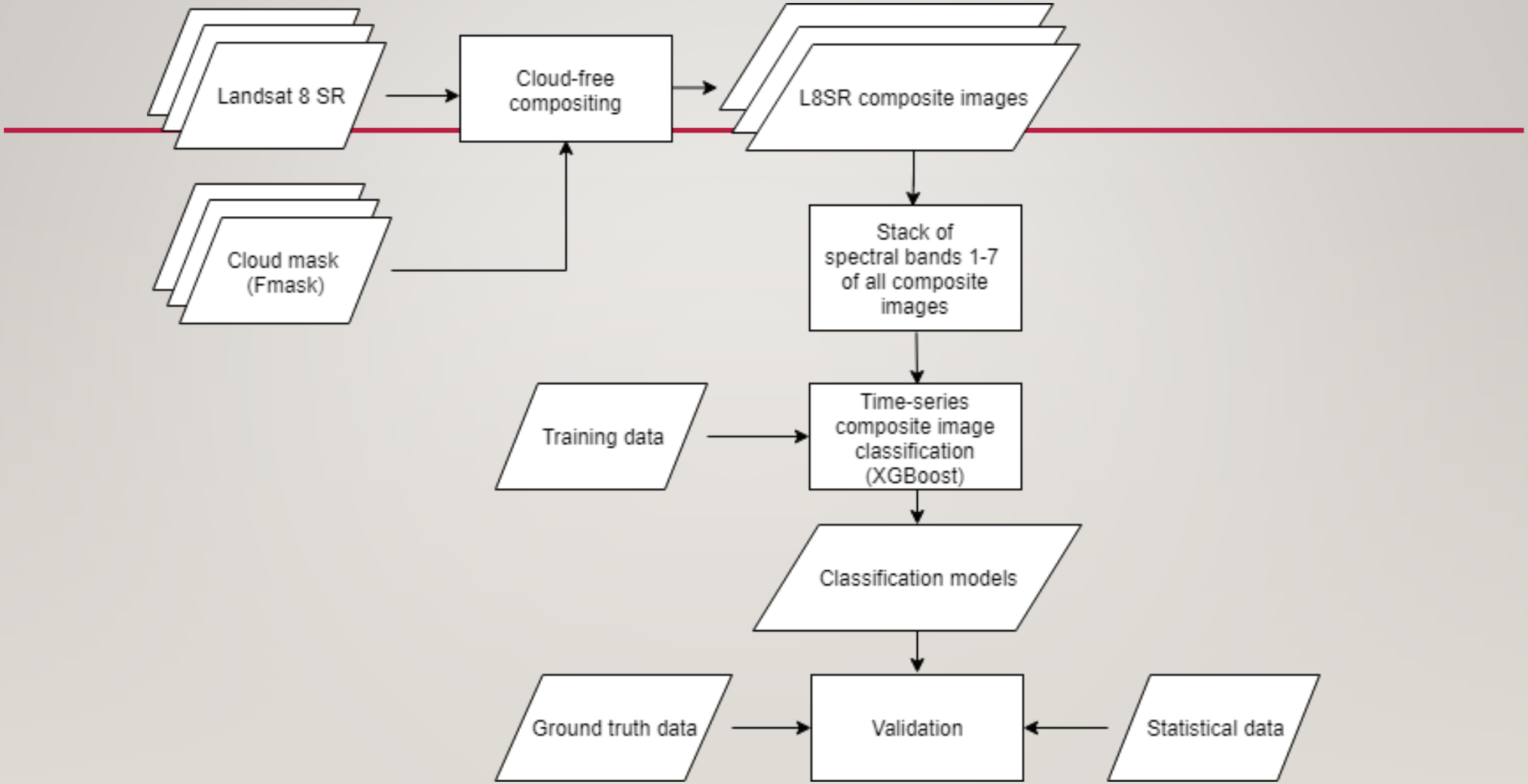
- To train classifier for classification
- Collected throughout the study area

Number of samples by class

Class	Number of points
Agriculture	750
Forest	1275
Grass/Shrub	907
Bareland & Rock	486
Industrial	575
Built up	1053
Rice	863
Water	418
Total	**6327**

METHODOLOGY

METHOD


Landsat 8 SR
Cloud-free compositing
L8SR composite images
Cloud mask (Fmask)
Stack of spectral bands 1-7 of all composite images
Training data
Time-series composite image classification (XGBoost)
Classification models
Ground truth data
Validation
Statistical data

GENERATION OF TIME-SERIES COMPOSITE IMAGES

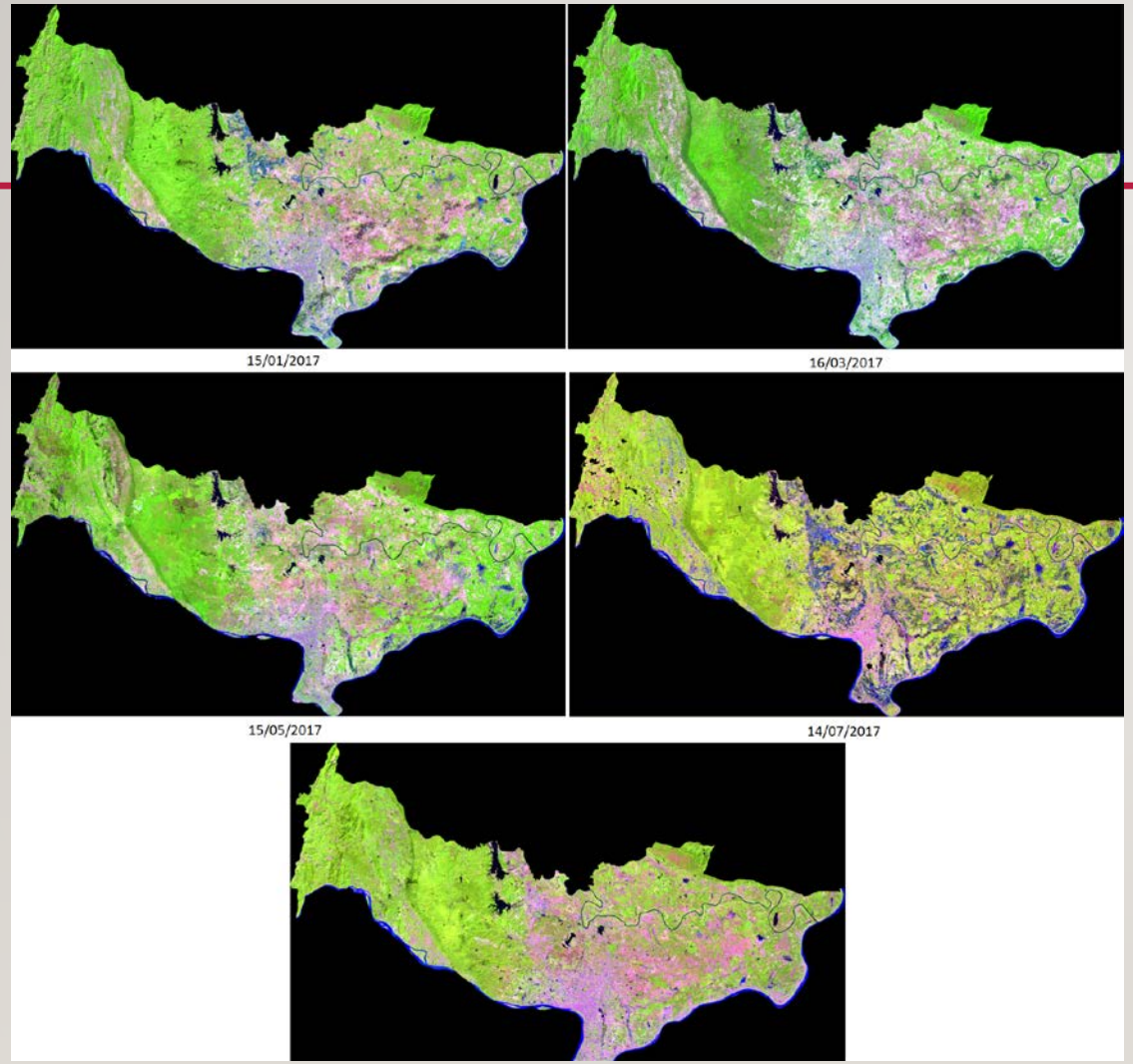
- Purpose
  - Generate a dense, cloud-free image time series
  - Input: all of the Landsat 8 SR images (2015-2017)
  - Output: 5 cloud-free composite images (15/01/2017, 16/03/2017, 15/05/2017, 14/07/2017, 11/11/2017 -> target images)
- Method: follow method from Man et al. 2018
  - Replace a clouded pixel in target image with a best unclouded pixel from a set of candidate pixel
  - Ranking strategy: maximum sum of scores:
    - Year score
    - Date of year (DOY) score
    - Opacity score
    - Cloud/cloud shadow score

FEATURE EXTRACTION AND CLASSIFICATION

- Feature extraction:
  - Create a single 42-band image by stacking 5 composite images
  - Features: 42 spectral bands, this integrate:
    - Temporal information
    - Spectral information
- Classification:
  - Classifier: eXtreme Gradient Boosting (XGBoost) – a tree-based classifier
  - Parameters: number of tree, maximum depth + minimum sample weight for regularization
  - Parameter optimization: 3-fold cross-validation on training set

EXPERIMENTS AND RESULTS

COMPOSITION RESULT



Cloud-free composite images of Vientiane Capital

LAND-COVER CLASSIFICATION RESULTS – GROUND TRUTH VALIDATION

	Agriculture	Forest	Grass/ Shrub	Industrial	Rice	Bareland & Rock	Built up	Water	Precision (%)
Agriculture	41	6	16	0	2	0	6	0	59
Forest	8	120	19	0	2	1	1	0	88
Grass/Shrub	18	10	46	5	10	1	6	0	51
Industrial	0	0	1	6	0	1	1	0	38
Rice	1	1	7	1	129	0	0	2	90
Bare land & Rock	1	0	2	2	1	6	2	0	67
Built up	0	0	0	2	0	0	47	0	75
Water	0	0	0	0	0	0	0	16	89
Recall (%)	58	79	48	67	91	43	96	100	75.13 (Overall Accuracy)

Confusion matrix

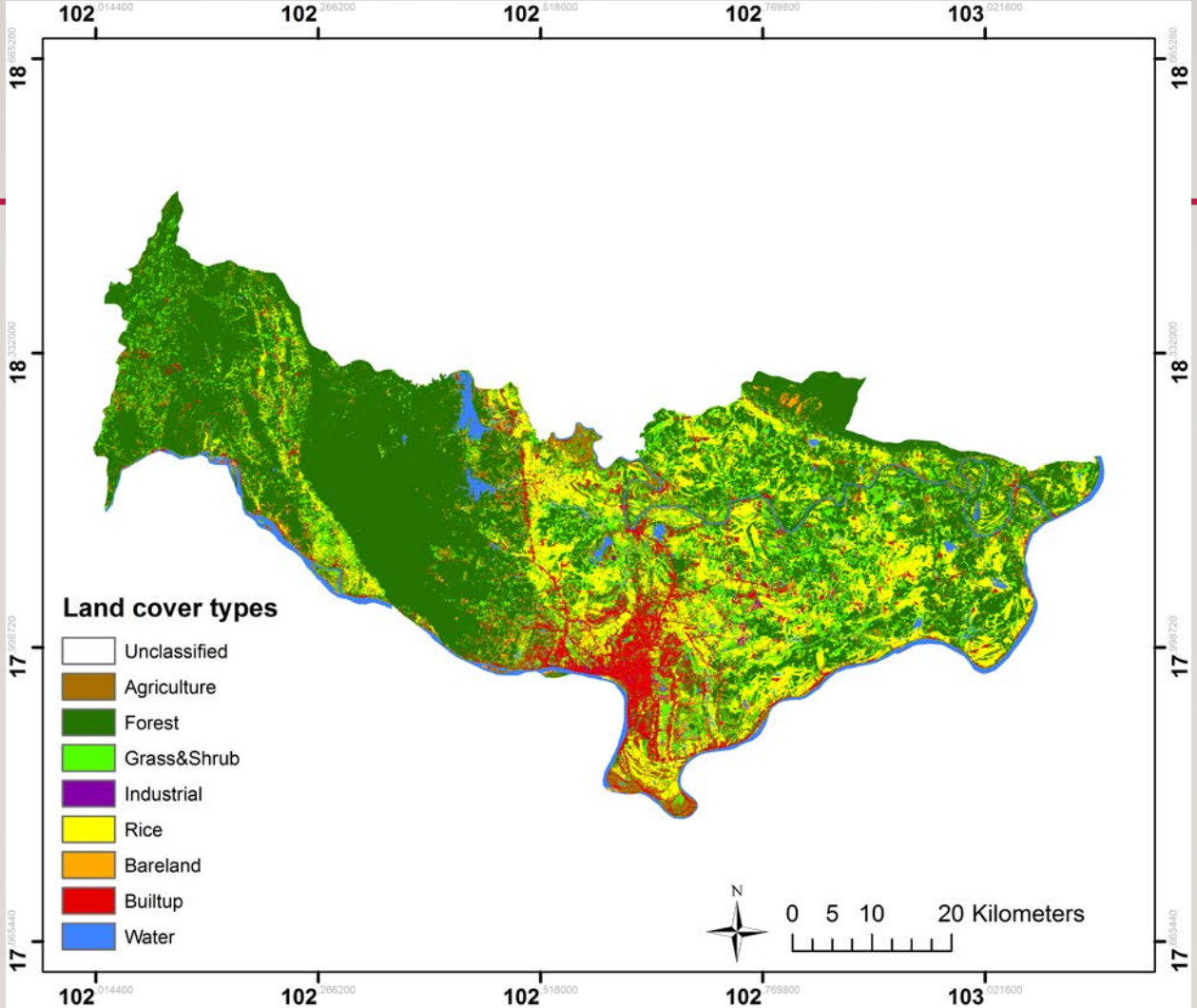
LAND COVER TYPES AREA

Area per class for Vientiane Capital (km2) by satellite-based mapping and official land use

	Agriculture	Forest	Grass&Shrub	Industrial	Rice	Bareland	Builtup	Water
Area by Landsat 8 in 2017	241.28	1774.38	624.40	44.87	539	41.53	243.93	160.07
Area by statistal data in 2014	335.95	2034.25	120.905	16.650	670.1	23.56	276.4 (including industrial)	204.71

- Agriculture land (rice and crop) are largely abandond in recent years, result in decrease of agriculture and rice and increase of grass&shrub
- Forest loss by 260 km^2 in 3 years

LAND COVER MAP IN 2017 FOR VIENTIANE CAPITAL



CONCLUSION

- Achievements
  - Multi-year composition increases cloud-free pixels in composites, especially over cloud-persistent areas such as Vientiane Capital
  - Accurate land cover maps could be derived by combining time-series composite images and machine learning classifiers
  - Rice, forest, water, built up can be classified accurately
- Drawbacks
  - Confusions between bareland/built up/industrial, grass/agriculture due to their similar spectral characteristics, even in temporal domain

FUTURE WORKS

- Improve classification for bareland/built up/industrial, grass/agriculture
- Increase number of land cover classes
- Integrate additional information for better classification (texture, radar,…)
- Study on the Environment Impact for Vientiane Capital

REFERENCE

- Chuc Duc Man, Kristofer Lasko, Thuy Thanh Nguyen, Hung Quang Bui, Thanh Thi Nhat Nguyen. *Improvement of Land Cover Classification over Frequently Cloud-covered Areas using Landsat 8 Time Series Composites and an Ensemble of Supervised Classifiers*. International Journal of Remote Sensing, Vol 39, Issue 4.

AGRICULTURE & FORESTRY LAND COVER

Thank you for your attention !