UPDATION AND METROLOGY OF CADASTRE AND VILLAGE BOUNDARY USING HIGH-RESOLUTION SATELLITE DATA

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Commission IV, WG-IV/9

KEYWORDS: Cadastre, High-resolution image, Land parcel, DGPS, Total station. FMB.

ABSTRACT:

A cadastre or land parcel is an extent of land and shown in the Government records associated with a set of ownership rights officially recognized as property. The scale of the village maps varies in different states but the most common being 1: 4000. The cadastre boundary is quite old which calls for fresh mapping / updating. The availability of high-resolution data from satellite-based platform has opened up new possibilities for cadastre mapping and updating with unique opportunity of natural resources appraisal from multi-spectral information. The village boundaries have also been modified using corrected satellite data, which follows certain topographic features clearly visible on the image. The features generally considered for modification of the village boundary are road, stream boundaries and field boundaries. IKONOS multi-spectral image after rectification using GCPs derived from DGPS survey was used to extract land parcels for updation. RMS Error at GCPs was 0.57 m and 0.70 m and at checkpoints, it was 1.57 m and 1.62 m in easting and northing respectively. The validation of the extracted field boundaries were carried out by comparing the area measured using total station survey and those from Field Measurement Book (FMB).

1. INTRODUCTION

A land parcel is an extent of land and shown in the Government record associated with a set of ownership rights officially recognized as property. The physical boundary of the parcel is contiguous and is defined uniquely in the official record. The said boundary is depicted in the form of two-dimensional map known as village map prepared by methods of plane tabling and chain and tape measurement. The village map shows individual parcels of all free hold, public and government land, encroachment and adverse possessions. The scale of the village maps varies in different states but the most common being 1: 4000. The land parcel boundary is quite old which calls for fresh mapping / updating. Also for developmental purposes it is important to associate present natural resources information with the land parcels. The availability of high-resolution data from satellite-based platform has opened up new possibilities for land parcel mapping and updating with unique opportunity of natural resources appraisal and its change analysis.

In this study, five contiguous villages were taken with the objectives;

- Geo-rectify the satellite image using highly accurate GCPs collected from DGPS technique.
- Update village and cadastre boundary using one-meter multi-spectral IKONOS image.
- Validate the area of the each cadastre, obtained from satellite data with in-situ total station survey.
- Create an updated and validated village and cadastre database associated with natural resources attribute.

In this study, an attempt has been made to update land parcel from high-resolution imagery in conjunction with Differential GPS (DGPS) measurements. Ground control points (GCPs) were established from DGPS measurements. IKONOS multispectral image was geometrically corrected using these GCPs. Cadastral maps mosaic was generated by georeferencing these maps with respect to the rectified image. The updation of the cadastral maps was carried out by overlying the map mosaic over geometrically corrected MSS image and digitizing the land parcels from the image. Accuracy assessment was carried out by total station survey and using Field Measurement Books (FMB). FMB describe the area of each parcel with the corresponding schematic diagram. The subdivision of each parcel is recorded and updated in FMB by the revenue department and these are not updated in the cadastre.

In addition topographic informations like streams, well, settlements etc. were also interpreted from the satellite image, which forms the part of cadastre database.

Aplin and Atkinson (2004) predicted missing field boundaries, Di and Li (2003) and Kay *et al.* (2003) have done Geometric correction for IKONOS image, Greenfield (2001) evaluated the accuracy of digital ortho photo quadrangle in the context of parcel based GIS, Raghavendran (2002) attempted Cadastral mapping. Singh (1998) has discussed different issues associated with Land Records and modernization of the same. Singh and Trivedi (2005) tried Digital cartography in cadastral mapping.

2. STUDY AREA

Five villages belong to Kanchipuram district of Tamil Nadu State were selected for this study. The study area covers about 28 sq.

km spanning from 80° 06' to 80° 10' in longitude and 12° 36' to 12° 40' latitude approximately. The area is almost flat terrain with ground elevation of 20 - 40 m above mean sea level. The major villages covered in the study area are Amayapattu, Kunnapattu, Karanai, Valavanthongal, and Mannavedudevadanam.

3. DATA USED

IKONOS data acquired during February 2001 was used for this study. DGPS observations in differential mode have been used to establish coordinates of GCPs and check Points (CP) in WGS-84 datum. Total Station instrument has been used to take field observations for the calculation of length and area of the selected plots. Village maps of all the five villages obtained from State Revenue Department had also been used.

PCI GEOMETICA V 9.1, ERDAS Imagine 8.7 and ARC GIS v. 8.3, SKIPRO v. 2.1 were used in this study.

4. METHODOLOGY

The major steps involved in the present study are shown in the **Figure 1.**

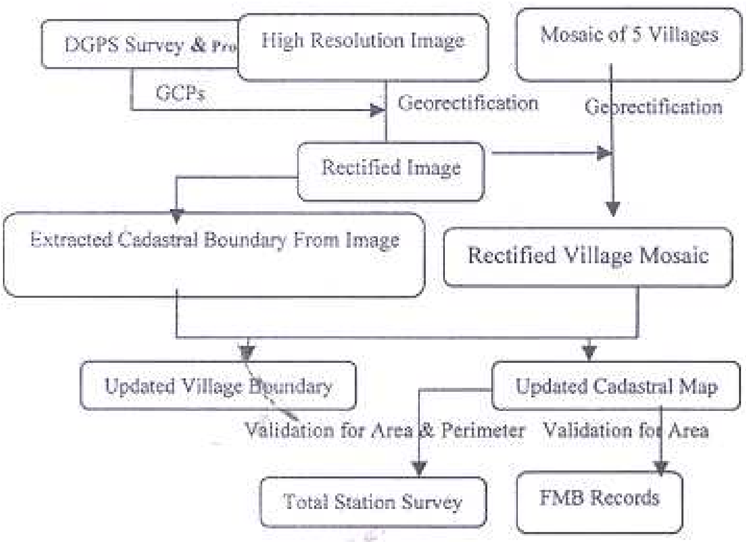

Figure 1: Methodology for Metrology and Updation of Cadastre

4.1 Differential GPS Survey and Processing of the data.

A differential GPS survey had been carried out to establish a reference station and 23 GCPs in and around the study area during 20 – 23rd Dec. 2004. High-resolution satellite images eases partly the job of reconnaissance survey to identify the probable GCP locations for DGPS survey. The points were identified in such a way that it can be easily identifiable on image as well as to get the visibility of sufficient number of satellites to the GPS receivers without any obstruction. Figure2 shows the locations of GPS surveyed ground control points on the image. Observations were taken for 72 hours at reference station and simultaneous one-hour observations each at GCPs. The maximum baseline distances between reference and rover stations were within 10 km.

A 12-channel dual frequency receiver (Leica GPS system 500) was used in the present study. The epoch of observation was set for 15 seconds and the cut-off angle was selected 15°. At each of the rover point six to eight satellites were available during observation and GDOP was better than 5. One of the GCP locations is shown in Figure. 3.

Post processing of GPS observations was carried out using SKI-PRO software. The processing was done in differential mode. The

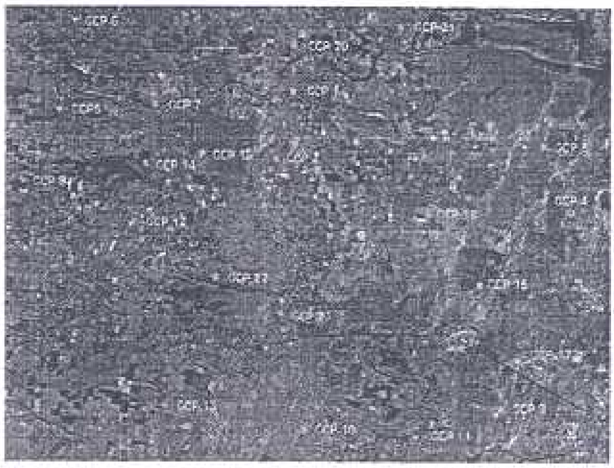

Figure 2: The locations of DGPS surveyed ground control points on the image

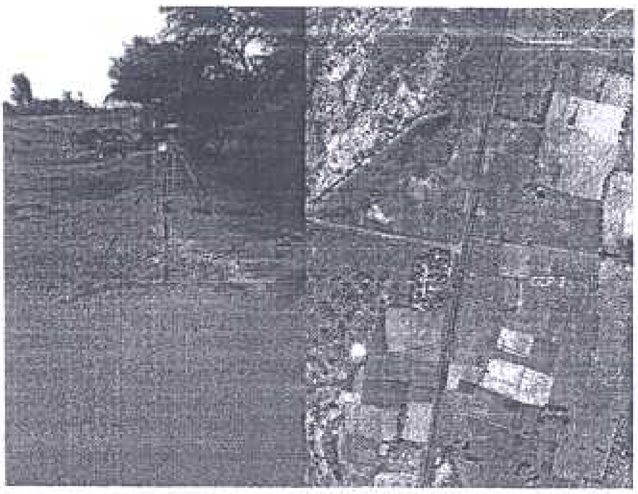

Figure3: Field Photograph and Corresponding Image Position

reference station was first established by network adjustment with IGS stations. With respect to the reference point, the coordinates of all the 23-GCPs were computed in WGS-84 datum. The result of the processing is shown in Figures 4 and 5.

4.2 Field Survey with Total Station

Total station (SOKIA) was used for in-situ measurement of distance, perimeter and area of plot boundaries. For this exercise, total 7 blocks were selected from the image. The total station uses infrared rays to compute the distances and angle.

4.3 Geometric correction of IKONOS Image

The IKONOS image was georeferenced with GCP's established using DGPS survey. UTM projection of zone 44 was chosen for geo referencing. Out of 23 Control points, 15 Control points were used for geo referencing and the rest 8 were used as check points. The RMS Error at GCPs was 0.56m, 0.67m in Easting and Northing respectively.

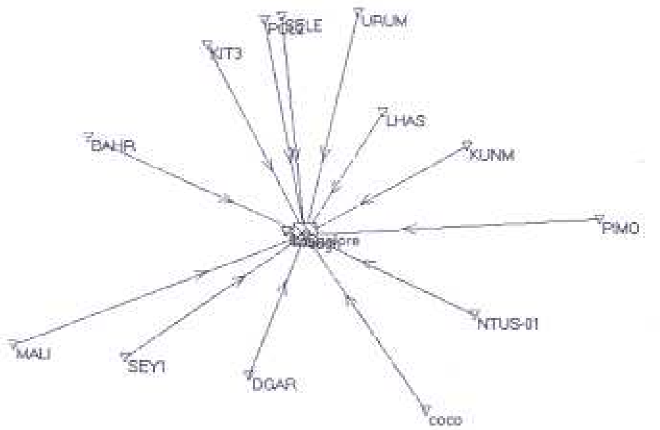

Figure 4 : Establishment of Reference station by network adjustment with IGS station.

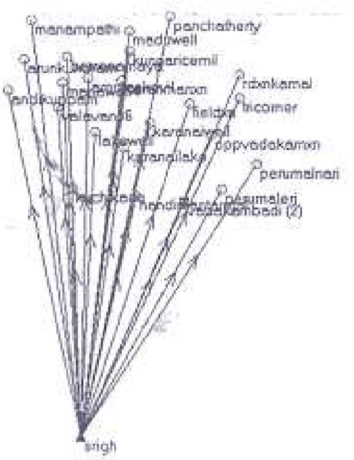

Figure 5: Establishment of GCPs by Base line analysis with respect to Reference stations.

4.4 Mosaic of the Cadastral map and geo-referencing

Village maps of Kunnapattu, Karanai, Mannveedudevadanam, Valavanthongal and Amayapatu village was digitized and Mosaiced by translations and rotations of the digitized cadastral map and then registered by taking geo-referenced image as a reference. For registration of village map with geo-referenced image, 40 tie points were used. The village boundaries from the said maps were used to clip the same area of extent from image. Figures 7 and 8 respectively show the field boundaries of five villages extracted from image and cadastral map. Figure 9 shows overlay of field boundaries from both the sources.

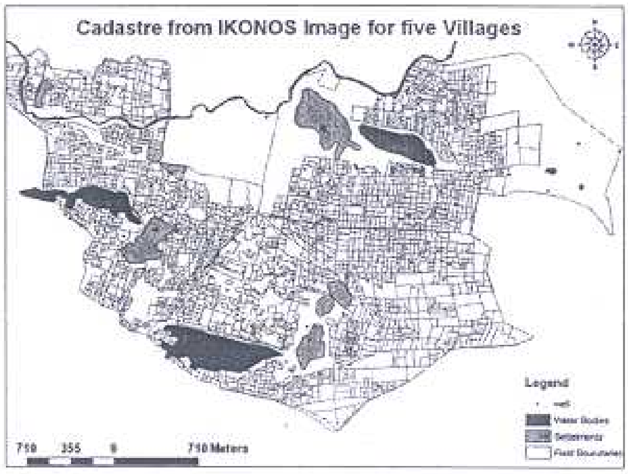

Figure 7 : The field boundaries of five villages extracted from image

Figure 8 The field boundaries of five villages extracted from Cadastral map

4.4 Extraction of Land parcels / Land Cover classes in GIS Environment

From geo referenced IKONOS image, various features like field boundaries, water bodies, settlements etc. was extracted by visual interpretation techniques. The extracted features were digitized in GIS Environment. Vector Editing was carried out to remove the dangle errors if any.

5. ACCURACY ASSESSMENT

Field boundaries from geo referenced IKONOS image has been extracted. Village map of scale 1:4000 was registered with field boundaries from image and comparison analysis was carried out. The planimetric accuracy of the land parcels was carried out by, comparing length and area of selected plot boundaries from image with in-situ field observations using total station and Field Measurement Book (FMB).
Accuracy of field boundaries prepared from image was validated by following methods.

- Comparison of coordinates of 8 checkpoints on the geo referenced image with GPS observed coordinate.
- Comparison of length and area of fields and its boundaries from geo referenced image with that of in-situ observations using total station.
- Comparison of the parcel area were also compared between those derived from Image and that of FMB

5.1 Comparison of coordinates

The accuracy of geo referenced IKONOS image was computed by comparing the coordinates at 8 check points. The root mean square error (RMSE) for 8 check points in Easting and Northing values are and 1.56m, 1.62m respectively.

5.2 Comparison of Field Boundaries

Field boundaries from FMB and that extracted from image were compared. Total of 19 Fields were selected. The number of fields and its area in each of the Field from village map and image was calculated in GIS environment and the results were compared. Figure 9 shows the comparison of selected fields from image and village map. The total area of the fields from image and that of from the FMB were 255168.948 sqm 254500 sq. m respectively The maximum and minimum % difference in area were respectively 7.24 and 0.02.

5.3 Validation of Land parcels from geo referenced IKONOS Image with Field Measurements

In-situ field measurements were taken with total station for the seven selected blocks as shown in Figure 10. Length of each side of the fields and its area was measured in the field. The results were compared with measured distance and area from image in UTM Projection. The line diagram for one of the seven blocks, E, was shown in Figure 11. Figure 12 shows the comparison of length of 207 field boundaries of selected blocks from image and field observations. The comparison of areas of 68 fields were shown in Figure 13. The comparison of perimeter was shown in Figure 14.

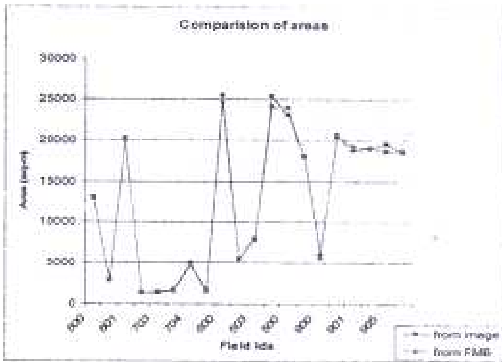

Figure 9: Comparison of Parcels areas from image and FMB

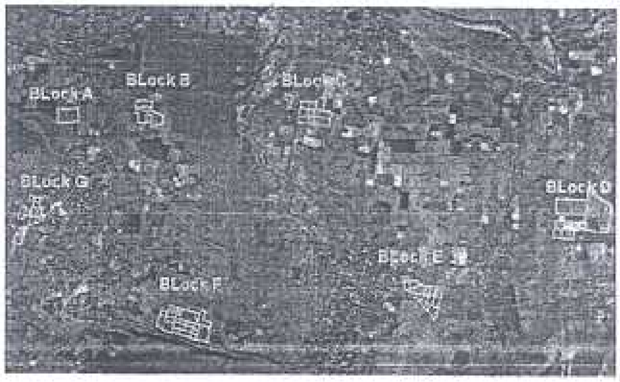

Figure 10: Distribution of seven blocks for field validation

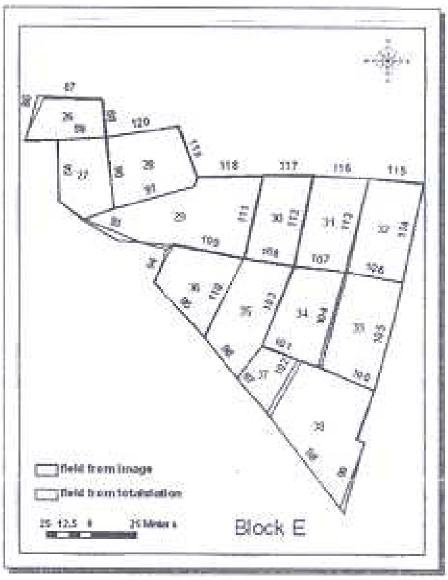

Figure 11: Block E with land parcels extracted from image and that from total station for one of the blocks

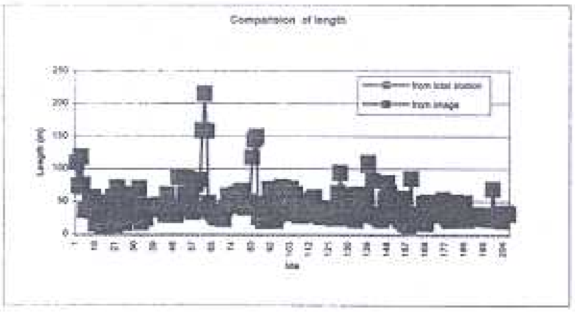

Figure 12: Comparison of lengths of fields from image and Total station measurements

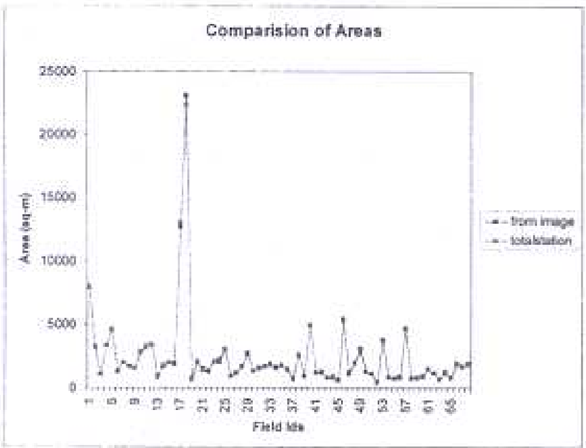

Figure 13: Comparison of areas of Land parcels from image & Total Station Measurement

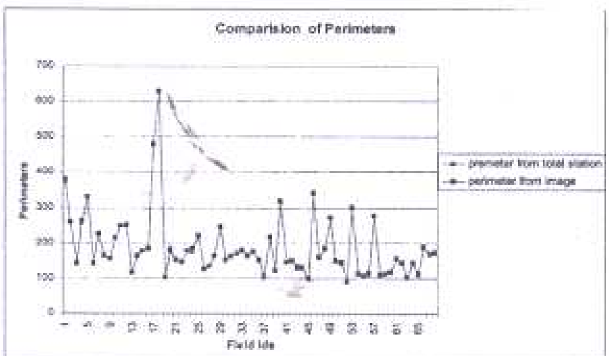

Figure 14: Comparison of Perimeter of Land parcels from image & field observations

5.4 Updation of Land Parcels

The number of land parcels as shown in Cadsatral Maps were very less as compared to that shown in high resolution images. The updated land parcels are available in Field measurement book specifying the division of the land parcels, area etc. The major issues involved in updation of the cadastral maps is the mosaicing of individual cadastre. High resolution images geometrically corrected using DGPS measurements allows the updation. The Mosaiced / geometrically corrected Village maps were overlaid over the IKONOS image and the additional land parcels which were not available in the cadastral maps were digitized and updated. The updated cadastral maps were shown in Figure 15.

5.5 Updation of village Boundary

Village boundary updating was carried out by overlying the village boundary extracted from the cadastral mosaic on the geocorrected image. The mismatched boundaries were updated following the prominent land parcel boundary, road / drainages. 52 % of the boundary was updated for all the five villages. The results are shown in Figure 16.

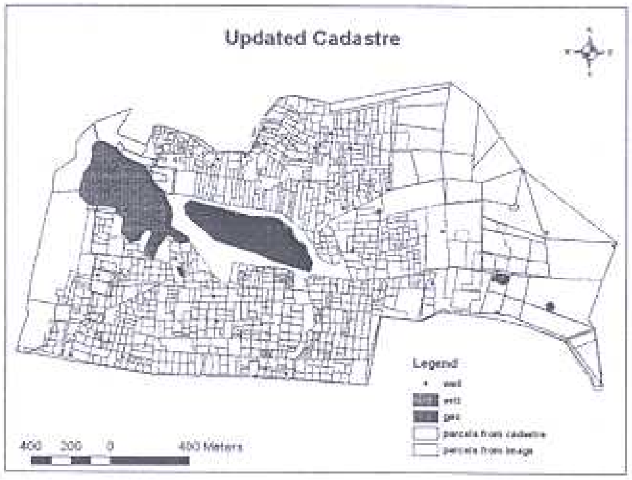

Figure 15: The Cadastral Map Updation using High Resolution images.

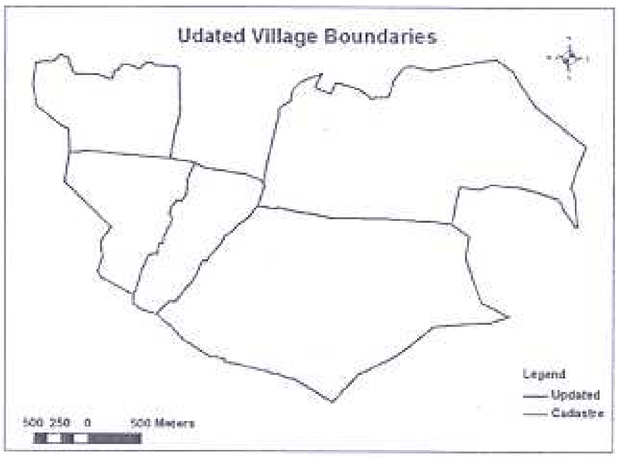

Figure 16: Updation of Village boundary

6. RESULTS AND DISCUSSIONS

Geo referenced IKONOS image in UTM projection has been generated from GPS observed ground coordinates. Field boundaries covering villages of Kunnapattu, Karanai, Mannveedudevadanam, Valavanthongal and Amayapatu were extracted from image. Length and area of fields were validated from Field Observations.

The RMSE for geo referencing of IKONOS image with GPS observed ground coordinates is 0.56 m in Easting and 0.67m in Northing. Table 2 indicates the number of parcels and area of field for selected 5 village from the village map and field boundaries extracted from image. The total area of land parcels from image is 255168.948 sq.m and the total area of land parcels from village map is 254500 sq.m.

For the validation of geo referenced IKONOS image in UTM projection, the length and area of fields of selected blocks (A, B, C, D, E, F, G) were validated from field observations. The field observations were taken with Total Station Instrument. Figure 12 indicates the comparison of lengths of fields for selected blocks from image and Total Station. The difference of distances for 207 plot boundaries shows a maximum of 6.02% and a minimum of 0.0093 %. The % difference of more than 3 was only observed for very few sides. Figures 13 and 14 show the comparison of parcel area and perimeter for selected 68 plots from image and Total station measurements. The maximum % difference in area is 11.28 and minimum is 0.075. The % Differences in perimeter shows a maximum of 5.53 and minimum is 0.008. Village boundary updation was also attempted by overlaying the village boundary from the mosaic cadastre on the georectified image and following features such as land parcel boundary, road or drainage from the image.

7. CONCLUSIONS

GPS measurements in differential mode has been used to establish the cartographic coordinates of GCP's which are used for geo referencing of IKONOS image. The Land parcels, roads, water bodies. etc were extracted from geo referenced IKONOS image in UTM projection. The positional accuracy of Geo referenced image is less than 0.5m.

The registration of village map with features extracted from image shows, the number of land parcels is more in image than that of the village map. The comparison of length, area and perimeter derived from the image with that of field measurements by total station shows that very small % difference. The study reveals that cadastre information in the form of map can be updated using high-resolution data. The village boundaries can also be updated and made available in digital form.

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ACKNOWLEDGEMENTS

The authors express their sincere gratitude to Dr. R. R. Navalgund, Director Space Applications Centre for his interest and motivation in this study. They also express their sincere thanks to Dr. K. L. Majumdar, Deputy Director, REISPA / SAC for his encouragement in this study. They are also thankful to Ritesh Agrawal and J. A. Vinoth Kumar for their help during analysis.