Cadastral applications using IRS-1C data – Some case studies

D. P. Rao, R. R. Navalgund* and Y. V. N. Krishna Murthy**

National Remote Sensing Agency, Hyderabad 500 037, India
*Space Applications Centre, Ahmedabad 380 053, India
**Regional Remote Sensing Service Centre, Nagpur 440 010, India

It is well known that remotely sensed data from satellites have the advantage of synoptic view of large areas repetitively in a multi spectral mode. The Landsat series of satellites since 1972 provided spatial resolutions starting from 80 m to 30 m and later SPOT satellites provided resolution in panchromatic mode up to 10 m. The scales of mapping improved with resolution, making it possible to map up to 1 : 50,000 scale. Indian Remote Sensing Satellite series started in 1988 with IRS-1A and later IRS-1B followed by IRS P2 provided resolution which made it possible to map up to 1 : 50,000 scale. Towards realizing the potential high resolution of IRS-1C data, an attempt has been made here to see how best this data can be used for the development of rural areas in our country. Three study areas have been selected in different parts of the country for this study. They are (i) part of Dharmapuri district in Tamil Nadu, (ii) part of Chandrapur district in Maharashtra, (iii) part of Ahmedabad district in Gujarat. PAN data of 5.8 m resolution and multi spectral data of 23 m resolution have been studied using the powerful computer systems available. Compatibility of IRS-1C data by overlaying on cadastral maps has been studied and it was found that there was a very good geometric fidelity of the satellite data when overlaid on cadastral maps of different study areas.

A cadastral map contains methodically arranged information on all properties (Parcels or Survey Numbers) within a given village or tehsil or district. The boundaries of properties or survey numbers are normally shown on large scale maps (1 : 4000 to 1 : 8000), together with village registers, in which the further details of the property namely—ownership, landuse, its value, size, etc.—are written for the purpose of collection of revenue from land, based on its use and also to ensure the security of the property to its owner or the legal heirs[1].

The cadastral system is advantageous both to the citizen having land properties as well as to the government in that

- the documented evidence of land ownership as a cadastre provides legal security and reduces or eliminates the risk of grabbing the property by others
- dealings in property transactions are easier, clear, faster and safer
- establishment of an orderly, efficient and equitable system for levying land or property taxes and also for implementation of land ceiling act
- the data from the cadastral system provide an inventory and monitoring of the existing landuse towards determining the sustainable future landuse, its implementation and management
- once satellite-based cadastral system is established throughout the country, it enables a considerable savings to the government for its updation and realistic implementation towards any changes in use of particular land.

Cadastral maps have been an indispensable tool for the administration in dealing with day to day revenue and development activities in the district. The administrative staff at field level are more conversant with cadastral maps rather than any other type of maps. Cadastral maps having details of development activities survey number wise will facilitate the district administration to take up implementation of these tasks. Updating the cadastral information is very essential so that transformations/changes of ownership/division of properties, etc. can be recorded in an orderly manner for documentation and further use[2]. In the past, this exercise was done by using chain survey and recorded in registers by village patwaris. With the advent of remote sensing technology these records in the form of maps can be updated as satellite remote sensing provides details of the study area approximately once in two weeks with higher spatial resolutions. Satellite imagery which forms the base for the generation of action plan maps, if overlaid on cadastral maps, can improve the details of the thematic maps as well as action plan maps. It also helps in the monitoring of changes that can be measured at plot/survey no. level[3,4].

Objectives

The study has been conducted with the following objectives.

- Overlaying of cadastral maps on IRS-1C PAN and LISS-III images.

- Correlation of landuse information available within each cadastral boundary on IRS-1C images.
- Study of spatial registration of each survey number with existing landuse as recorded in village registers (adangals).
- Comparison and updation of cadastral information using the latest data from IRS-1C images.

Study areas

Three areas, viz. (i) a cluster of six villages in Dharmapuri district in Tamil Nadu, (ii) A cluster of Ten villages in Chandrapur district, Maharashtra and (iii) one village, Moraiya in Ahmedabad district, Gujarat have been studied to overlay the respective cadastral maps on IRS-1C PAN image and PAN-LISS-III merged image on approximately 1 : 12,500 scale and reduced to 1 : 50,000 scale.

Materials

The data used for the study included:

1. IRS-1C digital data of PAN and LISS-III of January 1996.
2. Cadastral maps on 1 : 5,000 scale obtained from Directorates of Land Records and Settlements situated at Madras, Bombay and Ahmedabad for the respective study areas.
3. Village Registers and Records.
4. Topomaps of Survey of India on 1 : 50,000 scale of the respective study areas.

Methodology

The cadastral maps of the study villages were scanned using the Contex Black and White Scanner at 200 dpi. The raster data of all the maps thus obtained were vectorized and edited for the missing and non-relevant data using data path (RVCS) package. The individual cadastral maps after editing, were mosaiced. The boundaries between two adjacent villages were checked and corrected for proper mosaicing.

Survey of India toposheets of the respective study areas were also scanned using the Tangent Colour Scanner with 200 micron aperture, edited and mosaiced to be used as a single study area map.

Survey of India topomap was used as a reference for co-registration among the cadastral, IRS-1C PAN and LISS-III data. This was achieved by collecting Ground Control Points (GCPs) commonly available on all the datasets by employing geometric rectification technique available on the GCP works of the EASI/PACE image processing package at NRSA, Hyderabad and SAC Ahmedabad and VIPS-32 systems at RRSSC, Nagpur for the study areas in Dharmapuri, Ahmedabad and

Table 1. Ground control points and RMS errors

GCPs	RMS error (in pixel)	Resampling error		Geo referencing image		Uncorrected vector	
		X	Y	X	Y	X	Y
A	1.86	−1.19	1.44	906.4	559.4	269.9	481.1
B	0.55	−0.50	−0.21	1067.4	765.4	570.1	762.6
C	0.67	−0.07	−0.67	115.2	626.7	606.1	536.6
D	0.38	−0.3	−0.22	891.1	718.1	289.9	729.9
E	0.43	0.43	0.07	1025.6	818.1	520.4	853.9
F	0.30	−0.23	0.19	886.5	775.5	296.9	820.6
G	0.39	−0.16	−0.35	1040.1	785.6	533.9	880.2
H	0.71	−0.32	0.64	1116.9	717.1	633.1	676.6
I	0.11	0.10	−0.03	912.6	493.6	264.9	377.4
J	0.94	0.86	0.36	1157.1	761.9	707.9	734.4
K	0.45	−0.44	0.06	1185.4	752.4	747.1	711.4
L	0.05	−0.01	0.05	1226.5	501.5	744.5	314.1
M	1.05	0.85	−0.61	955.5	593.5	354.7	522.3
N	0.72	0.34	−0.64	862.6	532.4	199.4	445.1
O	0.63	0.26	0.58	1183.5	701.5	731.1	633.9
P	0.71	−0.11	−0.70	1209.6	749.6	783.6	699.1
Q	0.12	−0.11	0.05	1095.1	848.1	634.4	882.4

Third order overall RMS error: 0.76 (X) 0.84 (Y).
Note: X, Y = Pixel location.

Chandrapur districts respectively. An example of ground control points and RMS errors is shown in Table 1, with regard to Dharmapuri study area.

After the co-registration process, the map containing all the villages with cadastral information was overlaid on IRS-1C PAN and multispectral images.

Results and discussions

Study area 1

With regard to six spatially contiguous villages of Dharmapuri district, Tamil Nadu, two vector plotter products were generated using IRS-1C PAN and merged product of PAN and LISS-III data. These are shown in Figure 1 and Figure 2 respectively. The boundaries of cadastral maps matched well with image detail with respect to various features such as roads, railway line, streams, reserve forest boundary, plantation crops and other different agricultural fields. The error for image to cadastral registration was of the order of less than a pixel in general. It is clear from Figure 1 and Figure 2 that the landuse information at cadastral level can be updated using the high resolution IRS-1C imagery with great accuracy.

Study area 2

The cadastral map overlaid on false colour composite of simulated IRS-1C image of part of Chandrapur district is shown in Figure 3. A cursory look reveals that the overall registration of cadastral information on simulated IRS-1C image was extremely good with respect to various cultural and natural features like, roads, streams, agricultural fields, reserve forest boundary, etc. with a residual error of 0.5.

Study area 3

The cadastral map of Moraiya village in Ahmedabad district, Gujarat overlaid on IRS-1C image is shown in Figure 4. The accuracy of registration of cadastral map with satellite imagery was measured. The root mean square error was found to be 11 m. In the southeast of the village, some new linear geometric shapes (A) were seen which were not existing in the map. During ground truth, it was confirmed that these were new industries. The extension of village (B) in the particular survey number was clearly seen. Some new agricultural fields, which were not there on the map were seen in the imagery (C).

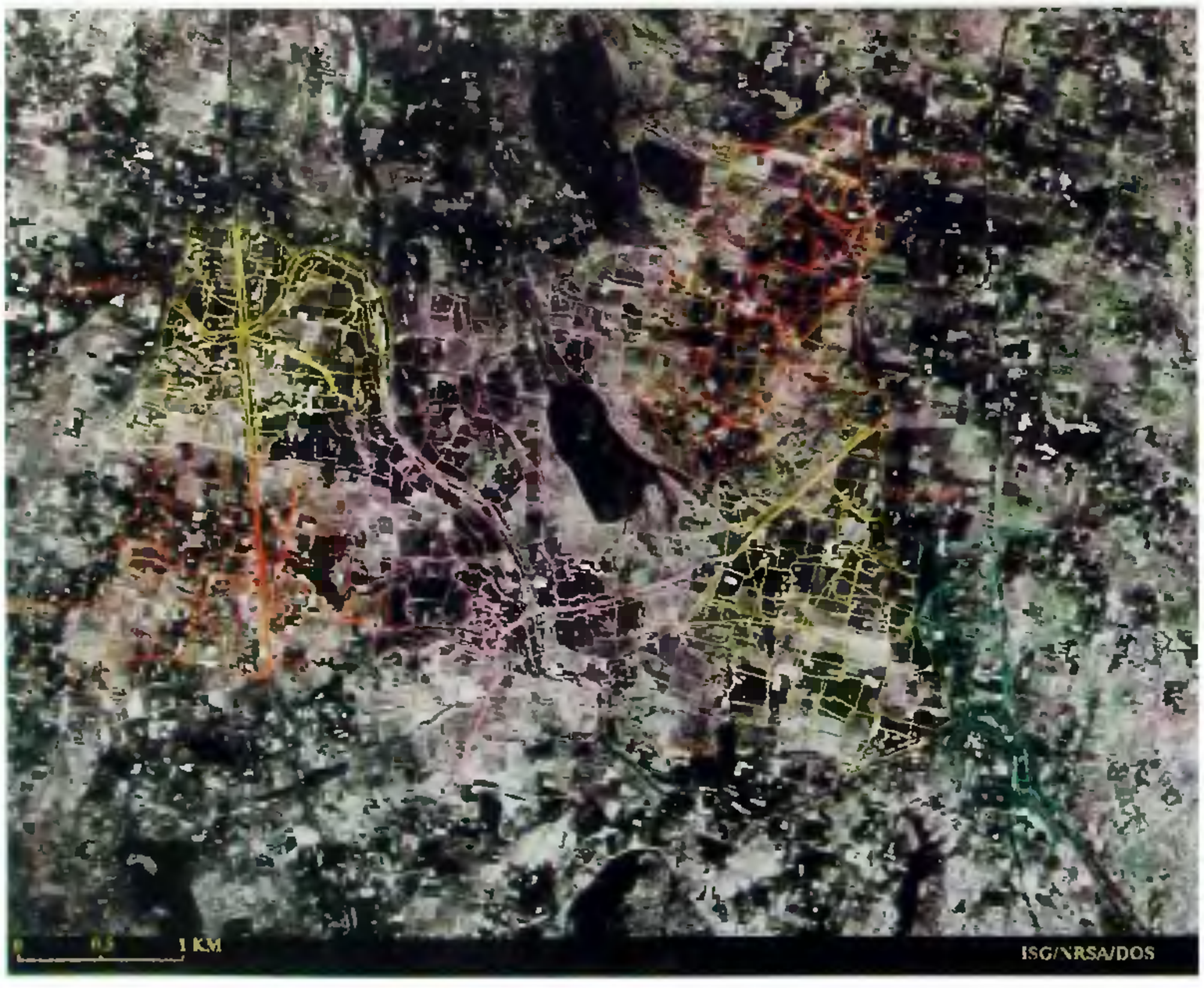

Figure 1. Cadastral plot on IRS-1C PAN image, part of Dharmapuri district, Tamil Nadu.

Figure 2. Cadastral plot on IRS-1C (PAN + LISS-III) hybrid image, part of Dharmapuri district, Tamil Nadu.

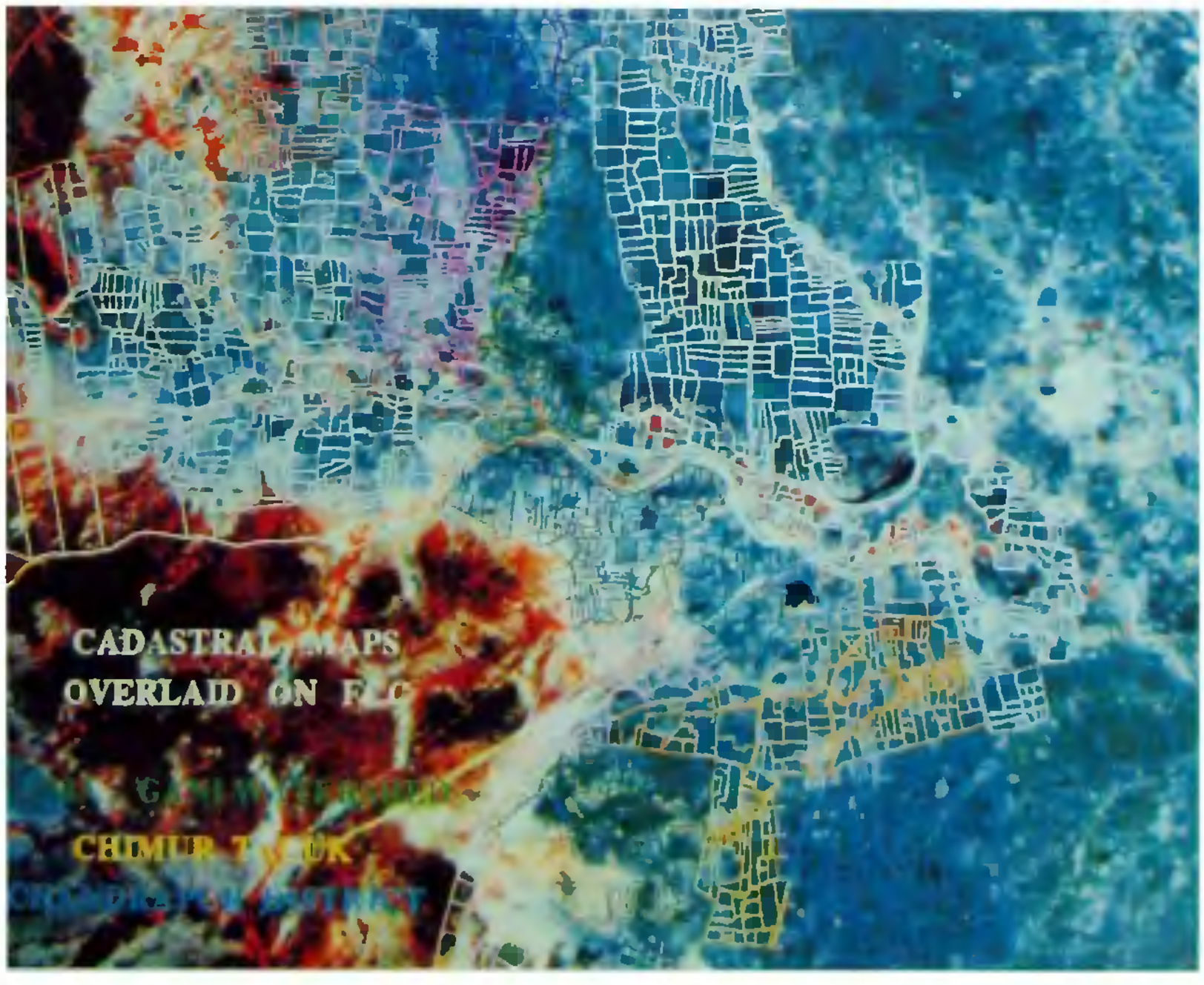

Figure 3. Cadastral maps overlaid on false colour composite of UMA Gani watershed, Chimur taluk, Chandrapur district.

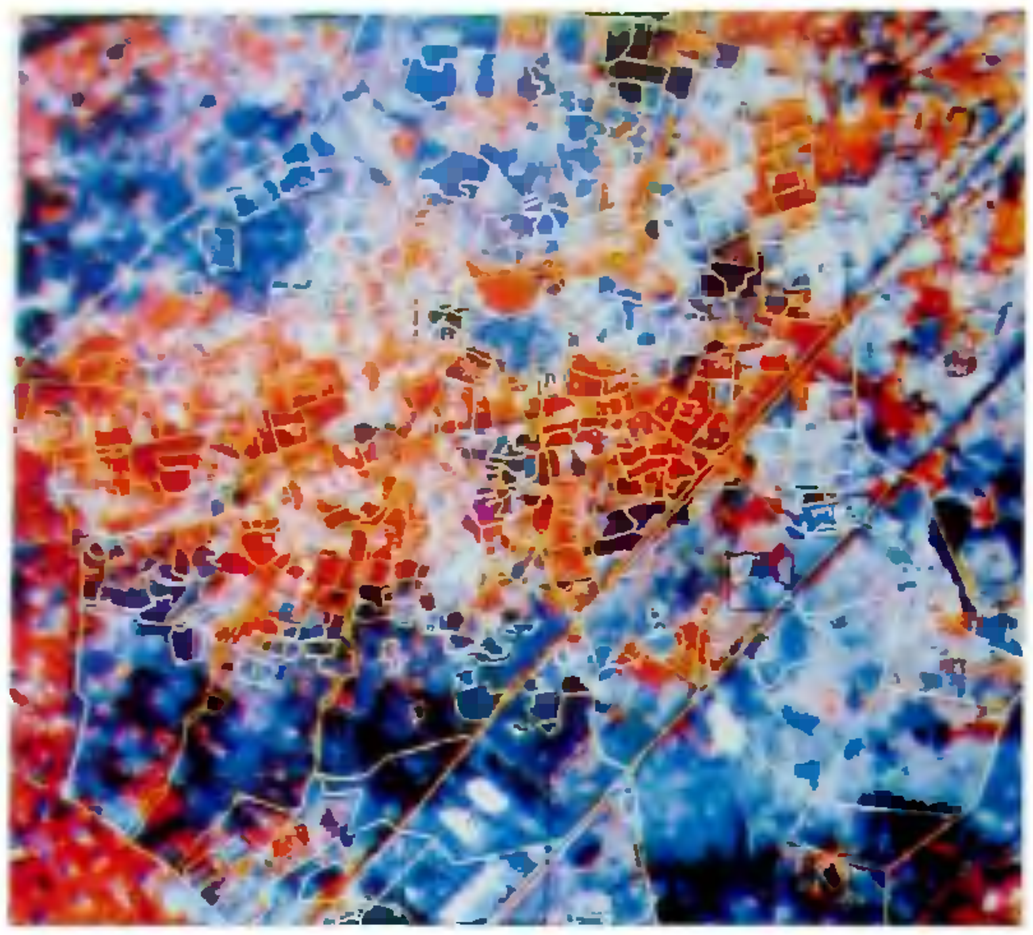

Figure 4. Cadastral map of Moraiya village in Ahmedabad district, Gujarat overlaid on IRS-1C image.

Conclusion

The study suggests that the high resolution (PAN and LISS-III) satellite data can be registered with the cadastral maps and a remarkable accuracy (less than 1 pixel size) has been achieved. Further, it reveals that the cadastral information in the form of maps and records can be updated using IRS-1C high resolution data of appropriate time or cropping season.

1. Khular, Y. L., Proceedings of All India Cadastral Surveys Seminar, 16–17 September 1985, Dehradun.
2. Corker, I. R., *Land Resource/Landuse Planning Handbook Project Record*, Development Centre, Surrey, UK, 1984, 66, 55–83.
3. Morley, L. W. in *Surveys for Development* (ed. Nossin, J. J.), Elsievier, Amsterdam, 1977.
4. Niemann, B. J. and Mc Carthy, M., in *American Society of Agronomy*, Publication No. 21, (eds) Beatty, M. T., Peterson, G. W. and Swindale, L. D., Madison, USA, 1979.
5. National Remote Sensing Agency, *Integrated Mission for Sustainable Development Technical Guidelines*, 1995.

ACKNOWLEDGEMENTS. D.P.R. thanks his colleagues Dr S. K. Subramanaian, Dr G. Ch. Chennaiah, Mr G. Hanumantha Rao, Dr S. V. C. Kameswara Rao and Dr J. Ramanamurthy of Integrated Surveys Group, NRSA, Hyderabad for their constant interaction during the preparation of this paper. R.R.N. thanks Mrs Tara Sharma and Mr T. P. Singh of SAC, Ahmedabad for the help received.