CHANGES IN LAND-USE: A PRELIMINARY STUDY OF THE SHUI-TIAN TRIBE USING FS2 IMAGES AND GIS/DEM DATA

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ABSTRACT: Formosat-2 images, combining Digital Elevation Model (DEM) and GIS data, are used to analyze the change of land cover/use at Shui-Tian village. A group of Atayal people, called Shui-Tian tribe, live in an indigenous reservation of Hsichu County at medium elevations. A summer image and a winter image of Formosat-2 satellite for the year of 2006, 2008 and 2010 are selected for this study. The six images are normalized and converted into Normalized Difference Vegetation (NDVI) images. The NDVI difference images are generated by pairs of NDVI images. At first, the new bare lands are identified from the NDVI difference image with an optimal threshold. By overlaying the GIS land use/cover classification data, and fine-tuning the threshold, we can get a better identification of land-use change areas. Finally, the changes ranges are determined by combined 3D simulated images.

In the preliminary results of study, Two bare lands could be identified from a summer and winter images in 2006. None can be identified to compare the summer images between 2006 and 2008. On the other hand, two new bare lands are identified to compare the winter images between 2006 and 2008. Two more new bare lands are identified to compare the summer images between 2008 and 2010. Another new bare land is identified to compare the winter images between 2008 and 2010. It is concluded that more new bare lands could be identified by using images pairs combining GIS and DEM data.

The identified new bare area is helpful for Shui-Tian villagers to understand the status and developing history of the abused lands.

1. INTRODUCTION

The heavy population in limited area have pushed people to develop the hilly lands in Taiwan. The cases relating to new communities development, agricultural lands development, recreation areas and new roads are increasing over the past years. The artificial activities will change the exited geomorphic status. Particularly after the 921 Earthquake, the topsoil of many areas became soft and runny because of the shaking of earthquake. Recently, heavy rain in typhoon seasons causes many mudslides and tremendous damages. Thus, it is an urgent need to have real time information about land use/cover to prevent from damage of the life and property (Chang, 2004).

Changes of land use/cover are studied in many other applications, such as change of coast lines, change of vegetation, land change after disaster and DEM change. A prompt and effective supervision of land to monitor status and change of territory is also requested urgently. The satellite image, characterized with frequent revisit and global coverage, is one of the best choices for this issue at a low cost.

Without self-owned and accepted resolution images, many applications of change detection were not possible at a reasonable cost before 2006. Formosat-2 (FS2) is the first Taiwan-owned satellite with good resolution and one-day revisit for the local researchers to do the related studies at a low cost. This study uses FS2 images to identify the change of land use/cover at Shui-Tian tribe.

2. REGION OF INTEREST AND OPTICAL SATELLITE IMAGES

2.1 Region of Interest

The study is focused on an indigenous tribal village, named Petlama at Shui-Tian village of Hsinchu County, which is located at a mountain area of medium elevation (Figure 1). The main population of the village is Atayal, one of the officially recognized 14 indigenous tribes in Taiwan. The villagers raise bamboo and fruits for making living. They have been engaged in terraced fields farming rice since the Japanese colonial time. The geomorphic status has been very stable and hardly had any disaster happened. However, recently many villagers because of economic difficulties rented their lands to outsiders who use the land illegally. The outsiders removed soil, rock and plants to create sandy fields for raising vegetables and gingers (Figure 2). The lands become very soft and runny. The worse is that they used forbidden chemicals to poison the lands and water of the village. The mudslides with poisoned materials are poured into the river and cause floods which have ruined houses and polluted public water resources. The villagers are not the only victim group. The people of the urban areas are also hurt because the polluted rivers are their main water sources.

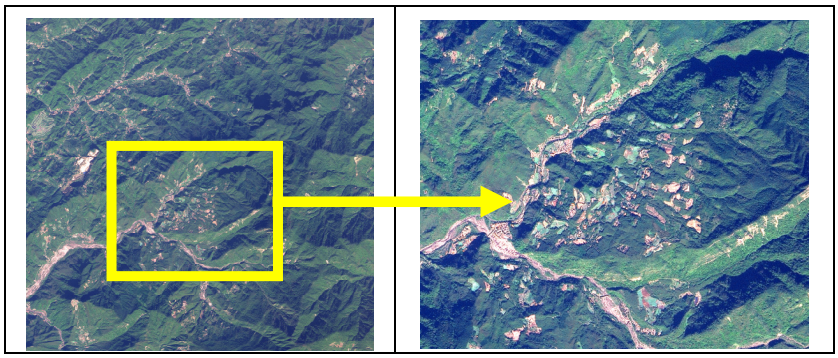

Figure 1: Region of Interest at Shui-Tian village of Hsinchu County (SPOT image dated Decenber 24, 2010)

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Figure 2: Sandy field at elevation of 800 meters

2.2 Optical Satellite Images

To identify the new bare land, the optical satellite images of different years are analyzed. A summer image and a winter image of Formosat-2 (FS2) satellite for each year of 2006, 2008 and 2010, shown in Figure 3, are selected for this study. The information of the selected images is shown in Table 1. Although FS2 image is characterized with 2-meter sharpen image fusing 2-meter panchromatic image and 8-meter color image, the 8-meter color images are used in the study to get the original spectral reflectance information. The sharpen 2-meter image is for visual reference only.

Table 1: Information of the selected FS2 images

Satellite	Imaging date	MS Resolution	Satellite	Imaging date	MS Resolution
FS2	2006/07/19	8 m	FS2	2006/11/12	8 m
FS2	2008/06/22	8 m	FS2	2008/11/12	8 m
FS2	2010/07/04	8 m	FS2	2010/11/22+12/09	8 m

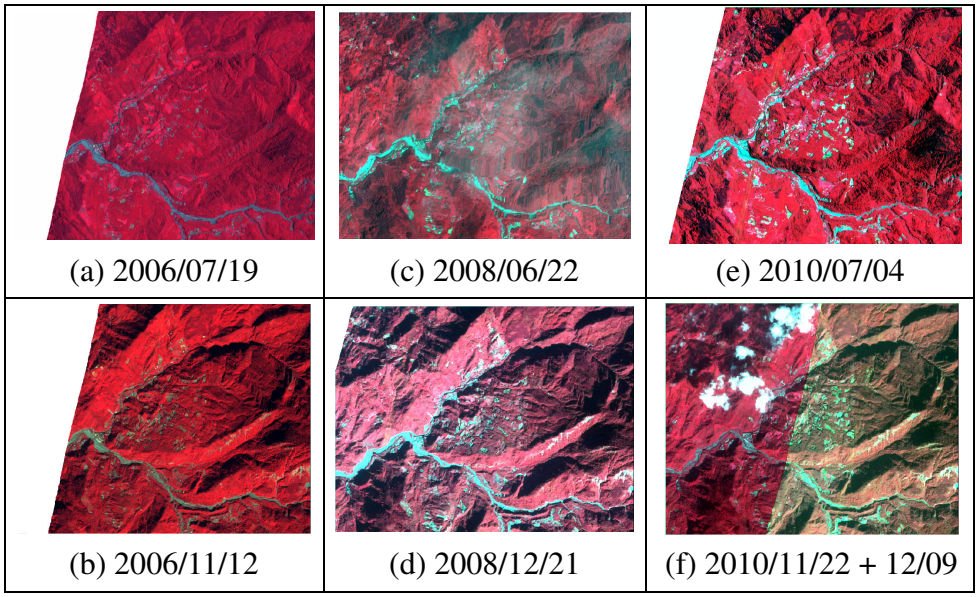


Figure 3: FS2 images at Shui-Tian village with upper-left conner at (270000,2743000) and botton-right conner at (280016,2731984)

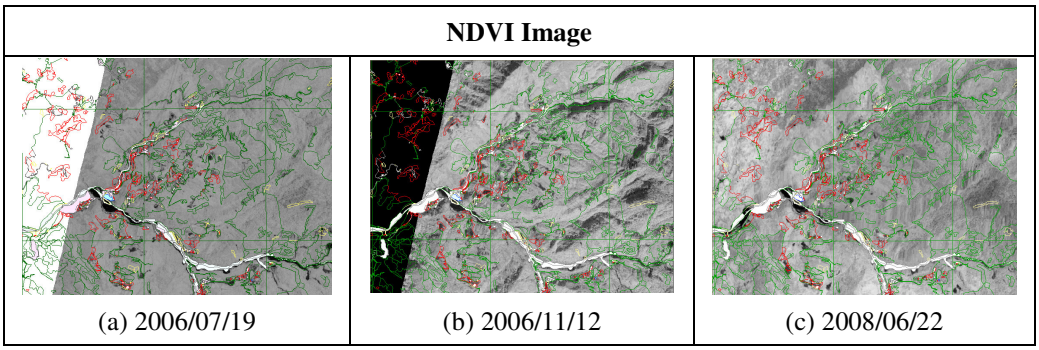
2.3 NDVI Images

The near-infrared (NIR) spectral reflectance is significantly reduced but decrease is relatively small in red spectral reflectance if the land cover is bare topsoil or sparse vegetation. Therefore, we can use a combination ratio of NIR and red bands, called NDVI index, to determine the increase or decrease of vegetation. The NDVI index is only as a relative amount of vegetation. It is the primary indicators of vegetation change and not suitable for assessment of absolute vegetation. The formula of NDVI shows mitigation effect of atmosphere interference. The NDVI index is calculated as follows:

$$NDVI = \frac{NIR - R}{NIR + R} \tag{1}$$

R: measurement of red-band; NIR: measurement of near-infrared-band

According to the formula (1), the NDVI index must be between -1 to +1. Due to the natural environment and hardware, the NDVI index may not be fully covered in this range. So the index value will plus 1 and is multiplied by 100 for better manipulation with an 8-bit computer. Because the NDVI index represents the relative vegetation, low value means that the land could be bare, harvested, or newly developed. So, NDVI reduced region is the lands be tracked in the study. Deriving from the six images in Figure 3, NDVI index and NDVI difference images estimate the vegetation and change of region of interest as shown in Figure 4.



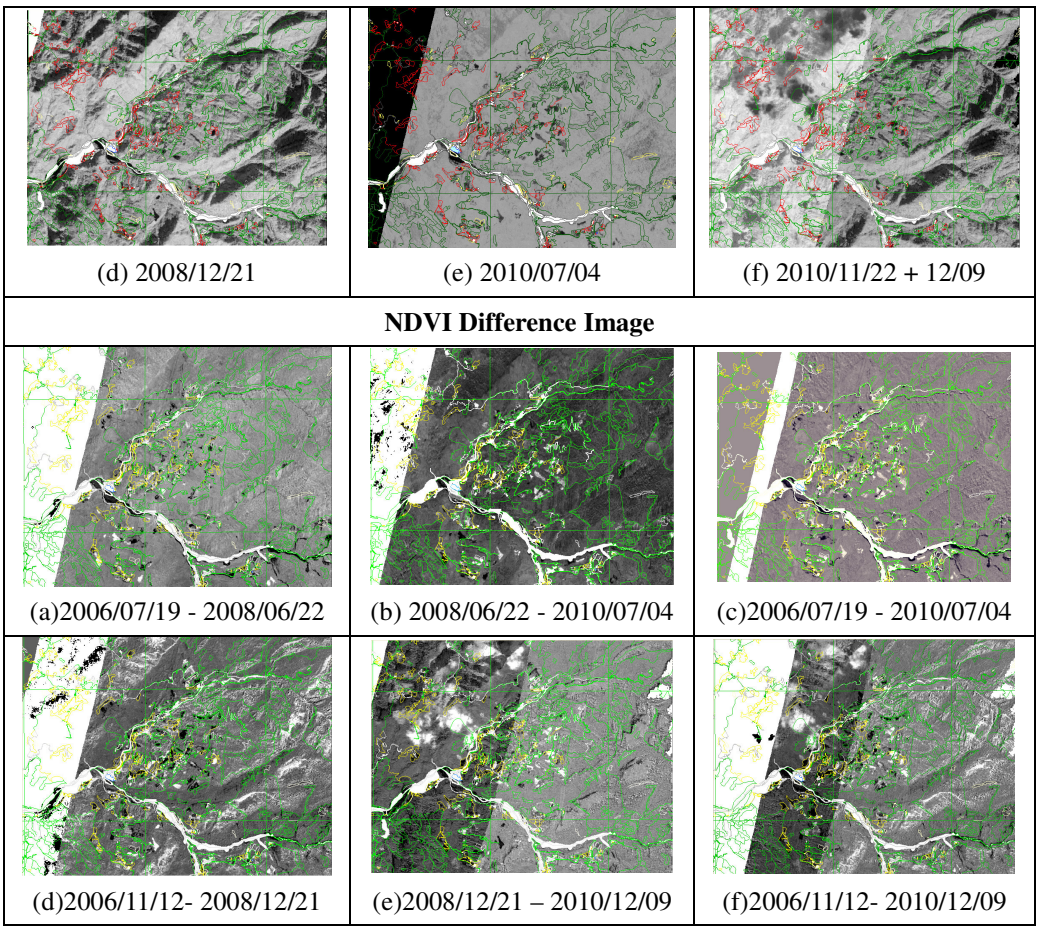


Figure 4: NDVI index images and NDVI difference images derived from FS2 six images

3. ANANYSIS METHOD ON CHANGE OF LAND USE/COVER

The illegal development has been greatly reduced after SWCB (Soil and Water Conservation Bureau) has monitored land use/cover using satellite data. Especially the large-area and beyond the scope of development has been significantly reduced. But the small-scale illegal development in hilly areas near Taiwan Central Mountain still exists. The study derives the NDVI difference images from FS2 multi-temporal images, supplemented with the land use/cover GIS/DEM data.

The first process of change analysis is to calculate the NDVI index of image at each period. The NDVI difference is calculated from the earlier NDVI index of the image minus the later NDVI for selected pair among the six images. The small value of NDVI difference shows the reduction of vegetation of region of interest. The frequency of NDVI difference of the image is calculated to determine an optimal threshold. By overlaying the GIS land use/cover classification data, and fine-tuning the threshold, we can get a better identification of land-use change areas. Finally, the change ranges are determined by combined 3D images. The workflow is shown in Figure 5.

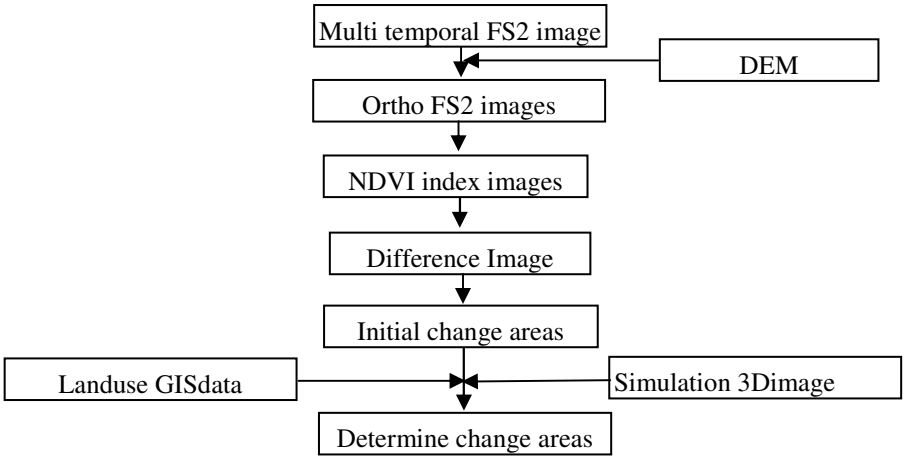


Figure 5: Remote sensing change analysis work flow

4. RESULTS OF PRELIMINARY ANALYSIS

Two seasons of the year, or two years of the same season are compared for determining change of the land use/cover. Two different images among the six ones are picked up and follow the work flow of Figure 5. The red area represents decreasing vegetation while green area represents increasing one.

Two spare lands, shown in Figure 6, are detected in the year of 2006. The two red areas, marked with #1 and 2, could be illegally developed while the other red areas are for finish of harvest. The same bare lands cannot be identified in comparing with the summer images of 2006 and 2008 (Figure 7(a)) while can be clearly identified again with the winter images of 2006 and 2008 (Figure 7(d)). Two more new bare lands, marked with #3 and #4 in Figure 7(b), could be identified in comparing with the summer images of 2008 and 2010 while another new one, marked with #5 in Figure 7(e), could be identified in comparing with the winter images of 2008 and 2010. The illegally developing history could be tracked by study of the multi-temporal images.

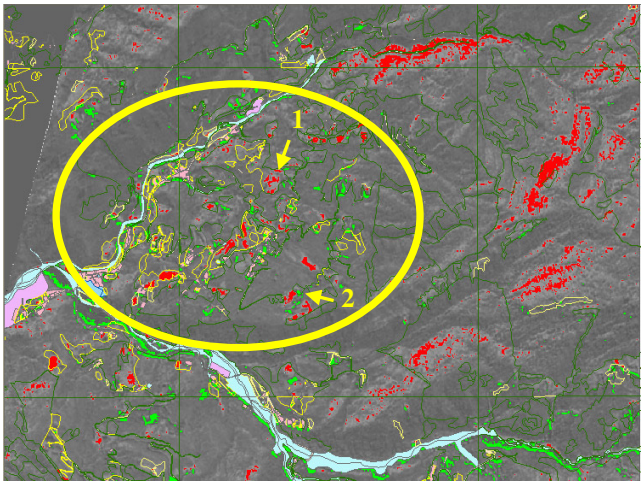


Figure 6: NDVI difference image between summer and winter in 2006 at Shui-Tian Tribe

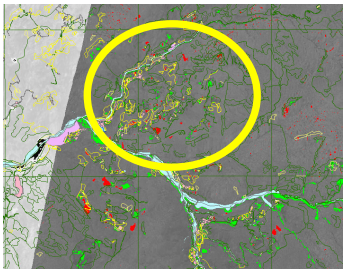
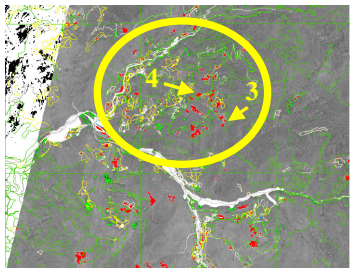
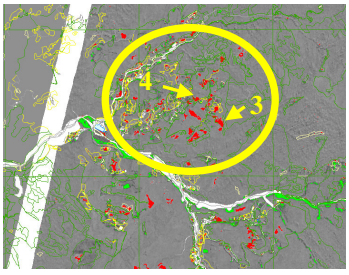
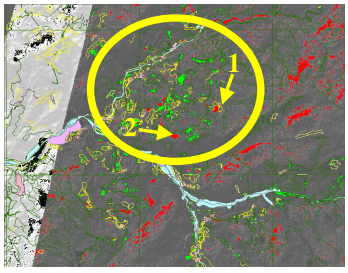
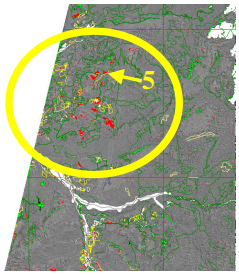
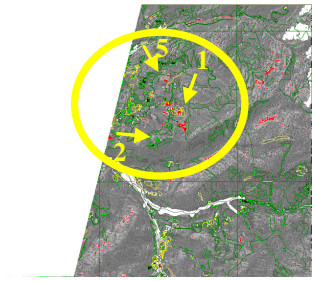
Summer Images		
		
(a)2006/07/19 - 2008/06/22	(b) 2008/06/22 - 2010/07/04	(c)2006/07/19 - 2010/07/04
Winter Images		
		
(d)2006/11/12- 2008/12/21	(e)2008/12/21 – 2010/12/09	(f)2006/11/12- 2010/12/09

Figure 7: NDVI difference image between different years in the same season at Shui-Tian Tribe

5. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusions

Six FS2 images are selected for this study in the years of 2006 to 2010. The change of land use/cover of Shui-Tian Tribe is studied with the FS2 images combining Digital Elevation Model (DEM) and GIS data. The NDVI difference image is generated by a pair of NDVI images. At first, the new bare lands are identified from the NDVI difference image with an optimal threshold. By overlaying the GIS land use/cover classification data and fine-tuning the threshold, we can get a better identification of land-use change areas. Finally, the changes ranges are determined finally by combined 3D simulated images.

The preliminary results of study reveals that two bare lands could be identified from the pair images of year of 2006. None can be identified to compare the summer images between 2006 and 2008. On the other hand, the same bare lands are identified to compare the winter images between 2006 and 2008. Two more new bare lands are identified to compare the summer images between 2008 and 2010. Another new bare land is identified to compare the winter images between 2008 and 2010. It is concluded that more information of identifying the new bare lands are derived by using images pairs combining with GIS and 3D data.

5.2 Suggestions

To detect a new bare land, two cases shall be carefully considered. First, vegetation recovers very quickly in Taiwan. An illegally developed area will be covered again with vegetation very soon. Second, harvest will change vegetation of topsoil. Since Taiwan owns FS2 satellite with daily revisit capability, multi-temporal images can be selected from the image database to study change of land use/cover. GIS and DEM can provide useful information to get a better result of identification.

On-site visit is one of the ways to validate the true land use/cover. Based on the preliminary results of NDVI difference images, on-site visit of the five possible new developed lands will be arranged.

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References

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