Updation of Cadastral Maps Using High Resolution Remotely Sensed Data

V. V.Govind Kumar, K. Venkata Reddy, Deva Pratap

Abstract:A cadastral map shows the boundaries of all land parcels on large scale maps together with the village registers which contains the ownership,land use andarea details.Updating the cadastral information is very essential so that transformations/changes of ownership of parcels etc. can be recorded in an orderly manner for documentation and further use. Presently, the cadastral maps are being updated with high resolution remotely sensed imageries using Geographical Information Systems (GIS) and Global Positioning System (GPS).Present paper discusses the updation of the geospatial information and quantification of the accuracy of the geo-referenced cadastral map of Venkatapuram village of Thorrour mandal, Warangal District, Andhra Pradesh, India. After mosaicing the Google Earth downloaded imageries of the study area, rectification of has been carried out using SOI toposheets. Vectorised cadastral map is prepared in the GIS environment using the scanned cadastral map of the study area and registered using Ground Control Points (GCPs) collected from GPS instrument.The features of cadastral map are updated by superimposing the vectorised cadastral map on the rectified imagery of the study area. The accuracy assessment of the vectorised cadastral map has been carried out. From the observation of mean percentage deviation, standard percentage deviation and parcel area deviation, it is seen that large area parcels have more accurate and less distortion than small area parcels. The methodology presented in this paper is useful to update the cadastral maps with low to medium accuracy.

Keywords: GIS, GPS, Google Earth High Resolution Imageries, Cadastral Map Updation.

I. INTRODUCTION

Cadastre is normally a parcel based, and up-to-date land information system containing a record of properties in land. Cadastral maps show the relative location of all parcels in a given village or tehsil or district. They are commonly range from scales of 1:4000 to 1:8000. Information in the textual or attribute files of the cadastre, such as land value, ownership, or use, can be accessed by these unique parcel codes (survey numbers) shown on the cadastral map (Raghavendran, 2002).

Cadastral maps are indispensable tool for the administration in dealing with day to day revenue and development activities in the district. In most cases, these maps have lost their relevance since the maps are not updated over a long time. Updating the cadastral information is very essential so that transformation/changes of ownership, size etc., can be record in an orderly manner for documentation and further use.(Singh 1996)

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In past, these maps are prepared by using plane table survey, chain survey tape measurement and recorded in registers by village patwaris.Now a days the cadastral maps are being prepared using Electronic Total station (ETS), Field measurement book (FMB), Record Of Rights (ROR) details**.** The state of art technology, i.e. aerial and space based remotely sensed high-resolution satellite images, GIS and GPS is revolutionizing the concept of large scale mapping, addressing the mapping issues at the scale of 1:10,000 and larger.

Demonstration of overlaying of cadastral maps over the merged product of IRS 1C PAN and LISS III data has been carried out by Rao (1996). The application of GPS in level surveying and also accuracy of the GPS is assessed with the conventional survey instruments byMasahiro (2000).Use of high resolution data for large scale mapping is discussed by Raju (2002). Raghavendran (2002) carried out a study on design and implementation of LIS.Murthy (2000) Land information System (LIS) for rural development, a technical proceeding.

Based on the above research studies an attempt has been made to create, update and validate a cadastre database using Google images, FMB records and in-situ GPS measurements.

1.1 Study area:

Venkatapuram village, Thorrurmandal of Warangal district, Andhra Pradesh, India has been taken as the study area. The study area is spanning from $79^0\ 37'\ 30''$ to $79^0\ 45'0''$ East Longitudes and $17^0 30' 0''$ to $17^0 37' 30''$ North Latitudes.

II. METHODOLOGY

The methodology used in the present study is shown in Fig. 1. Initially, the cadastral maps of the villages have to be collected from the Land Record Department (LRD). The cadastral maps have to be scanned and converted to vector format in ArcGIS 9.2 environment. Vector cadastral maps have to be combined with attribute data. Ground control points have to be collected using GPS instrument for Geo-referencing the Google Earth downloaded Images. Digital cadastral map has to be overlaid on rectified high resolution imageries to update the digital cadastral map. Then accuracy assessment of the digital cadastral map has to be carried out.

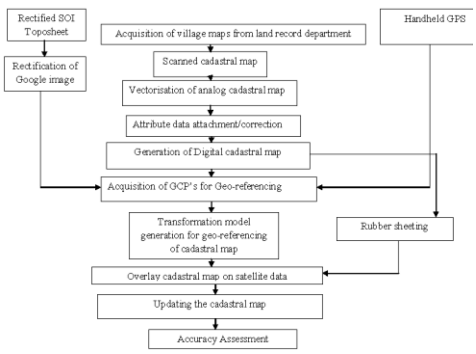

Fig. 1. Flowchartshowing the Methodology of the work.

2.1 Data Used

The cadastral map of Venkatapuram village at 1:8000 scale has been collected from Land Record Department, Warangal. The mosaiced Google Earth imagery of the study area has been rectified by selecting ground control points from SOI toposheet 56/O/10/SW at 1:25000 scale using ERDAS Imagine 9.1 and ArcGIS 9.2.The ancillary cadastral information in district census handbook and Patwari handbooks has been collected from Land Record Department, Warangal. Trimble Handheld Geo XM GPS is used for collecting GCP's for rectification of cadastral maps.

2.2 Digital Cadastral Map Preparation:

The digital cadastral map, the fundamental component of cadastral system, is not a map in the traditional sense. A basic cadastral map is organized into layers such as parcels, roads, rail, tanks, etc. In the present work, from the scanned cadastral map, digital cadastral map is prepared by digitization method in ArcGIS environment. The digitized cadastral map of Venkatapuram village is shown in Fig. 2.Then the digitized cadastral map is converted in coverage file to create the topology and to calculate the areas of land parcels. The vector layer of the cadastral map with full topological relationships is shown in Fig.3

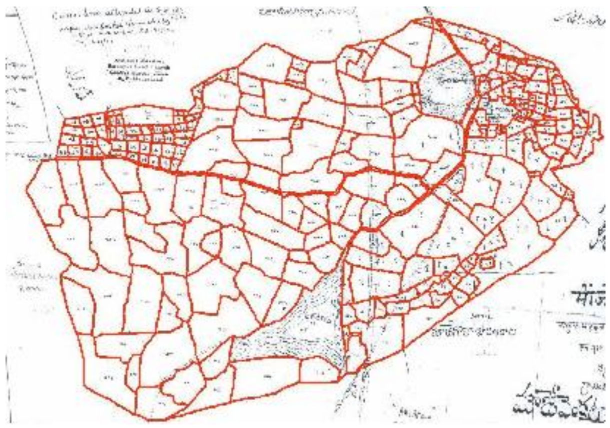

Fig.2.Digitized Cadastral map of Venkatapuram village.

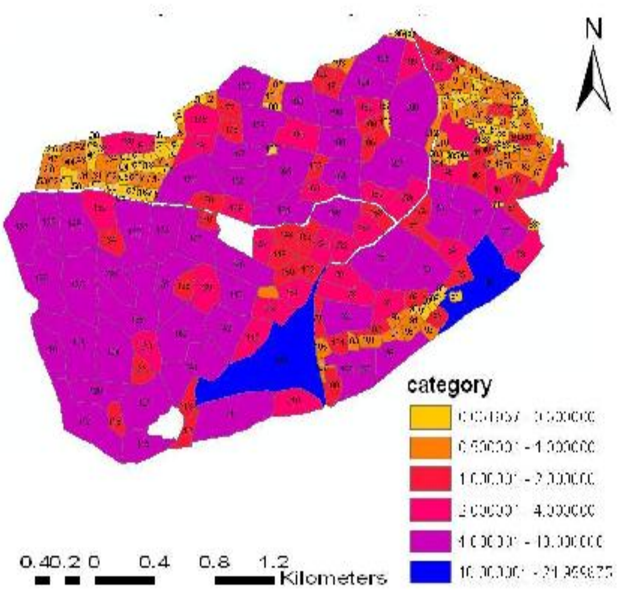

Fig. 3. Vector layer of Venkatapuram village

2.3 Geo-referencing:

Geo-referencing can be defined as the process of transforming the data from one grid system (image row and column coordinates) into another (map coordinate system) using an n^{th} order polynomial. For geo-referencing the cadastral map, sufficient number of GCP's with real world coordinates is required. This can be done through primary or secondary sources. The primary sources consist of three modes, ground control survey, topographical maps and coordinates obtained from GPS. The secondary sources consist of aerial images or high-resolution satellite images. The very high-resolution space images available today and planned in the near future have spatial resolution close to that of aerial images.

The high-resolution satellite images are rectified using the control network derived from topographical maps. The other source for deriving the real world coordinates is GPS which uses geodetic coordinate system based on WGS 84 Ellipsoid and provides coordinates on any point on earth's surface. The Everest spheroid is used as reference surface in India. Transformation models are used to transform coordinates from one system to another system.(Murthy, 2003)

2.*3.1 Geo-referencing of cadastral map using Google Earthimage*:

In this case, topographic map of the study area is used as a referenced map in geo-referencing the Google Earth image. Then the cadastral map is geo-referenced using Google Earth image. In geo-referencing, same points both on Google Earth image and in village cadastral map are considered. As the topographic map of the study area is correctly georeferenced, we fix the co-ordinates of the Google Earth image to cadastral map; there by the cadastral map is geographically referenced. For this study, third order polynomial is considered for more precise than the previous orderings. The digital cadastral layer overlaid on rectified Google Earth image is shown in Fig. 4.

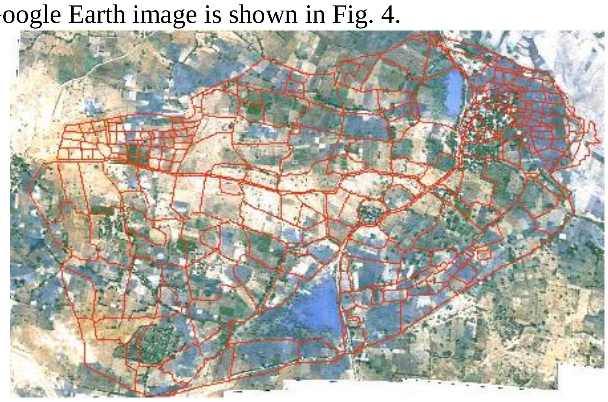

Fig. 4. Vector layer overlaid on rectified Google Earthimage.

2.3.2 Geo-referencing of cadastral map using GPS ground control points:

In this case, the cadastral maps can be geo-referenced directly using GPS based ground control points (GCP's). The GCP's are identified on the cadastral maps and corresponding geodetic coordinates are derived using the GPS observation for generating a transformation model. The GCP's may be well defined on the map, but on the ground it is very difficult to pinpoint exactly. As a matter of correct geo-referencing more points and evenness in distribution over the area is considered. So the fourth order which is having more points and evenness in distribution, its geo-referencing is precise than the previous orders.

2.4 Rubber sheet adjustment for Geo-referenced vector layer:

After geo-referencing of the cadastral map the vector layer is not exactly matching with the parcel boundaries in the satellite data. At this time the spatial adjustment concept like rubber sheet is used. The rubber sheet adjustment creates coordinates from the displacement links to adjust features. The spatial Adjustment tool supports two types of rubber sheet methods: Natural neighborand linear interpolation methods. The Natural neighbor method is the default. If rubber sheet adjustment is doing for some parcels the reaming parcels are disturbed. To avoid this problem use a tool called mask. The mask tool is applied to geo-referencing the vector layer.

2.5 Accuracy assessment

The Accuracy assessment is carried out for the task of vectorisation and geo-referencing of cadastral map.

2.5.1 Accuracy assessment of vectorisation of cadastral maps

The vectorisation of analog village (cadastral) maps involves scanning, digitization, attribute attachment. The accuracy of digital conversion is assessed through one-to-one matching of the vectorised cadastral maps with the original analog map, attribute data assessment, particularly zero fills and duplicate labels and assessment of parcels area in vectorised map with respect to the area of parcels mentioned in revenue records.

2.5.2 Accuracy assessment of geo-referencing of cadastral maps

The methodology adopted for accuracy assessment in the process of geo-referencing of cadastral maps is presented below. The two modes of accuracy assessment, visual (quality) and numerical (quantitative) are attempted in the present study. The visual assessment includes validation of geo-referenced map for each village independently and with neighborhood using the high-resolution satellite as the reference. The quantitative method includes transformation model assessment (process accuracy) and positional and area accuracy (product accuracy) (Murthy 2003). The details accuracy assessments are presented below.

2.6 Results and Discussion

The parcels are classified into 6 categories based on parcel area, category-1 (area <0.5 ha), category-2 (0.5-1.0 ha), category-3 (1.0-2.0 ha), category-4 (2.0-4.0 ha), category-5 (4.0- 10.0 ha) and category-6 (area > 10.0 ha).

2.6.1 Accuracy assessment of vectorisation of cadastral maps

The important accuracy test is carried out on the attribute data entry. Each polygon in the parcel (polygon) coverage represents a parcel and it will have unique parcel number. Even after the intensive drive, some polygons are observed with error of zero labels/duplicate numbers. From the LRD these errors can be edited and rectified. The parcels area generated in the vectorised coverage, prior to geo-referencing, should match with that of revenue records. To asses this accuracy, the data is collected for Venkatapuram village and compiled below in the Table 1 and depicted in Figure 5.

From the Table 1.0, it is observed that the mean of percentage deviation decreases with increase in parcel area for the village. It is of the order of around 16% for category-1, 16% for category-2, 15% for category-3, 11% for category-4, 8% for category-5 and 2% for category-6. The maximum percentage deviation decreases with increase in parcel area for the village. The maximum deviation is in the order of 88% of category-1, 87% category-2, 80% of category-3, 47% of category-4, 28% for category-5, 3% for category-6.

Table 1Mean and Standard deviation of absolute percentage deviation (GIS – LRD) of parcels area

Category	Range	Mean	Maximum	Minimum	Standard deviation	Variance
1	< 0.5	16.83	87.186	0.004	23.27	541.543
2	0.5 - 1.0	16.13	85.68	0.467	17.27	423.841
3	1.0 - 2.0	15.69	79.61	0.368	17.94	321.879
4	2.0 - 4.0	11.18	46.94	0.000	11.93	142.313
5	4.0 - 10.0	8.26	28.67	0.001	6.92	47.841
6	>10.0	2.16	3.10	1.215	1.33	1.776

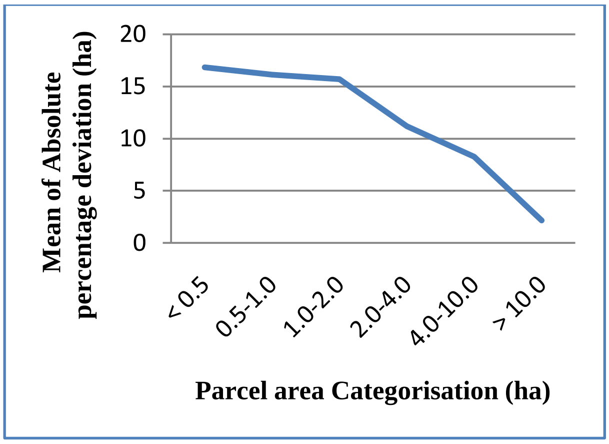

Fig 5 Distribution of parcels area deviation and parcel size.

From the statistical analysis, it is concluded that the accuracy of parcels representation depends upon the parcel size. The large parcels are represented more accurately than the smaller parcels.

As it is observed that the deviation of parcels area is decreasing with increase in size, as assessment is carried out to identify the category wise distribution of percentage of number of parcels in a given village and the percent of area occupied by respective categories. To arrive at the conclusion, the data is collected and compiled in the following Table 2.0.

Table 2 Category wise distribution of percentage of number of parcels

Category	Parcel Area(ha) Range	Number of Parcels	% of Parcels.	Area(ha)	% of area.
1	< 0.5	73	35.27	19.93	4.42
2	0.5 - 1.0	36	17.39	27.03	5.99
3	1.0 - 2.0	29	14.01	44.05	9.78
4	2.0 - 4.0	27	13.04	76.81	17.05
5	4.0 - 10.0	40	19.32	250.10	55.51
6	>10.0	2	0.97	32.65	7.25
		207	**100**	**450.57**	**100**

From the Tables 2.0, it is evident that around 36% of parcels are less than 0.5 ha and they are occupying an area of 5% of village area, 18% parcels are 0.5 - 1.0 ha and occupying 6% of village area, etc. Another important conclusion that can be drawn from these statistics is that, lesser area is subjected to higher deviations in area and vice versa.

2.6.2 Accuracy assessment of geo-referenced village (cadastral) maps

The transformation model of the geo-referencing process is presented in the following Table 3. The result of the location accuracy for a village is presented in Table 4. One of the observations from the transformation models is that the scale varies from 1.886 to 1.910 in both directions. This is made possible because of the grid approach used in generating the digital cadastral maps. This approach has helped in making the raw product geometry very close to the real world geometry. The results indicate that the image distortion due to registration is very less, signifying the fact that the geo-referencing is very stable.

Table 3 Transformation Model of Cadastral Map rectified using Google image

GCP ID	Ground Coordinate System (Satellite Image)		Raw Image Coordinates (Cadastral maps)		Residual		RMS Error
	X	Y	X	Y	X	Y	
1	96541.309	99957.438	3045.408	-1385.661	1.539	0.307	1.569
2	97455.095	99810.303	3928.577	-1487.174	0.775	-1.375	1.578
3	96089.579	98942.981	2593.673	-2367.805	-0.705	1.923	2.049
4	94989.939	100071.016	1541.000	-1343.023	-0.709	3.030	3.111
5	95942.444	99660.586	2458.063	-1696.000	-2.033	-1.779	2.702
6	95973.420	99952.275	2490.000	-1414.988	-3.580	0.946	3.702
7	94809.246	98628.060	1350.000	-2725.000	0.219	-0.288	0.362
8	96742.652	100801.528	3251.000	-578.000	2.262	-3.006	3.762
9	96205.738	99740.607	2719.000	-1607.571	2.938	-1.061	3.123
10	96995.621	100246.545	3485.898	-1090.000	-1.757	1.650	2.411
11	97000.784	100156.199	3490.651	-1175.000	-0.942	2.258	2.447
12	94897.011	99252.738	1444.000	-2129.774	1.994	-2.605	3.281
Scale (X, Y) = (1.886, 1.910); Translation = (96136.90317, 99768.35633)							
RMS Error (input, output) = (1.621, 1.682) = 2.508 m							

Table 4 Location (relative) accuracy of a geo-referenced village

SR.NO	Check points Coordinates on reference image		Check points Coordinates on geo-referenced vector file		Residual Error		Residual Distance
	X	Y	X	Y	X	Y	
1	96540.78	99957.72	96548.54	99961.61	-7.76	-3.88	8.68
2	96032.38	99610.66	96034.39	99622.68	-2.01	-12.02	12.19
3	97453.15	99820.70	97460.13	99824.25	-6.98	-3.55	7.83
4	95969.58	99955.22	95964.07	99955.22	5.51	0	5.51
5	94996.15	100071.04	95001.66	100076.55	-5.51	-5.51	7.79
6	96897.87	100046.22	96904.41	100060.01	-6.54	-13.79	15.26
7	96744.47	100341.28	96750.74	100355.83	-6.27	-14.55	15.84
MS Value (input, output) = (5.797, 7.614) = 10.443 m							

The major component of the geo-referencing process is the translation value. For geo-referencing of cadastral maps, the state level coordinate system is used and accordingly, the false origin coordinates are given very high value of 1lakh in both directions. The translation values indicatethe approximate location of the geo-referenced village in the state level coordinate system. The residual error, the difference between the users coordinates and the projected coordinates of the GCP's is at an average 1.621m (x-direction) and 1.682m (y-direction) for satellite data and the value is 2.508m which is less than 5m, indicates the rectification of the cadastral map is done accurately.

2.6.3 Accuracy assessment of geo-referenced village (cadastral) maps using GPS points

GPS data is used as control for rectification of reference image (satellite data) for geo-referencing of cadastral maps and for directly geo-referencing of the cadastral maps.The location accuracy of the geo-referencing of the cadastral maps using GPS is presents in Table 5.

Table 5Location accuracy of a geo-referenced village

SR.NO	GPS check points		Check points on geo-referenced image		Residual error		Residual distance
	X	Y	X	Y	X	Y	
1	96329.78	100049.63	96487.95	99966.00	158.17	-83.63	178.92
2	95783.58	99618.92	95958.62	99551.54	175.04	-67.38	187.56
3	95862.98	99051.06	96025.54	98980.57	162.56	-70.49	177.19
4	96574.21	100573.05	96730.33	100483.84	156.12	-89.21	179.81
5	95766.81	100046.68	95918.48	99957.47	151.67	-89.21	175.96
6	94584.72	100211.73	94736.38	100104.67	151.66	-107.06	185.64
7	96538.52	100416.93	96681.26	100327.71	142.74	-89.22	168.33
8	96743.71	100247.42	96859.69	100140.36	115.98	-107.06	157.84

From the Table 5, it is observed that the location accuracy derived using GPS points are in the range of 157.84 to 185.64 m. The value is very high because, the precision in GPS instrument is 20m. If DGPS has been used instead of GPS the accuracy may be more and geo-referencing the cadastral map is good.

2.6.4 Accuracy assessment of village area

The village area from revenue department is collected for the village. The corresponding areas of vectorised files and geo-referenced files for village area analysis are shown in Table 6.

Table.6. Village area analysis.

SI NO	Village	Revenue area (ha) (LRD)	Geo-referenced area (ha) (GIS)	Difference (ha) (GIS-LRD)	% Difference
1	Venkatapuram	472.5005	465.0356	7.4649	1.58

The results also show that the percentage difference of the total village area between the LRD and GIS maps is very small in the range of 1.58 %. At an average the percentage deviation is less than two percent. This smaller value indicates less distortion from pre to post geo-referencing, in the total area of the village.

III. CONCLUSIONS

Present paper discusses the updation of the geospatial information and quantification of the accuracy of the geo-referenced cadastral map of village using high resolution satellite imageries, GIS and GPS. The accuracy assessment of the vectorised cadastral map has been carried out. From the observation of mean percentage deviation, standard percentage deviation and parcel area deviation, it is seen that large area parcels have more accurate and less distortion than small area parcels. The methodology presented in this paper is useful to update the cadastral maps with low to medium accuracy. However, the high accurate cadastral maps can be prepared with high resolution satellite imageries obtained from professional organizations like National Remote Sensing Centre (NRSC) using Differential Global Positioning System (DGPS).

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