Potential of land classification by CubeSat in Monsoon Asia

F Kondo¹, K Noda¹,³, and C Phompila²

¹Faculty of Applied Biological Sciences, Gifu University, Yanagido 1-1, Gifu, 501-1193, Japan.
²Faculty of Forest Science, The National University of Laos, Vientiane Capital 0100, Lao People’s Democratic Republic
³Corresponding author: anod@gifu-u.ac.jp

Abstract. Frequent and severe flood by climate change is a big problem in the world. But there are many areas where water use and flood control facilities are not fully installed especially in developing countries. In these areas, a flood caused by heavy rainfall is getting frequent and now more serious. Few previous researches have analyzed the range and season of inundation due to lack of high resolution and frequency satellite imagery. Today, Planet Labs provides high resolution (±3.0m-) and high frequency (1 day-) CubeSat imagery. The primary goal of this research is to develop a model to analyze the range and season of springing in rainy season for Laos with clear rainy and dry season. We analyzed some land use areas from satellite imagery during rainy season with two indexes, Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) are the indexes where is identify vegetation and water covers. We analyzed seasonal change of two individual values and the relationship of two values and we distinguished from the degree of two indexes for each land use (City area, Water area, Wetland, Paddy Field). It suggests that each land use has its own value depending on the season.

1. Introduction

These days, many extreme disasters caused by climate change have become more frequent, especially flood and drought in monsoon Asia, including Laos. The disaster causes catastrophic damage to the live of people. However, in such areas, water facilities are not sufficiently developed and needed to install water facilities immediately. Some countries in monsoon Asia have received large investments from various countries to promote economic development. However, due to a rapid economic development, aquatic environments are under threats. In city development, the development of sewer system is delayed because it is developed drinking water. In the past, sewage was diluted or naturally purified in wetlands and discharged into the river. This system maintained the quality of water flowing into the river. However, due to the increase in sewage spillage in recent years, there is a concern that it will not be able to be treated with conventional system and cause environmental problems [1]. In addition, because climate change is expected to progress further, more floods are expected to occur due to heavy rains. To deal with these situations, it needs to proceed with plans to efficiently drain water. When drainage plan is made, land use needs to be considered. So, we used satellite image to distinguish land use during the rainy and dry season.

We can get high frequency and resolution satellite image with developing small and low-priced satellite. Because it achieved mass production of low-priced small satellites and lower launch costs, it is relatively affordable for commercial satellite companies to launch and operate. Planet Labs operates more than 120 Cube Sats, 14 SkySats and 5 RapidEye and provide images of the entire earth with a
resolution of 3–5m almost every day [2]. This large amount of frequent and high resolution images retains the potential value of hydrological applications because it is the simplest land cover for distinguishing visible/NIR images. Also, frequent observations are required to track dynamic hydrological processes such as floods and rivers [3].

Hydrological analysis could be done by using elevation data such as Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). ASTER data are used to create detailed maps of land surface temperature, reflectance, and elevation [4]. However, Vientiane Plain (study area) is relatively flat, so using elevation data alone is not suitable. Thus, it is efficient to use a high resolution of satellite images for analyzing in this research. The primary goal of this research is to develop a model to analyze the range and season of springing in rainy season for Laos with clear rainy and dry season. We analyzed some land use areas from satellite images during rainy season with two indexes. Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) are indexes to identify vegetation and water covers. Determining land use in this research can be used it for future drainage measures. NDVI is suitable for detecting vegetation and NDWI is suitable for detecting changes in surface water. [5] NDVI is also used for distinguishing other than vegetation, but NDWI isn’t used much. In this study, land use is determined by combining the values of NDVI and NDWI. Furthermore, areas such as wetlands and paddy fields that are difficult to distinct from a single image were identified by comparing their values in the rainy and dry season. The purpose of this study is to identify the main land use (City area, Water area, Wetland, Paddy Field) from satellite images by specifying the degree of two indexes for the land use.

2. Methods

2.1. The study area
Laos is located in southeast Asia. Monsoon Asia, including Southeast Asia, is defined by the monsoon climate in Asia (Figure 1). Laos is also one of the countries where economic activity has been flourishing in recent years. About 70% of the country is forested and about 20% is farmland. This region has a rainy season from June to October and a dry season from November to February. Agriculture in the plains of Laos is based on rice cultivation in the rainy season and most of it is run in rain-fed paddy field that rely on rainfall [6]. The target area is the Vientiane Plain including the capital city of Laos, Vientiane. The Vientiane Plain is very flat and drainage analysis with DEM data is almost impossible, so far there hasn’t been land use analysis leading to detailed drainage analysis. The target area includes the Mekong River, small rivers draining it, residential areas, paddy fields, wetlands and so on.

![Figure 1. Location of study area](image-url)
Figure 2. Detailed map of the study area

Figure 3. Image of February 23, 2019
2.2. **Using data**

Planet Scope4Band by Planet labs was used for the analysis of NDVI and NDWI. Planet Scope4Band has four band that is blue (455–515nm, band1), green (500–590nm, band2), red (590–670nm, band3) and nir infrared (780–860nm, band4) [7]. The ground resolution is 3.7m. Planet Scope4Band don’t have cloud mask that removes clouds in the images, but it has clod cover that shows how much clouds is in the image. Day of image was selected that covers less than 20% of the cloud cover and more than 90% of the survey area. Because an image projected with UTM using WGS84 data, we create a seamless image from multiple images of study area by clipping to a tile grid structure. The images captured in two different time were used, shown in Figure 3 and Figure 4; dry season (Feb, 2019) and; rainy (Sep, 2018). A total of 17 scenes

2.3. **NDVI and NDWI**

NDVI is defined using NIR (near infrared) and Red band by [8].

\[ NDVI = \frac{NIR - Red}{NIR + Red} \]  

NDWI is defined using Green and NIR band by [9].

\[ NDWI = \frac{Green - NIR}{Green + NIR} \]

NDVI and NDWI value are between -1 and 1. Vegetation pixels approach 1 in NDVI and water pixels approach 1 in NDWI. We drew a map of these indexes in rainy and dry seasons. In addition, we compared the land use discriminated from these draw maps and aerial photographs and analyzed the degree of these indicators for each land use (City area, Water area, Wetland, Paddy Field) with eyes. The degree is divided three (Low, Middle, High). Low is -1.00–about-0.25, Middle is about 0.25–about0.25, High is about0.25–1.00.

3. **Results**

3.1. **Dry season**

NDVI value of dry season was divided into approximately 3 groups. Vegetation area was positive value (High). Undeveloped soil roads and areas that were not cultivated were near zero (Middle). Water area

![Figure 4. Image of September 16, 2018](image-url)
and city area were negative value (Low). (Figure 5) On the other hand, NDWI value was divided into approximately 4 groups. Water area was positive value (High). City area was lower positive value (Middle) than water area. Undeveloped soil roads and areas that were not cultivated were near zero (Middle). Vegetation area was negative value (Low) (Figure 6).

![Normalized Difference Vegetation Index](image)

**Figure 5.** NDVI (February 23, 2019)

![Normalized Difference Water Index](image)

**Figure 6.** NDWI (February 23, 2019)

### 3.2 Rainy season
NDVI was more areas with positive values than dry season. Vegetation area (paddy field, field, forest and so on) was positive value (High). Undeveloped soil roads and areas that were not cultivated were near zero (Middle). Water area and city area were negative value (Low) (figure 7). On the other hand, NDWI has more negative value areas than dry season because vegetation shows negative value. Also, water area was shown more clearly than dry season. City area and Undeveloped soil roads and areas that were not cultivated were near zero (Middle). (Figure 8)
3.3 Land use

Four typical land use (City area, Water area, Paddy field, and Wetland) for each indexes of dry and rainy season are divided into three stages (High, Middle and Low) (Table 1) and tabulated. And we summarized data can be distinct for each land use. NDVI in dry season, three land uses (City area, Water area, Paddy field) are low, and Wetland is high. In NDVI of rainy season, City area and Water area are low and Paddy field and Wetland are high. NDWI in dry season, City area and Paddy field are middle, Water area is high and Wetland is low. NDWI in rainy season, City area and Water area are middle and Paddy field and Wetland are low. We made this distinction a flowchart. (Figure 10) By the distinction of NDVI in dry season, Wetland is only high and can be distinct. Secondly, by the distinction of NDVI in rainy season, Paddy field is only high and can be distinct. Thirdly, by the distinction of NDWI in rainy season, water area is high and City area is low. So, land use can be distinct with NDVI in dry and rainy season and NDWI in dry season.

Figure 7. NDVI (September 16, 2018)

Figure 8. NDWI (September 16, 2018)
Table 1. Dividing into three stages for land use

| Land use      | Indicator | Rainy season | Dry season |
|---------------|-----------|--------------|------------|
| City area     | NDVI      | Low          | Low        |
|               | NDWI      | Middle       | Middle     |
| Water area    | NDVI      | Low          | Low        |
|               | NDWI      | Middle       | High       |
| Paddy field   | NDVI      | High         | Low        |
|               | NDWI      | Low          | Middle     |
| Wet land      | NDVI      | High         | High       |
|               | NDWI      | Low          | Low        |

Figure 9. Examples of land use locations

Figure 10. Distinct land use procedure
4. Discussion
It’s expected that flooding due to climate change and deterioration of water environment due to economic development will occur more and more in the future. High resolution and frequency satellite images developed in recent years were used as a means of collecting land use data that would lead to this countermeasure. We classified four main land use classifications based on NDVI and NDWI degree during the rainy and dry seasons as land use classification methods.

When NDVI values were compared between the dry and rainy seasons, there were more areas that showed positive values overall in rainy season. This indicates that rice cultivation is actively grown using abundant precipitation. In dry season, there were many areas that showed negative values overall. This indicates that rice cultivation wasn’t grown and the soil has a negative value near zero. In addition, areas where the NDVI value of dry season was positive are areas where vegetation can be seen even in dry season, that is, they are vegetation such as forests, wetlands and so on other than cultivated land.

When NDWI values were compared between the dry and rainy season, there were more areas that showed negative values overall in rainy season. This is probably because the surface water is covered with vegetation that shows negative value. Also, in rainy season, there are some water areas that were not seen in dry season and it is thought to be due to precipitation. On the other hand, it indicates that many areas that show negative values in dry season are the part of the soil where crops are not cultivated. Although the numerical values are different because the response function of the sensor is deferent from the research using other satellite images, but the tendency of the result is the same as [10].

We made this distinction a flowchart. (Figure 9) By the distinction of NDVI in dry season, Wetland is only high and can be distinct. Secondly, by the distinction of NDVI in rainy season, Paddy field is only high and can be distinct. Thirdly, by the distinction of NDVI in rainy season, water area is high and City area is low. So, land use can be distinct with NDVI in dry and rainy season and NDWI in dry season.

5. Conclusion
The land use change could be confirmed by comparing NDVI and NDWI in dry and rainy season. Some areas where vegetation was seen in dry season are not used for rice cultivation and they are considered other dry season crops, wetlands or forests. In addition, it was possible to identify which indexes could be used for the land use of four typical land use (City area, Water area, Paddy field, Wetland), but the reliability is low because it was result of visually confirming the analysis images. This needs to be confirmed in the field survey and it is necessary to analyze land use and flooded areas and use them for flood countermeasures that may expand. In the feature, it is expected to develop a model specialized for discriminating water areas and specify more detailed NDVI and NDWI values for each land use. If this is realized, it will be possible to easily get the data on daily land use changes and surface water changes. It is also useful for drainage planning to deal with abnormal floods due to climate change not only in Laos but also in various regions.

Reference
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Acknowledgment

This research was supported by “Advancing Co-design of Integrated Strategies with Adaptation of Climate Change in Thailand (ADAP-T)” supported by the Science and Technology Research Partnership for Sustainable Development (SATREPS), JST-JICA and KAKENHI Grand No.JP19H03069, 19K12413 from the Japan Society for the Promotion of Science.