ラオス国ビエンチャン市における水田面積の減少と都市面積の増加
Paddy Rice Field Change Detection in Urban Watershed Area, Vientiane Capital, Lao PDR

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I. Introduction

Rice is the primary daily grain consumed in Southeast Asia countries. The rising population is leading to an increased demand for rice production. The ASEAN hunger numbers rose to 45.4 million in 2021, while Laos was ranked at a moderate level among huger countries. To ensure food securety, paddy rice field areas should be monitored and enhanced. In the developing country, ongoing intensification and sprawl of urban growth make a serious impact on the paddy field area and its environmental services, specifically in Vientiane Capital city, farmlands vulnerably converted to urban area. Therefore, understanding paddy field land use/ cover change is critical for sustainning rice production and supports undertaking policy measures. So, remote sensing technology with multitemporal image data analysis can provide valuably spatial information on how paddy rice field has changed over the periods. The objective of this study is to analyze the periodical change in the paddy rice field area.

II. Material and Method

Mak Hiao River Basin covers an area of 454.4 sq.km of Vientiane Capital (VC).

The basin covered the urban area of the capital city and holds a population of 321,599 in 2015 approximately. The topography of the basin ranges between 142 and 227 m and is covered by a tropical monsoon climate. Croplands mostly locate in middle and downstream areas, while upstream is dominated by urban areas. Mak Hiao River is the main drainage river. The rice planting is divided into irrigated and rainfed seasons, its phenological stages see Fig. 2.

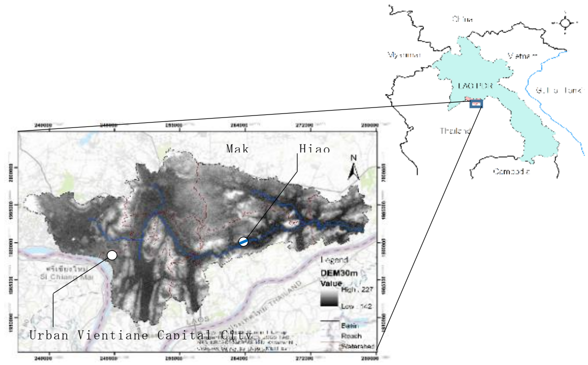

Fig 1. DEM in Mak Hiao River Basin

We collected the temporal image data of Landsat-5 and 8 Surface Reflectance Products from Jun-Jul, Oct-Nov, and Dec-Jan in 1989, 2000, 2013, and 2021. Then, cloud masking and atmospheric correction were performed for vegetation indices. The ground points data were obtained to evaluate and verify the accuracy of classified maps.

The vegetation and water indices of EVI, NDVI, LSWI, and NDWI including the built-up index are calculated as the following equations:

$$EVI = 2.5\frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + (6 * \rho_{red}) - (7.5 * \rho_{blue}) + 1}$$

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$$NDVI = \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + \rho_{red}} \quad LSWI = \frac{\rho_{nir} - \rho_{swir1}}{\rho_{nir} + \rho_{swir1}}$$

$$NDWI = \frac{\rho_{green} - \rho_{swir}}{\rho_{green} + \rho_{swir}}; \quad NDBI = \frac{\rho_{swir} - \rho_{nir}}{\rho_{swir} + \rho_{nir}}$$

Where ρblue, ρgreen, ρred, ρNIR and ρSWIR are the band number in different wavelength of Landsat dataset.

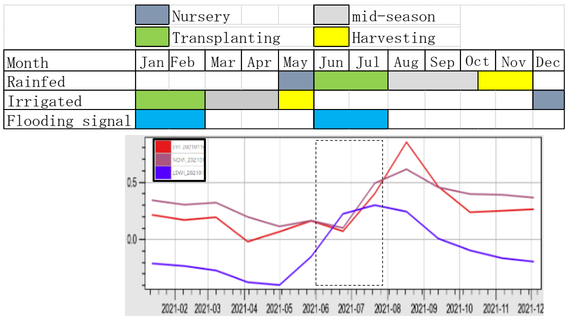

Fig 2. Paddy rice growing stages in Laos and remote sensing analysis

According to typical stages (see Fig. 2). the transplanting period is crucial to detect the flooding signals and rice transplanting in the paddy rice field with an assumption of LSWI > EVI or NDVI. However, individual farmers have their own schedules for flooding and rice transplanting. Therefore, Xiao et al (2005) introduced a threshold for identifying a flooding/transplanting pixel as follows: LSWI+0.05 > EVI or NDVI is a flooded pixel.

Then, the classified maps were evaluated by User and Producer accuracies, and the Kappa coefficient through ground truth data points.

III. Ongoing Results and Discussion

Overall features, vegetation and paddy field areas declined significantly while urban areas rose throughout the period. On the other hand, water and other lands fluctuated.

Vegetation and paddy field areas decreased 54.46% and 26.88% during 2000-2021, respectively. Meantime, urban area in 2021, expanded to 1.6 times approximately compares to the

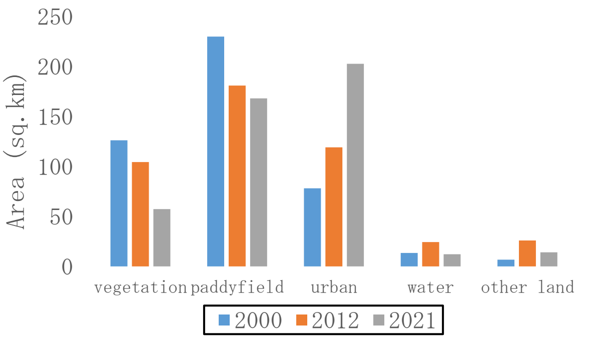

Fig 3. Area change of each land use class

year 2000. While, water and other lands areas quite fluctuated but they were significantly reduced of 49.51% and 45.28% during 2012-2021 respectively, see Table 1.

Table 1 Percent of area change of land use

Land use class	% Change		
	2000-2012	2012-2021	2000-2021
Vegetation	-17.20	-45.00	-54.46
Paddyfield	-21.35	-7.03	-26.88
Urban area	52.25	70.07	158.93
Water	79.76	-49.51	-9.24
Other land	280.22	-45.28	108.06

Table 2 Rate of change of land use class

Land use class	Rate of change (sq.km/year)		
	2000-2012	2012-2021	2000-2021
Vegetation	-1.81	-5.22	-3.27
Paddyfield	-4.09	-1.41	-2.94
Urban area	3.41	9.27	5.92
Water	0.90	-1.34	-0.06
Other land	1.59	-1.30	0.35

The ratio of change showed the urban area expanded to 9.27 sq.km/year, while vegetation cover decreased to 5.22 sq.km/year during 2012-2021. meanwhile, the paddy field declined by 4.09 sq.km/year between 2000-2021. Another, water and other lands kept constantly changing about 1.3 sq.km/year approximately over the period. *(Ongoing results...)*

IV. Conclusion

The paddy rice field area decreases throughout the period, a significant reduction could be observed from 2000 to 2012.