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IDENTIFYING SETTLEMENTS ON THE SIR-B IMAGES OF RIMBOBUJANG AND THE SURROUNDING AREAS, SUMATRA, INDONESIA

by
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ABSTRACT

The use of remote sensing techniques is indispensable for Indonesia due to the large size of its territory, most of which is of difficult access and of little known regional potential. Some areas are covered by clouds almost all the year round so that remote sensing systems using visibilities up to the thermal portion of the electromagnetic spectrum fail to record them. There is no other way but to apply the microwave energy for such areas, the passive as well as the active one.

This paper deals with the data extraction from Sir-B image of Rimbobujang area and its surroundings, in Sumatra, Indonesia, with special reference to the identification of settlements. It is a result of image interpretation followed by a three-days fieldcheck in the study area. Comparison is also made with SPOT and Landsat MSS images.

SIR-B image proves to be a reasonably good tool to identify rural settlement in an open area, especially for that with high density of houses. Its use to identify towns and cities is more recommended.

INTRODUCTION

Radar remote sensing is the only system of that kind which can be operated in all weather conditions. This advantage is of paramount importance for some areas of Indonesia which are cloud covered almost all the year round. However, because there is a trade-off between wavelength and spatial resolution, the radar image has a coarse spatial resolution due its long wavelength of the electromagnetic spectrum.

This paper deals with the identification of settlements on SIR-B image of Rimbobujang and the surrounding areas, Sumatra, Indonesia in which the scale is blown up from 1:400,000 up to 1:100,000. Two images are used in this study. One covers the Rimbobujang area and another covers Lake Kerinci, with a central incident angle of 52.2^0 and 52.1^0, respectively. The ground resolution is 17.8 m in the range direction and 28.0 m in the azimuth direction. The study is meant to promote the SIR-C image for similar use.

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THE STUDY AREA

The study area is under the coverage of the SIR-B image of Sumatra. It is a narrow strip of 50 km wide, crossing the island of Sumatra through Lake Kerinci in Jambi Province (Figure 1).

SETTLEMENT IDENTIFICATION

The identification of settlement was carried out on the SIR-B image of October 1984, which was checked in the field in August 1986. There are five check points in this respect, i.e.: (i) transmigration settlements of the Rimbobujang area, (ii) settlements on the river bank, (iii) Kampung Pulau Tengah, (iv) logging plots, and (v) small settlements and school buildings.

Transmigration Settlements

Transmigration settlements are the most distinctive check points to identify. It is characterized by: (i) bright lines which run parallel to each other, and (ii) site in the dark-gray area, indicating unforested ones.

Dwelling houses in this type of settlement are of similar size and equally spaced, each facing to a street. These houses are built in a relatively flat land. The walls act as corner reflectors and the roofs may act as medium or rough surfaces because of the corrugation which ranges from 5 cm to 7.5 cm or around one fifth to one third of 23.5 cm, the wavelength of the band which is used for the SIR-B. As houses are closely spaced, each row of houses forms a bright line. The lines are parallel to each other because the rows of houses are built in that way. It looks similar on the SPOT image of the same area. The difference is, however, that the parallel bright lines on the SPOT image represent streets, and it represents rows of houses in the SIR-B image (A in Figure 2).

The transmigration area is located in the forested land which looks light-gray on the SIR-B image. The settlements are located in the homestead and agricultural land which look dark-gray. The dark-gray background makes the parallel bright lines more distinctitive. The feature is hardly discernible on the Landsat MSS band 7 covering this area.

Settlement on the River Bank

Some settlements on the banks of Muara Tebo, Muara Bungo, and Batang Hari rivers are easily discernible due to: (i) the white tone in contrast to the dark tone of water and unforested land, and the light-gray background of the forested land, (ii) the location on the river banks, causing easier acces to water sources as well as for inland transportation (B in Figure 2). This is the case for settlements without dense homestead vegetation cover, or for settlements of around 50 houses. Settlements with dense vegetation cover, however, are hardly discernible even though the number of houses may amount to 200 or more. It stems from the fact that the radar reflection is more dominated by the dense vegetation cover, so that the tone on the SIR-B image is much similar to the light-grey tone of the forest.

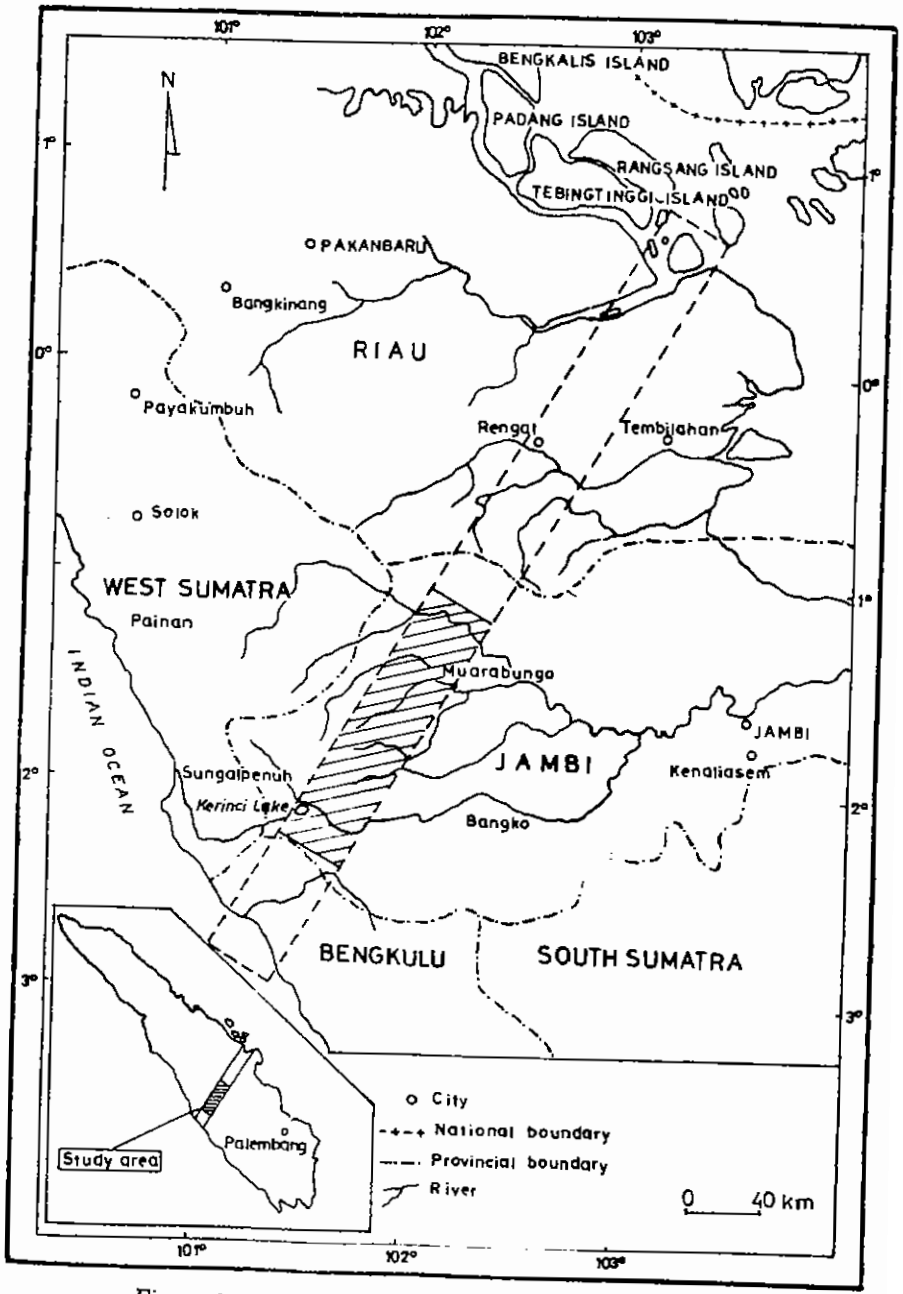

Figure 1. Location of the Study Area

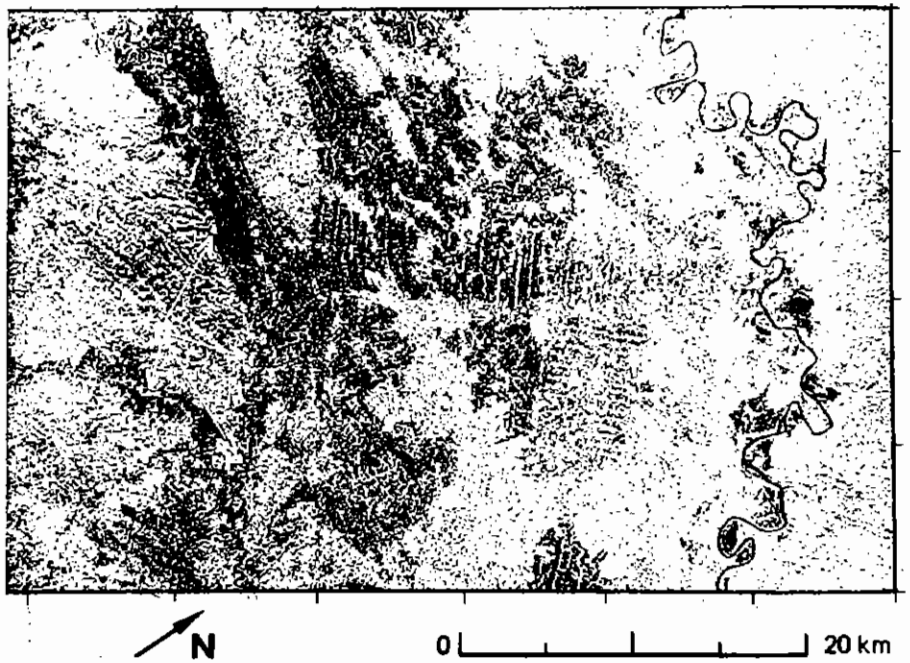

*Figure 2. SIR-A Image of Rimbobujang Area (*Ford *et al.*,1986*)*

Kampung Pulau Tengah

Kampung Pulau Tengah is a settlement surrounded by rice fields of relatively large extent. This settlement looks very bright in tone, much brighter as compared to other settlements of similar size. This outstanding feature prompted the writer to count the number of houses which in fact amounted to 264 (A in Figure 3).

It seems likely that the bright tone of Kampung Pulau Tengah is caused by the following factors :

1. The large area of rice fields acts as a specular reflector, whilst the walls of houses act as corner reflectors. The radar return is strong accordingly. The radar return is stronger in case the rice fields contain water at the time of its recording.
2. Form of the Houses. A rural house is usually made in the form of a 'kampung' with a rectangular roof, or as a 'limasan' with trapezium roof (Figure 3). Because the fore roofs act as fore slopes (with brightening) and a 'kampung' roof has a larger surficial area, consequently the radar return from a kampung roof is the stronger one. Almost all houses in this settlement are made in the form of kampung so that it results in a brighter tone.

Figure 3. SIR-B Image of Kampung Pulau Tengah (Courtesy of BAKOSURTANAL)

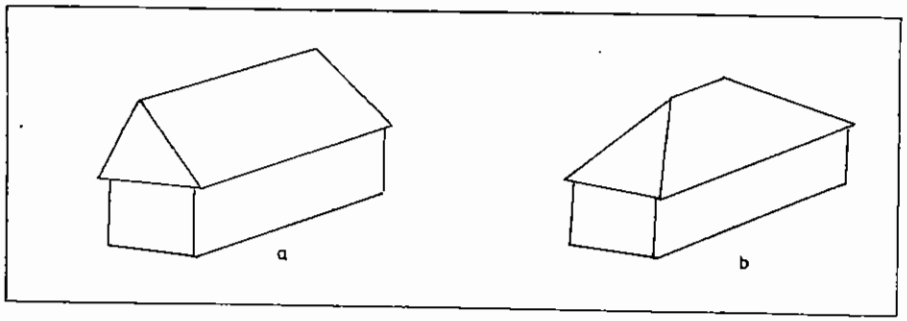

Figure 4. Form of Rural Houses : (a) Kampung, (b) Limasan

3. Direction of the houses. Houses are mostly built in rectangular form. Hence, the radar returns are greatly affected by the direction of the houses in relation to the direction of the radar illumination. Radar returns from the long sides are greater than those from the short sides of the houses. The direction of the houses is mostly perpendicular to the radar illumination and hence, the radar return is greater. That is why the settlement looks brighter.

4. House Density. Houses are densely spaced in Kampung Pulau Tengah so that homestead vegetation is almost absent, making factor makes the tone looks brighter.
5. Roof Roughness. House roofs are made of corrugated iron sheets of tiles, of which the roughness ranges from 5 cm to 7.5 cm. It may act as a medium or rough surface in relation to the radar wavelength so that the radar return from the roof is likewise medium to strong. A calculation can be made whether the roof act as a medium or a rough surface.

As has been stated before, the central incident angle of the SIR- B image covering kampung Pulau Tengah is 52.1^0. The central depression angle (α) is 37.9^0 accordingly. Kampung Pulau Tengah is located very close to the edge of the near range, with a distance of 24 km from the central line of the SIR-B image. Considering the altitude of space shuttle H which equals to 225 km above the earth, the radar geometric characteristics of Kampung Pulau Tengah can be constructed (Figure 4).

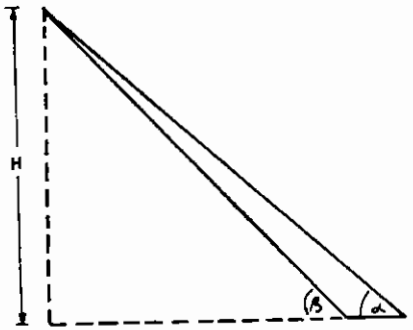

Figure 5. Geometric Characteristics of SIR-B Image of Kampung Pulau Tengah

The depression angle of Kampung Pulau Tengah (β) can be calculated with the following equation:

$$\beta = \text{arc tg} \frac{H}{H \text{ cotg } \alpha - AB} \quad (1)$$

where

α = central depression angle, 37.9^o
β = depression angle of Kampung Pulau Tengah
AB = distance from the central line to Kampung Pulau Tengah, 24 km
H = altitude of the space shuttle, 225 km

$$\beta = \text{arc tg} \frac{225}{225 \text{ cotg } 37.9 - 24} = 40.33^o$$

Referring to the Rayleigh criteria, micro relief is said to be smooth if the height difference (h) fulfills the following equation:

$$hs < \frac{\lambda}{8 \sin \beta} \quad (2)$$

where

h_S = smooth micro relief/surface
λ = wavelength of the radar energy, 23.5 cm in this respect
β = depression angle of the radar antenna, 40.33^0

Solving Equation 2, we will find $\frac{\lambda}{8 \sin \beta}$ equals to 4.54 cm. It is less than 5 - 7.5 cm so that the roughness of the roof is not smooth. Still there are two possibilities concerning the roughness of the roof, i.e. medium or rough. It can be solved using the modification of Equation 2 (Avery and Berlin, 1985), as follows:

$$h_S < \frac{\lambda}{25 \sin \beta} \quad (3)$$

$$h_r > \frac{\lambda}{4.4 \sin \beta} \quad (4)$$

$$h_S < h_m < h_r \quad (5)$$

Solving this problem with Equation 4:

$$h_r > \frac{\lambda}{4.4 \sin \beta}$$

$$\frac{\lambda}{4.4 \sin \beta} = \frac{23.5}{4.4 \sin 40.33} \text{ cm} = 8.25 \text{ cm}$$

Again it is not the case for h > 8.25 cm, as h equals to(5 -7.5)cm. The figures are in fact 4.54 < (5 - 7.5) < 8.25. The roof corrugation is therefore grouped into medium roughness, with the consequence of medium strength concerning the radar return.

Logging Areas

A logging area which is located on the bank of Batang Hari River looks light-grey on the SIR-B image. It consists of three buildings sizing about 30 m x 30 m and three buildings of 12 m x 6 m each, separated about 40 m from each other.

Logs of wood are placed in an open area of about 300 m x 100 m. The tone of the logs is brighter than that of the buildings. It may stem from the surface roughness of the wood heaps (C in Figure 2).

Small Settlement and School Buildings

There are two school buildings of 30 m x 6 m each, which are built in an open flat area in Rimbobujang area (D in Figure 2). Four buildings of around 8 m x 6 m each, are built close to the school buildings to be dwelled by the teachers. Inspite of the small area, it looks bright in the SIR-B image due to: (i) the open flat land in front which may act as specular reflector, (ii) the walls of the buildings which act as corner reflector, (iii) the fore roofs as fore slopes as far as macro relief is concerned, and (iv) the corrugated roofs which act as medium surface, reflecting medium strength of radar return.

IMPORTANT KEYS FOR IDENTIFICATION

Tone is the most important key for identifying settlements on SIR-B image of Rimbobujang and the surrounding areas. Tone is affected by : (i) the backgroud which may or may not be specular reflector, (ii) the density of houses and the absence of vegetation cover, (iii) the form of house roofs (macro relief), (iv) the roughness of house roofs (micro relief), and (v) the direction of houses in relation to the radar illumination. Form and pattern may be used as the next key particularly for transmigration settlements as this type of settlements are built with a specific pattern. Sites may also be used as a key to identify settlement on SIR-B image. The transmigration settlement which is located on unforested land (dark) and some settlements on the river banks are examples of the importance of side type.

CONCLUSION

SIR-B image is a reasonably good tool to identify settlements in an open land, but not for settlements embedded in dense vegetation cover. Its use to identify town and city is therefore more recommended than the identification of rural settlements in forested lands, because homestead vegetation looks quite similar to forest. In densely populated settlements with agricultural land as the background, however, it may be a useful tool because the homestead vegetation may look brighter than the agricultural land. This statement needs further study to clarify.

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