Evaluation of Land Cover due to soil erosion in the Abukuma Basin Using satellite image analysis within a time scale

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1. Introduction

Japan is economic activities and population growth since the mid 19th century have contributed to major changes in development changes to land cover and land use. The country is sitting along the Pacific Ring of Fire and is prone to several natural disasters such as earthquakes, tsunami, and typhoons. These ongoing natural disasters also contribute to land cover and land-use changes. March 11, 2011(GEJE : Great East Japanese Earth Quake) is one of the natural disasters that caused a lot of damage to the eastern part of Japan - particularly the Tohoku Region. The disaster has led to the explosion of the FDNPP which deposited a massive amount of radio-nuclides in the region. The disaster has left some people in the region with no choice but to vacate the farmlands and communities. To reduce the radiation levels in the evacuation zones, the government has started decontamination activities to this day and is encouraging people to return where necessary. The recent Hagibis typhoon(Typhoon201919) in October of 2019 also brought some major damages in terms of flooding and landslides to some parts of the Tohoku region. These ongoing land-use changes due to the natural disasters such as the GEJE and other manmade activities have lead to land degradation and massive soil erosion which may have some major environmental concerns such as river bed build-up, sea shoreline variation, flooding, etc, especially in the vulnerability areas such as hilly terrain areas and the decontaminated areas. Evaluating the land cover is, therefore, an important task that would be able to assist decision-makers in the land and water resource management and planning as well as predicting future disasters. The vegetation index, which is extracted from the Landsat and Sentinel imagery, is often applied to detect the variation in the land surface variation. The main objective of this paper is to evaluate the land cover changes in the Abukuma Basin utilizing the vegetation index.

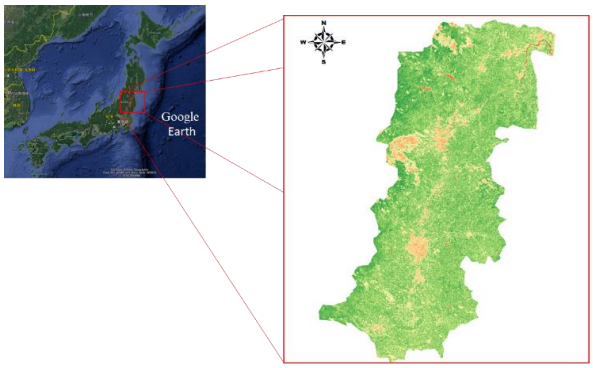

Fig.1 Study area

2. Study area

The study area is approximately 5390 km^2 of watershed area and a total river length of 234km which runs from Fukushima prefecture to Miagi prefecture(Eq Fig.1). Abukuma River Basin is the second-longest river in the Tohoku region and sixth in the whole of Japan. It collects its water from the affluent in the high mountains of Abukuma and discharges into the Pacific Ocean.

3. Methodology

As dataset of analyze land cover change, The Modis satellite images from the Nasa Earth Observation (*https://neo.sci.gsfc.nasa.gov/*) to obtain the large time scale) and the Landsat 8 satellite has been utilized from the USGS website (*http://earthexplorer.usgs.gov/*) to obtain the spatial and short time scale images to observe the land cover changes in the Abukuma Basin. The Landsat 8 satellite provides entire images of the earth every 16 days using its two sensors namely Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). Basing on the land cover mapping, the Landsat images would support the inventory of land degradation. It would visualize and map the past degradation of land surface including soil erosion, landslide, vegetation removal or land-use changes (Mwaniki et al. 2015[1)], Thuy et al. 2018[2)]). To evaluate the changes in vegetation state and density by the satellite image instruments, a vegetation index is often utilized. The vegetation index is an indicator for green vegetation which we extract from the

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Red and near-infra-red (NIR) bands of imagery. It quantifies the vegetation by measuring the difference between NIR which vegetation reflects and Red-light which vegetation Absorbs and the resulting Index will get – which runs from -1 (low) to +1 (high) vegetation. It is calculated as a normalized difference between the near-infrared spectral band (NIR) and red band (Red) in each cell:

$$NDVI = (NIR-Red)/(NIR+Red) \quad (1)$$

In this paper, we have chosen to observe summer season – with the months from May 2010 to October 2019 as a long term time scale also some short time scale periods to evaluate the land cover changes in the vegetation index (NDVI).

4. Results

The average NDVI values from the analysis of the 10 years (using Modis database) indicate that the lowest index seems to fall within May with average values ranging from 0.46– 0.6. The highest value seems to fall within July and August with index values ranging from 0.8 – 0.85. There has been a slight decline after the GEJE2011 in which the index value dropped from 0.5 and 0.72 in 2010 to 0.4 and 0.7 in 2011 May and June. There are also some slight declines following the 2011 disaster in which several areas were decontaminated but these changes seem to be not so significant and have since gradually increased to 0.57 to 0.75 over the last 5 years after the GEJE2011 disaster. In general, the vegetation index during this period normally increases 0.4-0.8 from May to August and then decreases to down to 0.6 in October. Taking into account the Land Use pattern of Abukuma basin (spatial image analysis from the Landsat 8 satellite imagery - 2018-2019) the rice or paddy field areas is observed to have major changes in the NDVI, however, a greater NDVI change was observed towards the south to south-east hilly and forested areas (Fig. 3).

5. Discussion and conclusions

The variability of NDVI values can be noticed from different areas (highlands to low lowlands) of a region and which may be influenced by vegetation changes due to man-made activities such as farmers in the farmlands and natural disasters such as landslides and other activities. The lowland regions which is converted into rice paddy fields and croplands in the Abukuma Basin. These areas do not have major effects in terms of soil erosion as the index changes with planting, growing and harvesting seasons. The changes in the highlands regions are the main concern areas as the vegetation is mostly covered

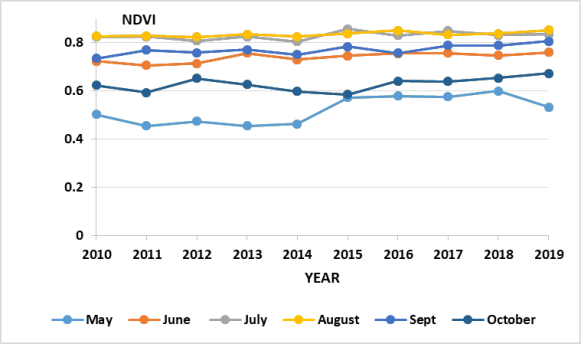

Figure 2: Average NDVI variations in Abukuma basin (2010-2019)

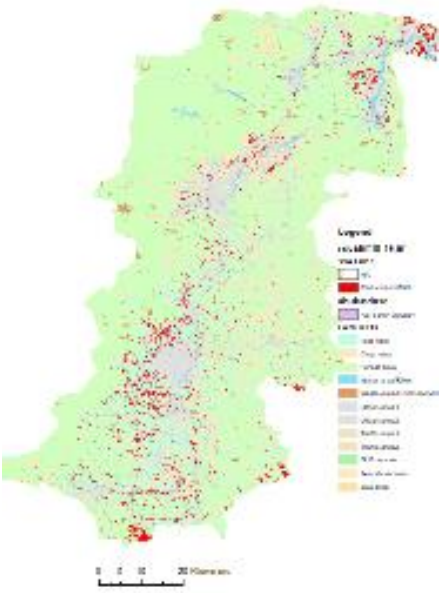

Figure 3: A spartial Image Analysis of Abukuma

with forest vegetation and the index within these areas is expected to be of very high values. The change in vegetation overserved (figure 3-spatial image analysis) towards the south to south-east hills of Abulkuma is a great concern. This could have resulted from a landslide or probably due to deforestation. Hence, may contribute to erosion and sediment buildup within the Abukuma River.

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