The Use of Multi-Sensor for Illegal Human Settlement Detection

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ABSTRACT

The paper presents preliminary results of legal and illegal settlement extraction in Pulau Gaya, Sabah using high resolution Quickbird and SPOT-5 multi-spectral imageries using automated house detection technique. The technique developed is spatial-based using tree counting approach. From the results, edge to edge of the house features was found precisely separated and can be delineated between houses that less than 2m distance. Results show that the technique able to delineate legal houses from Quickbird image more than SPOT-5. Differs results would be due to different spatial and spectral resolution of images.

Keywords: Quickbird, SPOT, spatial filter, tree counting

INTRODUCTION

Adequate knowledge of the size and spatial distribution of human population is essential in determining and deriving meaningful indicators of health status, health services, and health systems for which population data are used as denominators. Traditionally, census data have been the primary source of information on population distribution and demographic characteristics to assess human exposures and risks to health outcome. Continuous migration flows have largely contributed to an increase of the unstructured built-up areas (Stasolla and Gamba, 2007). One of the main

effects of such a situation is the transformation of settlement structures. Unstructured (informal) human settlements are usually defined as dense settlements comprising communities housed in self- constructed shelters under conditions of informal or traditional land tenure (Acqua, Stasolla and Gamba, 2006). They are common features of developing countries and are typically the product of an urgent need for shelter by poor people, especially in an urban context. These areas are characterized by rapid, unstructured, unplanned development and no viable way is now available for an extensive, efficient monitoring of these areas. However, some countries (and not the developing countries) have difficulties conducting censuses, whereas others have no censuses at all. These difficulties are due to unaffordable costs, gaps in the civil registration system, extensive population movement (e.g., rural), inaccessible remote areas, high rates of population growth and political troubles. In many cases, also, census tracts do not conform to, or nest within the other spatial structures for which information is available, so that population data may need to be translated between different spatial structures for the purpose of data linkage and analysis (Briggs et al., 2007).

Satellite remote sensing offers a cheap and effective solution to map settlements and monitoring urbanization at range of spatial scales (Tatem, 2004). The studies on human settlement are always being the critical issue over the world because the impact on the environment (ESCAP, 2007). Effective management of human settlements was recognized as an important prerequisite for environmentally sound and sustainable development (Heinzle *et al*., 2002). Strategically, it is important to study the pattern of human settlement, so that the impact of settlement to environment can be evaluated (Abbott, 2001). The advent of very high spatial resolution satellite images and digital images processing techniques renewed the interest in using remote sensing to estimate human population counts. Both sensors have $\geq$ 5 meter spatial resolution seems sufficient to discriminate individual features (e.g., buildings, streets, and trees) within the urban mosaic.

STUDY AREA

Pulau Gaya is one of the islands in Sabah situated in Borneo Island. The area has been gazetted as a National Marine Park, rich with natural resources such as coral reefs, fishes, mangroves, coastal vegetation, and beautiful

beaches with clear blue waters (Maipol, 2001). The existing of informal settlement at this area is one of the factors that lead to environmental issue such as vegetation loss, environmental pollution, water shortage, increasing demands of natural resources, problem with drainage system and also waste disposal problem (Maipol, 2001). Moreover, it is difficult to local authority to monitor the pattern of settlement by conventional method. This is because settlements are highly condensed and difficult to access for survey (Karishma *et al*., 2008). Thus, it is important to conduct the study on how to monitor the existence of informal settlement continuously and less time consuming. Pulau Gaya with its length of 16 miles shoreline is the largest island in Tunku Abdul Rahman Park. Providing shelter to quaint floating population of both Malay and Filipino refugees, Pulau Gaya interestingly obtained its name from the Bajau word "Gayo" which means big. The island is covered by pristine coastal Dipterocarp forest – the only one undisturbed so far in Sabah. Such excellent standing is largely due to Pulau Gaya has been declared a forest reserve before its establishment into the Park (Taupek and Ainy, 2001). Figure 1 shows the study area for this study, Pulau Gaya, Sabah. One of the villages at Pulau Gaya is Kg. Pondo is one of five squatter settlements on the fringes of densely jungle Pulau Gaya Island in the cross-hairs of police and immigration inspectors whereas immigrant and poor local resident lives here. The images used in this study are SPOT-5 image dated 28th April 2009 and Quickbird image were acquired at 28th April 2009 provided by Malaysian Remote Sensing Agency (MRSA). Both images covers the entire Pulau Gaya at 6°0'40" N, 116°2'60" N and 5°59'40" N, 116°4'9" N.

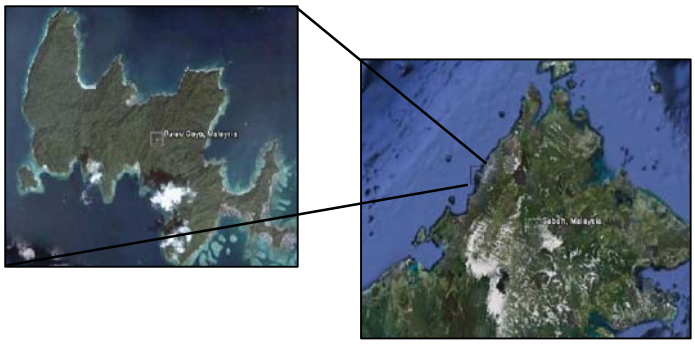
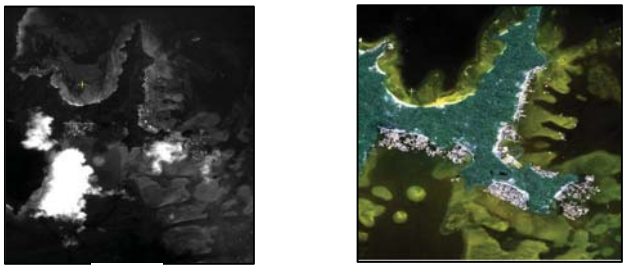


Figure 1: Pulau Gaya, Sabah (drawn not to scale)

RESULTS AND ANALYSIS

House Detection Technique

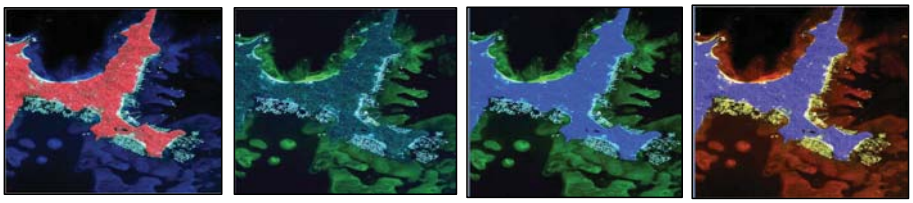
Linear enhancement has improved overall contrast of the images by stretching the minimum and the maximum of the values image over the entire of the available dynamic range (Figure 2).



(a) (b)

Figure 2: Image after linear enhancement (a) SPOT-5 (b) Quickbird II

Different combinations of image band were applied after enhancement process (Figure 3). Results show the combination between band 4, 3 and 2 was clearly identified between building (house) and land area.



(a) Band 4, 3, 2 (b) Band 1, 2, (c) Band 1, 2, 4 (d) Band 2, 3,

Figure 3: Band Combination technique for Quickbird II image: (a) Band 4, 3, 2 (b) Band 1, 2, 3 (c) 1, 2, 4 (d) Band 2, 3, 4.

Then, ratio between Red, Green and Near-infra red (NIR) were applied on the Quickbird image. Results shows that the best band ratio is ratio between NIR and Green band, then later will be used for further analysis. Using this combination, three classes are water, land and house features can be distinguished precisely (Figure 4).

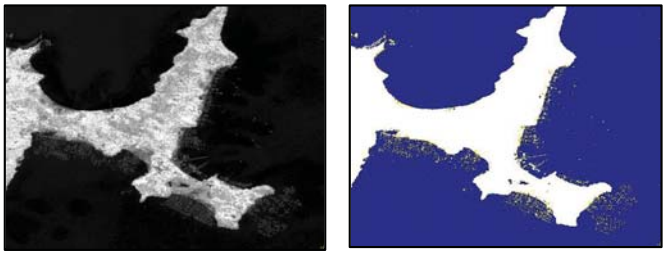


Figure 4: Band ratio of NIR/Green band (760-900/630-690)

House Extraction

Gaussion filter with 5 X 5 windows was performed for delineating the edge house features, subsequently with a 7 X 7 windows for inner high intensity diameter of the house area and finally the individual house centroid were marked out using image threshold technique. Through the filter effectively separation can be done between land and houses.

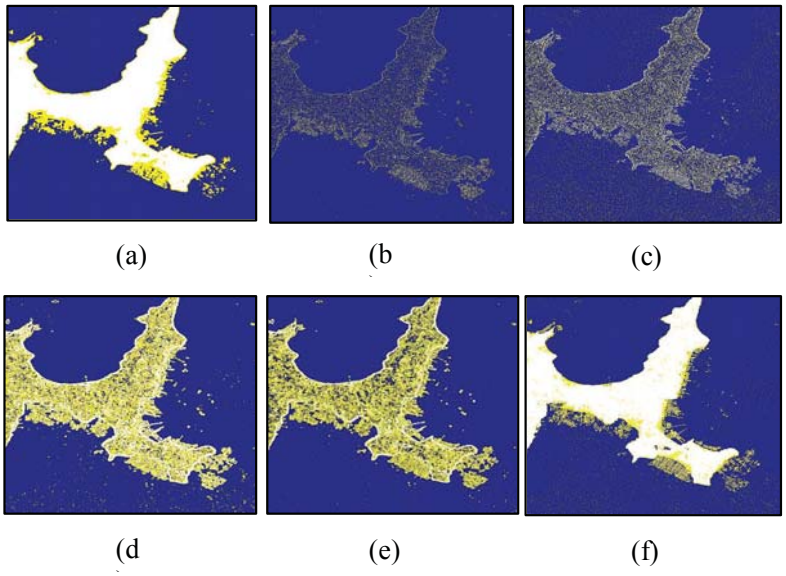
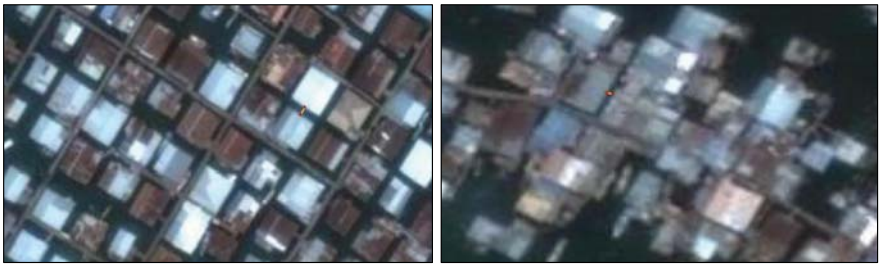


Figure 5: (a) Gaussian filter (b) Type 1: Laplacian Edge detector Filter (c) Type 2: Laplacian edge detector filter (d) Sobel Edge Detector Filter (e) Prewitt Edge Detector Filter (f) Edge Sharpening Filter

House Delineation

Vectorization process was applied to delineate house features for both formal and informal. The process was essential in order to detect the number of settlements in Pulau Gaya. According to Karishma *et al*., (2008), one of the criteria of informal settlement is higher density. Besides, informal settlement has lack of basic services, inadequate building structure and overcrowding. Measured distance for illegal houses is less than 2 meter (Figure 6).



(a) (b)

Figure 6: Zoom in housing structure from Quickbird image and distance measured using PCI function for (a) formal settlement (b) informal settlement

From the results, both formal and informal can be identified from Quickbird II imagery. Both of the images were divided into five regions Kg. Pulau Gaya, Kg. Lubuk Urai, Kg. Pasir Putih, Kg. Pondo (Figure 7). Due to cloud cover, only three areas can be identified from SPOT image (Figure 8).

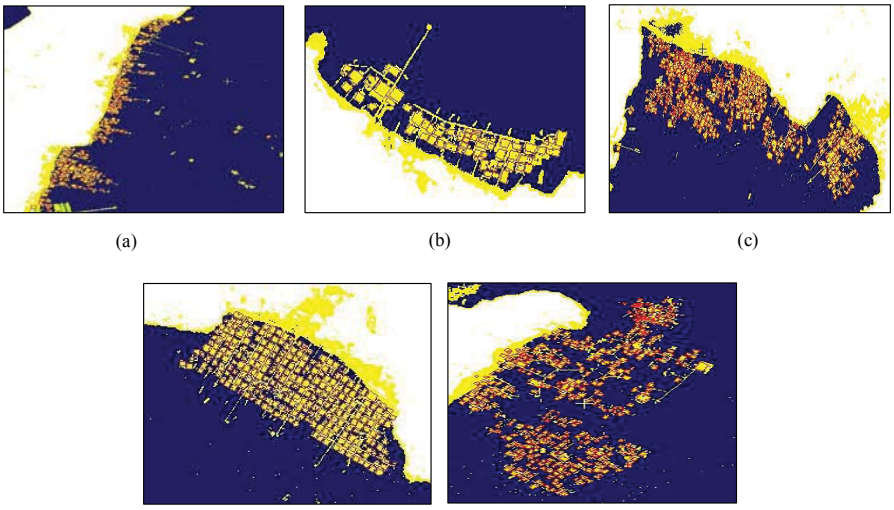


Figure 7: House delineation process on Quickbird image (a) Kg. Pulau Gaya (informal) (b) Kg. Pulau Gaya (formal) (c) Kg. Lubuk Urai (informal) (d) Kg. Pasir Putih (formal) (e) Kg. Pondo (informal)

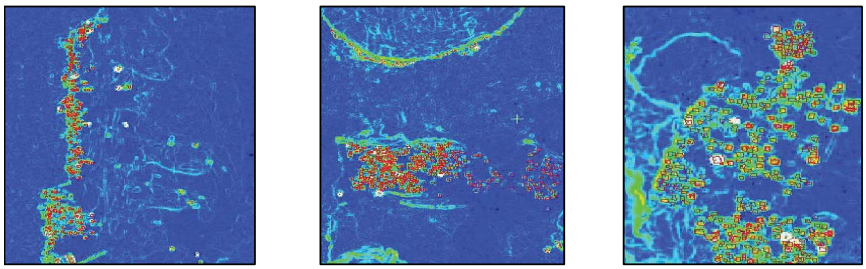


Figure 8: House delineation processes on SPOT pan image (a) Kg. Pulau Gaya (informal) (b) Kg. Lubuk Urai (informal) (c) Kg. Pondo (informal). Only three villages can be identified due to cloud cover some parts of Pulau Gaya image.

DISCUSSION

Counting technique was applied to count the number of informal and formal settlement from both images. From Table 2, the number of houses structure counted at five regions (Kg. Pulau Gaya, Kg. Lubuk Urai, Kg. Pasir Putih, Kg. Pondo. The total number of house counted derives from SPOT image was 553 for informal settlement at Kg. Pulau Gaya, Kg. Pondo and Kg. Lubuk Urai but not available for informal settlement at Kg. Pasir Putih and Kg Pulau Gaya due to cloud cover. Meanwhile, 332 counted houses for formal settlemet at Kg. Pasir Putih and Kg. Pulau Gaya derives from Quickbird. Informal settlement using the technique used managed to count about 1036 houses for three areas are Kg. Pulau Gaya, Kg. Pondo and Kg. Lubuk Urai. Limitation of this work is there is no field data collection or census statistic for the study area available for validation. From the finding, apparently the number counted for informal settlement is higher than formal settlement. In reality this is make sense, the area involved were occupied by the immigrant flow. Due to accessibility and safety reason, lack of monitoring and enforcement operation from local authority has been done. This had encouraged unplanned house built within the area without taking any consideration of land policy, proper utilities, water supply and clean environment.

The success of automatic building detection is still largely impeded by scene complexity, incomplete cue extraction, and sensor dependency of data (Sohn and Dowman, 2007). Moreover, image quality may vary for the same scene even if images are captures by the same sensor, but at different dates and times. So when detection algorithm is applied to two different images of the scene, the outcomes may well be different (Mohammad Awrangjeb *et al*., 2012).

CONCLUSION

In this paper, we have introduced an automated counting technique of human settlement from remotely sensed data. The technique developed in this work, can efficiently used to provide quick data for informal settlement data inventory. Tree counting technique is adopted to count the number of houses at study area for both formal and informal house structure at the

study area. Our future work will involves automated production of maps of human settlement based on object-oriented approach integrated with technique used in this work. To minimize false positives, future work will experiment with robustness of the approach to geo-cultural, seasonal, illumination, look-angle variations and additional study on the parameter used in ach stages. The scarcity of reliable data for map validation and the difficulty in obtaining other data such as census statistics as the main obstacles to settlement mapping at study area. Finding of this study is to provide the useful techniques on how to monitor illegal settlements from multi-sensor data at Pulau Gaya, Sabah.

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