Agriculture Monitoring in Japan Using NOAA/AVHRR Data

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Abstract

Using NOAA/AVHRR Local Area Coverage(LAC) data received in Japan, we made NDVI Maximum Value Composites(MVCs) and got the monthly data set of 12 Japan Vegetation Index (JVI) for one year. Cropping-pattern was analyzed in agricultural areas in Japan using JVI.

1. Introduction

Many studies have shown that satellite remote sensing technique is a powerful tool for agriculture monitoring. However LANDSAT data can only be acquired once in 16 days and are highly restricted by clouds. This makes LANDSAT data not very reliable source for temporal variation analyses in countries like Japan. NOAA/AVHRR data on the other hand, can be acquired daily and comparatively free from cloud restriction.

National Oceanic and Atmospheric Administration(NOAA) has prepared weekly Global Vegetation Index(GVI) images using NOAA/AVHRR data since April 1982. A Very high correlation is reported between vegetation Index and the biomass production (Justice et al., 1985).

Spatial resolutions of GVI images are more than 10km. It is excessive large value to apply to monitoring agricultural crop-pattern in Japan. So we prepared monthly Japanese Vegetation Index(JVI) images that have spatial resolution of 1km using NOAA/AVHRR data.

2. Methods

2.1. Sensor and data

We used NOAA-11/AVHRR data to prepare JVI images. Scanning width of NOAA/AVHRR is 2800km. Spatial resolution is 1.1km at nadir observation. The JVI images were created using AVHRR CH1(visible red: 580 - 680nm) and CH2(near-infrared: 725 - 1100nm) measurements.

2.2. NDVI

Some remote sensing data are related to the activity of the vegetation. Often visible and near-infrared reflectances are combined to compute vegetation indices in order to bring out the difference of radiometric response between the active green canopy and bare soils. Normalized Differential Vegetation Index (NDVI) (Yates et al., 1984) is most commonly used to estimate the amount of vegetation. NDVI is defined as follows:

$$NDVI=(CH2-CH1)/(CH2+CH1) \quad \dots\dots\dots\dots\dots\dots \quad (1)$$

where CH1, CH2 are observation data of CH1 and CH2

The value of the NDVI takes theoretically between -1 and 1. The higher the vegetation activity is the closer the NDVI gets to 0.5. Where there is no vegetation cover(bare soil), the NDVI is nearly 0. The values of the NDVI become negative in cloud, snow and water areas.

2.3. Japan Vegetation Index (JVI)

Using NOAA/AVHRR Local Area Coverage(LAC) data received in Japan, daily LAC datasets were created. We then compiled monthly NDVI images using NDVI Maximum Value Composites(MVCs) and got 12 JVI for one year.

Cropping-pattern was analyzed in agricultural areas in Japan using JVI. These areas were shown figure 1.

3. Results

3.1. Temporal variations of NDVI in agricultural area

JVI images from April 1991 to March 1992 were compiled. In April, the most values of the NDVI to the north of Kanto-district are less than 0.2 while those to the south of Kanto-district are higher than 0.2. In June, the values of the NDVI throughout Japan become higher than 0.2 except in the agricultural areas(paddy fields and upland farming fields) where the values of NDVI are about 0.1. This is because crops in those areas are at the beginning stage of their growth. In August, the values of the NDVI higher than 0.25 are found everywhere except urban areas like Tokyo and Osaka. At this time of the year, the agricultural areas are widely covered with grown crops. In October, after the harvest time, the values of the NDVI fall steeply in the agricultural areas.

3.1.1. Paddy fields

As for paddy fields, we selected the following 10 sites; Ishikari Plain, Hachiro-gata, Sendai Plain, Niigata Plain, Aizu Basin, Kanto Plain(near Utsunomiya), Nobi Plain, Okayama Plain, Tokushima Plain and Saga Plain. Shown in figure 2 are monthly NDVI variations from April 1991 to March 1992. Figure 2(a) represents northern part of Japan, (b) central part and (c) south-western part respectively. NDVI variations of Niigata Plain are shown both in (a) and (b) as a standard used for purposes of comparison.

In northern part of Japan shown in figure 2(a), the NDVIs reach their maximum values either in July or in August and keep values less than 0.05 from December to March everywhere. Only in May, a clear difference in the value of the NDVI can be found. The kind of crop planted in paddy fields not used for rice and the area of these fields make this difference. There are few paddy fields for winter wheat in Niigata while there are 20% of all paddy field in Sendai, 40% in Ishikari and Hachiro-gata. In Hachiro-gata, winter wheat grows fast resulting in an apparent peak in May while there is no such peak in Ishikari. Less snowfall in Sendai makes wheat and vegetable grow in wintertime resulting in the NDVIs about 0.05.

In central part of Japan, as shown in figure 2(b), the general shape of the two curves of Niigata and Aizu is the same. The NDVIs of both Utsunomiya and Nobi reach their maximum value in August and maintain a certain amount of value even in wintertime. This is partly because their winter wheat and vegetables grow in winter and also because their rice yield late in comparison with other areas. Average NDVIs are low in Nobi because of the urbanization.

In south-western part of Japan, two-crop system is possible which results in an apparent double-peak shape of NDVI time profiles in figure 2(c). These peaks represent the harvest time of rice and winter crops' mainly winter wheat.

3.1.2. Upland farming fields

As for upland farming fields, we selected the following 6 sites; Tokachi Plain, Abashiri Plain, Hokuso Plateau in Chiba prefecture, Tsumakoi Plateau in Gumma prefecture, Nansatsu district in Kagoshima prefecture and Miyakonojyo Basin in Miyazaki prefecture. Monthly NDVI variations are shown in figure 3.

Shown in figure 3(a) are Tokachi, Abashiri and Hokuso that are located in potato and sugar-beet zone. The NDVI time profiles show an apparent peak in summertime. Snowfall in Tokachi and Abashiri keeps NDVIs almost zero from December to March.

Shown in figure 3(b) are Tsumakoi, Miyakonojyo and Nansatsu that are located in vegetable zone. The NDVI curves in these areas have multiple peaks according to the dominant vegetables in each area. Miyakonojyo and Nansatsu located in south-western part of Japan maintain a certain value of NDVI even in wintertime.

3.1.3. Grassland

As for grassland, we selected Konsen Plain in Hokkaido and Aso district in Kyusyu. In both areas the NDVIs in figure 4 increase as pasture plant grows from Spring to Summer. In Summer, the NDVIs drop because of grazing.

3.1.4. Urban areas

As for urban areas, we selected Tokyo and Osaka. Figure 4 shows the NDVI time profiles of the two cities. The NDVIs in Tokyo show a kind of seasonal variation while the NDVIs in Osaka keep low values throughout the year.

Acknowledgments

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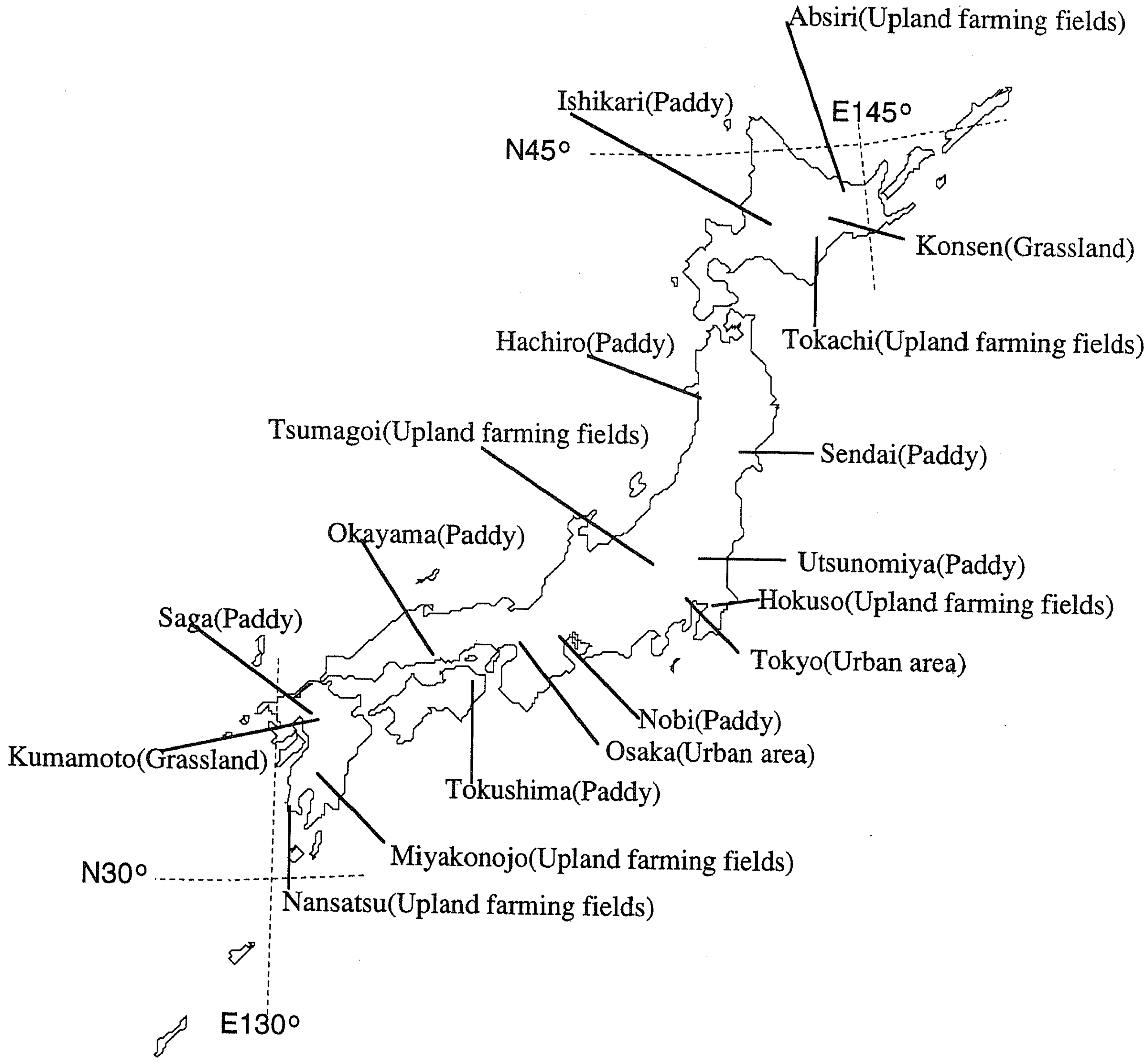

Fig. 1 The Areas of Cropping-Pattern Analysis

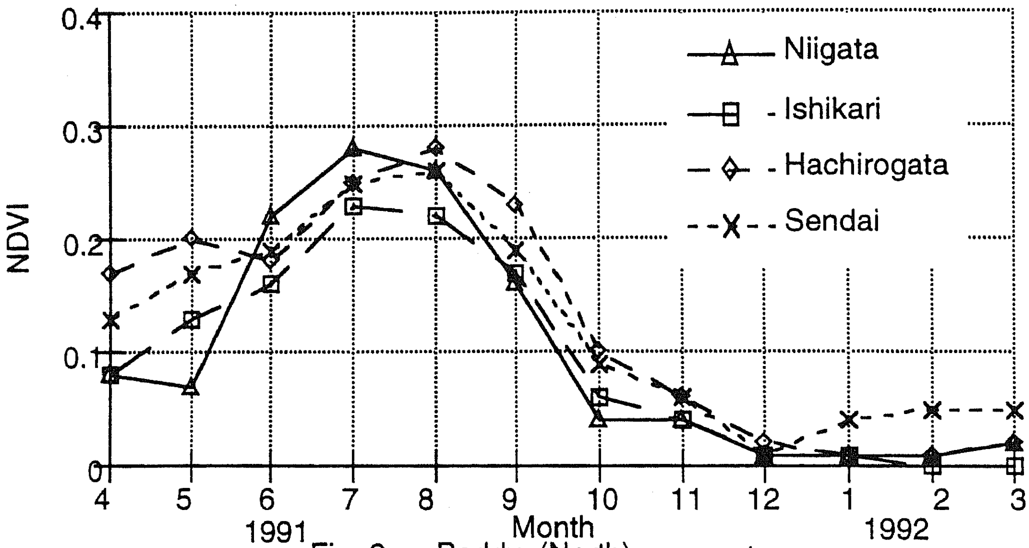

Fig. 2-a Paddy (North)

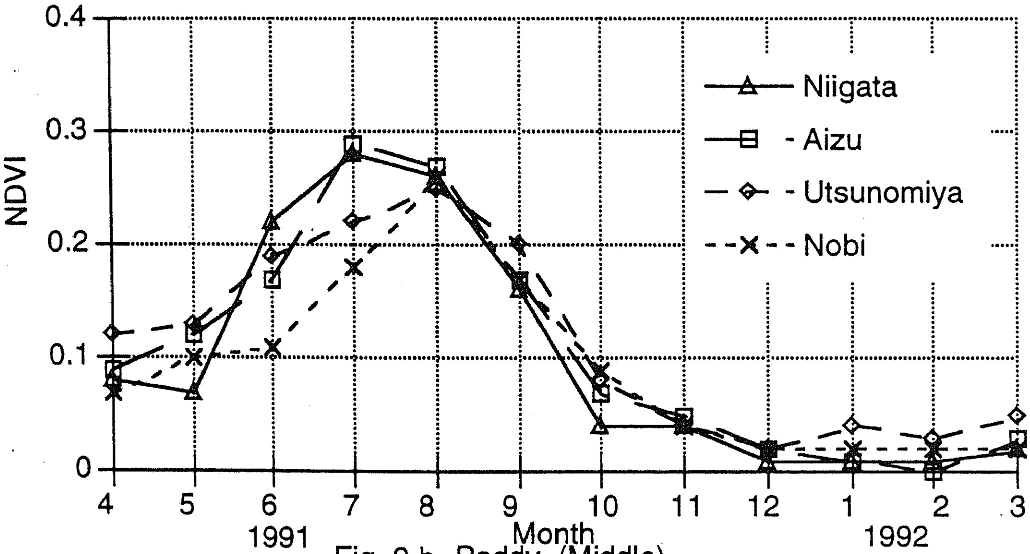

Fig. 2-b Paddy (Middle)

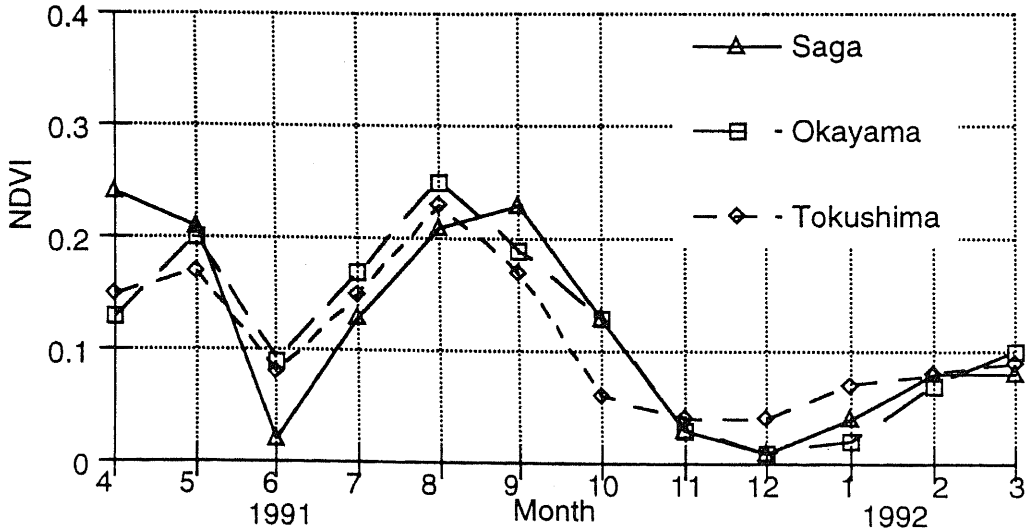

Fig. 2-c Paddy (Southwest)

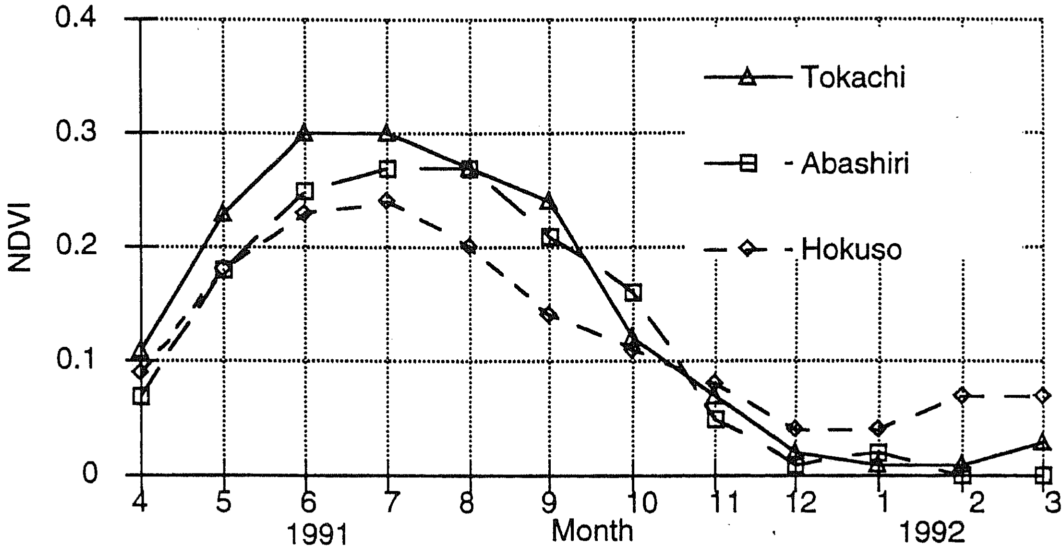

Fig. 3-a Upland Farming (Potato and Sweet Potato)

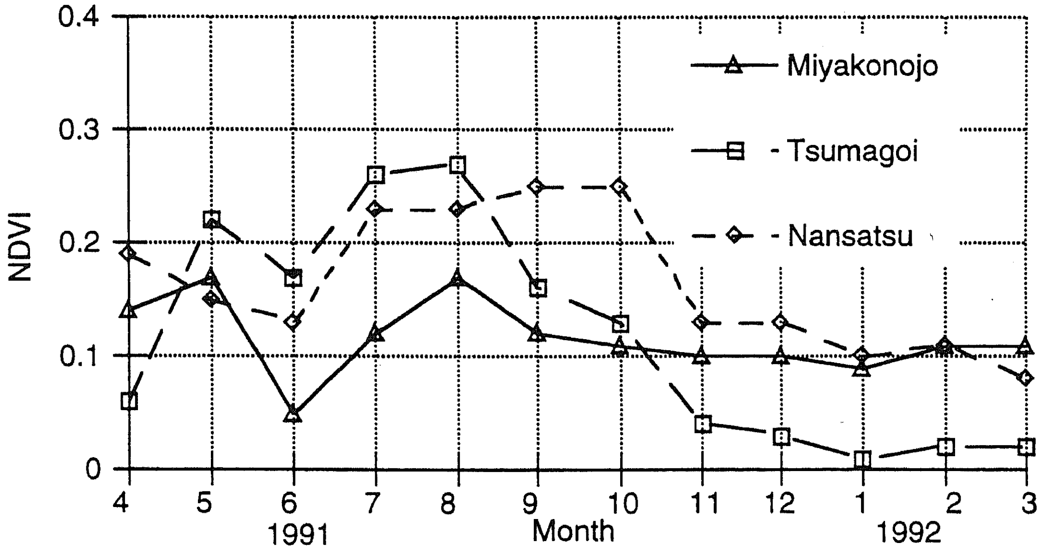

Fig. 3-b Upland Farming (Vegetable etc.)

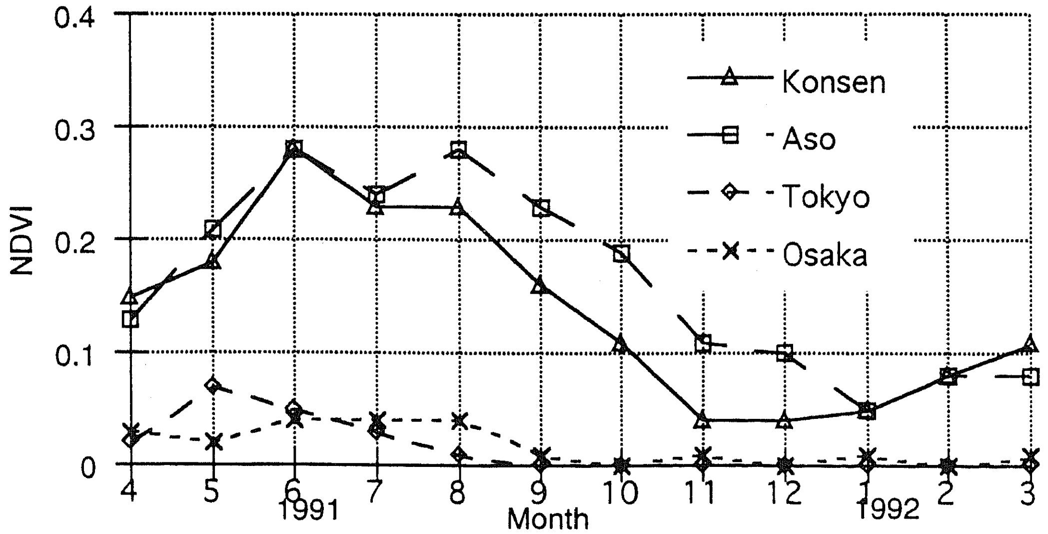

Fig. 4 Grass-land & Urban Area