RECOVERY MONITORING OF TSUNAMI DAMAGED PADDY FIELDS USING MODIS NDVI

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ABSTRACT: On March 11, 2011, Great East Japan Earthquake struck Tohoku Region of Japan. Huge area in the northeast coast of Japan was seriously damages by the magnitude 9.0 earthquake and subsequent tsunami. Since then, the authors have been monitoring the recovery of the tsunami damaged areas of the Miyagi Prefecture by ground survey and satellite image data analysis. In this study, the authors have investgated how the NDVI seasonal variability of inundated puddy fields change from year to year after the tsunami. The authors have selected some test site of normal puddy fields, inundated inshore paddy fields, and inundated inland paddy fields. Usually, the NDVI of typical paddy field gradually increase from May to August and suddenly decreases in September due to harvesting. As for the year 2011, the NDVI of the paddy fields damaged by the tsunami in March did not increase much even in the summer time. However, in inland paddy fields which were suffered by the Tsunami, the NDVI variability became almost the same as that of normal paddy field in 2012. This means, that those inland paddy fields were recovered within one year. On the other hand, the inundated inshore paddy fields did not show such clear recovery.

1. INTRODUCTION

Remote Sensing is a necessary technology for monitoring the damages of disasters. On March 11, 2011, Great East Japan Earthquake with a magnitude of 9.0 struck the northeast part of Japan. Especially, the huge area along the coast was seriously damages by the tsunami associated with the earthquake. The maximum height of tsunami was 9.3m recorded in Soma, Fukushima (JMA, 2011), and the total of 561 sq. km was inundated by the tsunami (Nagayama et al., 2011). 19,418 people were lost and more than 2,592 people are still missing (FDMA, 2016). At that time, more than 5000 satellite images were taken within two weeks after the disaster under the international cooperation (Takahashi et al., 2012). The comparison of the images taken before and after the disaster enhanced the serious damages of the area. In other words, main role of remote sensing in disaster monitoring is damage identification. Since 2011, the authors are monitoring the recovery of the tsunami damaged areas of the Miyagi Prefecture by ground survey and satellite image data analysis (Cho et al., 2013,2014,2015). In this study, the authors have applied multi temporal analysis of MODIS NDVI to evaluate the recovery status of paddy fields.

2. TEST SITE

Figure 1 shows the location of the test site of this study. The map on the right is a part of the inundated map of Miyagi Prefecture produced by Geological Survey Institute (GSI) of Japan (GSI, 2011). The red colored area is the area inundated by the Tsunami. The authors have selected three types of paddy field which are normal paddy field, inundated inshore paddy field, and inundated inland paddy field. The normal paddy field is the paddy field which were not suffered by the Tsunami. Inundated inshore paddy field is the paddy field which is located

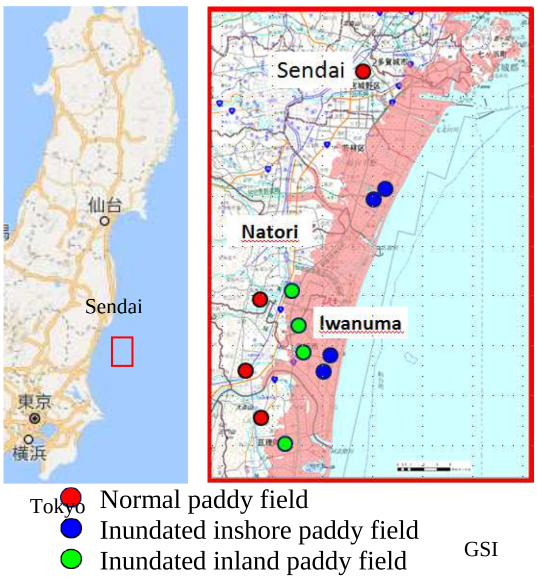


Figure 1. Location of the test site

inshore and was inundated by the Tsunami. Inundated inland paddy field is the paddy field which is located inland and was inundated by the Tsunami.

3. ANALYZED DATA

NDVI (Normalized Difference Vegetation Index) defined by the following formula is a typical index for estimating the condition of vegetation (Weier et al., 2000).

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

Where NIR:Near infrared band

VIS: Visible red band

Generally, if the reflected radiation in near-infrared wavelengths is much higher than in visible red wavelengths, the vegetation in the area is likely to be high dense and healthy. Thus, by calculating NDVI, one can estimate the vegetation condition of the area. In this study, the 16 days composite of MODIS NDVI dataset provided by NASA was analyzed. Table 1 show the specifications of MODIS. For calculating NDVI with formula (1), MODIS Band 1 is used for VIS and Band 2 is used for NIR.

Table 1. Specifications of MODIS

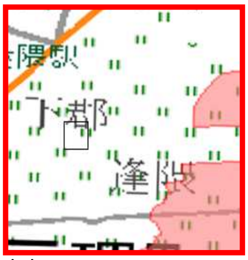
	Band	Wavelength[μm]	IFOV	Swath
MODIS	1	0.620 - 0.670	250m	2330km
	2	0.841 - 0.876		
	3 -7	0.459 - 2.155	500m	
	8 – 36	0.405 - 14.385	1000m	

4. METHODEOLOGY

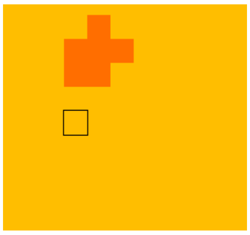
4.1 Test area extraction

In this study, the authors have examined the 1/100,000 scale inundated map produced by GSI (GSI, 2011) and selecting the three types of paddy field as explained in Chapter 3. Then the MODIS NDVI data of the three type of paddy field were extracted. Figure 2 shows an example of the extraction of the test area for inundated paddy field. The blue box in Figure 2(b) shows the extracted test area from the map and Figure 2(c) shows the corresponding area overlaid on the NDVI image. In order the improve the reliability, several areas were extracted for each paddy types.

(a) Inundated map (Provided by GSI)



(b) Zoom up of the inundated map



(c) NDVI image

Figure 2. Test t area extraction

4.2 Seasonal variability evaluation

By using the 16 days composite MODIS NDVI data of the test areas, the NDVI seasonal variability of each paddy type were examined. Figure 3 shows the typical NDVI seasonal variability of the normal paddy field. Usually, the NDVI of a paddy field gradually increase from May after rice planting, and reaches to the peak in August. In September, NDVI suddenly goes down after the harvesting. We have compared the NDVI seasonal variability of each paddy type from 2010 to 2015 to evaluate the impact of the Tsunami to the paddy fields and the recovery from the Tsunami.

MONTH

Figure 3. NDVI seasonal variability of normal paddy field.

5. RESULT

5.1 Normal paddy field

Figure 4 shows the NDVI seasonal variabilities of normal paddy fields from 2010 to 2015. Since these paddy fields were not inundated by the tsunami, the seasonal variability pattern of each year are almost the same.

5.2 Inundated inland paddy field

As shown on Figure 1, many paddy fields along the coast of Miyagi Prefecture were damages by the tsunami associated with the huge earthquake occued on March 11, 2011. The orenge line on Figure 5 shows the NDVI variability pattern of the inland paddy fields for the year 2010 (before the Tsunami), and the black line shows the NDVI variability pattern of the same area for the year 2011. Compared with the orange line of 2010 which shows the typical NDVI pattern of normal paddy fields, the black line of 2011 shows the clear reduction of NDVI from spring to summer due to the damage of Tsunami on March 11.

Figure 6 shows the NDVI seasonal variability pattern of the same area from 2010 to 2012. The blue line shows that the NDVI variability pattern of 2012 has recovered to the level of 2010. Figure 7 shows the NDVI seasonal variabilities from 2010 to 2015. It is clear that those inundated inland paddy fields have recovered as paddy fields in 2012 and are regularly used as paddy fields since then.

5.3 Inundated inshore paddy field

The orange line on Figure 8 shows the NDVI variability pattern of the inshore paddy fields for the year 2010 (before the tsunami), and the black line shows the NDVI variability pattern of the same area for the year 2011. Like Figure 5, it is clear that the inshore paddy fields were seriously damaged by the tsunami.

Figure 9 show the NDVI seasonal variability pattern of the same area from 2010 to 2015. Until 2015, the NDVI seasonal variability pattern did not recover to the level of 2010. This means that those areas were not recover as paddy fields by 2015.

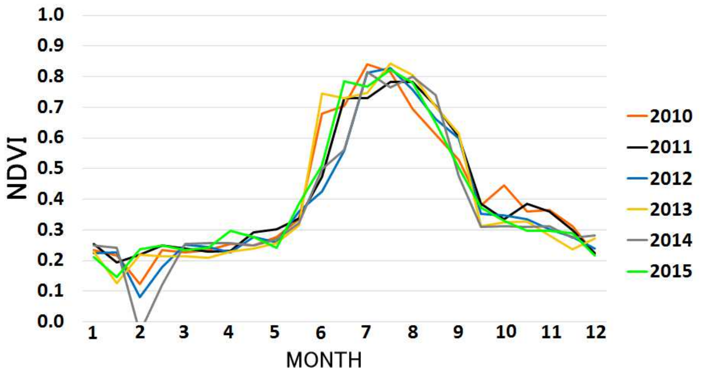


Figure 4. NDVI seasonal variabilities of normal paddy fields (2010 to 2015)

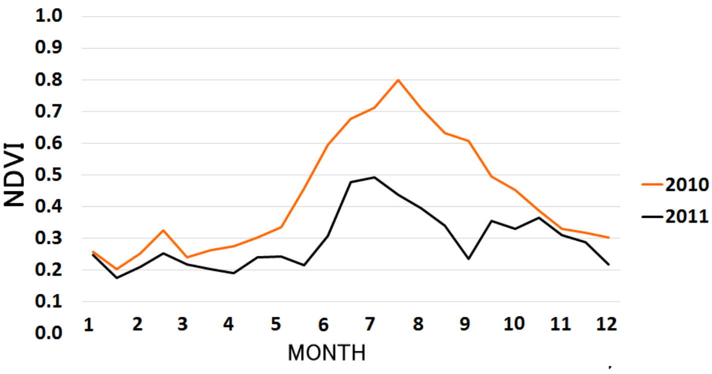


Figure 5. NDVI seasonal variabilities of inundated inland paddy fields (2010 and 2011)

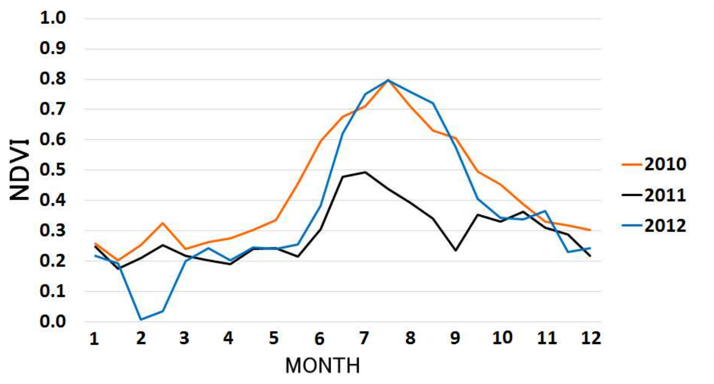


Figure 6. NDVI seasonal variabilities of inundated inland paddy fields (2010 to 2015)

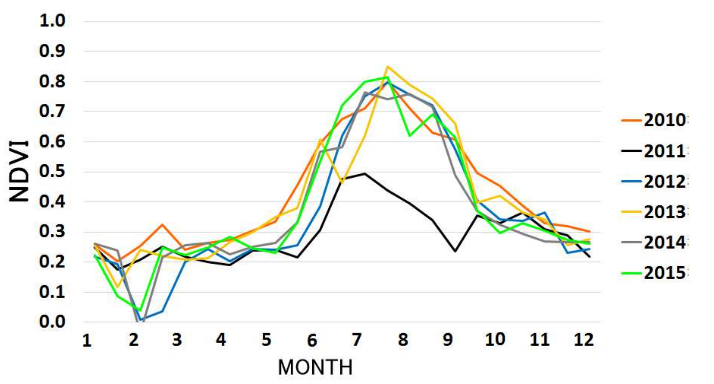


Figure 7. NDVI seasonal variabilities of inundated inland paddy fields (2010 and 2011)

6. CONCLUSION

In this study, the authors have analyzed the time series of 16 days composite MODIS NDVI data for evaluating the recovery of paddy fields in Miyagi Prefecture of Japan which were damaged by the huge tsunami associated with the Japan Earthquake occered on March 11, 2011. The result suggested that in 2011, because of the tsunami, most of the inundated paddy fields in this region were seriously damaged. However, many inland paddy fields were recovered in 2012. On the other hand, the inundated inshore paddy fields investigated in this study were not recovered as paddy field yet even in 2015. One of the reason of this recovery delay is that the government is still regulating the use of damaged areas along the coast. The government is still performing several meters of landfilling and making large break water along the coast to prevent the damage of the area from future tsunami.

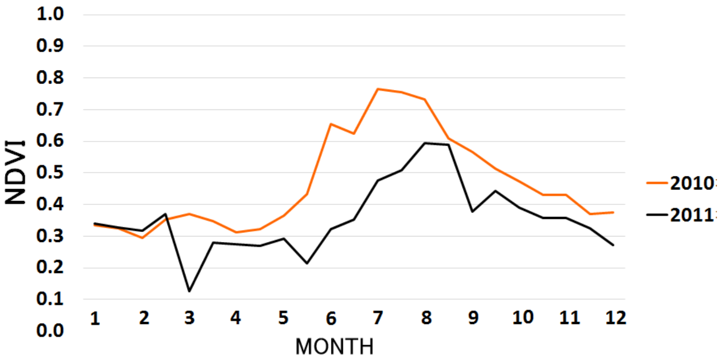


Figure 8. NDVI seasonal variabilities of inundated inshore paddy fields (2010 to 2012)

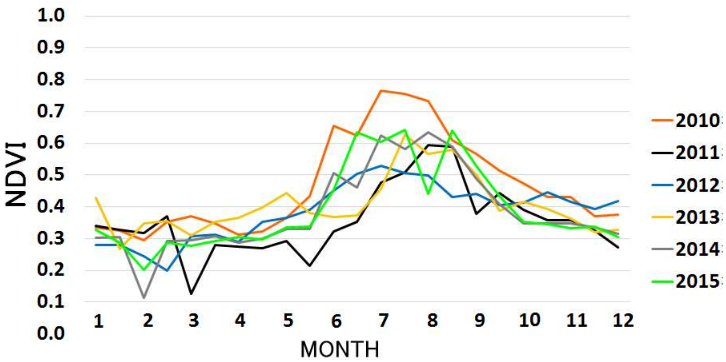


Figure 9. NDVI seasonal variabilities of inundated inshore paddy fields (2010 to 2015)

ACKNOWLEDGEMENT

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