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Mouza map updating by high resolution satellite images and GIS

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Abstract: A mouza map is very important as it comprises the boundaries of all land parcels and contains methodically arranged information like the ownership, land use and area details. Currently, the maps are available mainly on hard copy with out-dated information. Therefore regular updation of the mouza map is of paramount importance. Present paper discusses the methodology of registering multiple mouza maps with the use of rectified GeoEye panchromatic imagery and mosaicing them. After mosaicing rectification has been carried and vectorised mouza map is prepared in the GIS environment. The features of mouza map are updated by superimposing the vectorised mouza map on the rectified imagery of the study area. From the observations, it is concluded that the methodology presented in this paper is useful to update the mouza maps with good accuracy to create a unique database for future use.

Keywords: Mouza map, GeoEye panchromatic imagery, GIS, EKW, GCP

1. Introduction

A cadastral map (herein mouza map based on revenue survey) shows the boundaries of all land parcels on large scale generally in 1m : 3.96 km or 16":1 mile. Mouza maps do not have any graticule information. These maps show only the survey numbers and relative location of all land parcels in a given village and attribute information such as ownership, landuse, size and value. This attribute information aids in revenue collection and also ensures the legal security of the property to its owners or legal heirs (Khular, 1985).

Mouza maps are indispensable tool for the administration, management and planning projects. In most cases, these maps have lost their relevance since the maps are not updated for a long time. At the national level the updation of mouza maps has been given due priority. The process of converting the mouza maps into digital format and updating them is a big challenge being faced because of temporal difference between mouza maps and high resolution satellite data. Updating the cadastral information is very essential so that transformations / changes of the ownership / division of properties, etc can be recorded in an orderly manner for documentation and further use (Corker, 1984). Mouza maps, when overlaid on high resolution satellite data, help in the monitoring of changes at plot level.

2. Objectives

The primary objective of this study is to take advantage of fine spatial resolution of GeoEye-1 PAN imagery and discriminate / delineate the land use information within each parcel as shown in the mouza map.

3. Study area

The East Kolkata Wetlands (EKW) adjoining the metropolitan city Kolkata, Bidhannagar and upcoming Rajarhat New Town spread over an area of 12,500 hectare and cover 30 full mouzas and 7 part mouzas in districts of 24 Parganas South and North.

EKW (East Kolkata Wetlands) has been declared as Ramsar Site (site no. 1208) under the Article 8 of the Ramsar Convention on August, 2002. This is the only one Ramsar Site of the State of West Bengal. After the declaration of EKW as a "wetlands of international importance", the West Bengal Legislature has passed the East Kolkata Wetlands (Conservation and Management) Act, 2006 for conservation and management of EKW and for matters connected therewith and incidental thereto. As per section 9 of the said Act, 2006 any action of any landholder that will reduce the area of the land, change its character, and convert it to any other use other than for which it was recorded is prohibited. The said Act, 2006 also prohibits the East Kolkata Wetlands Management Authority (EKWMA) constituted under section 3 to give permission to any kind of change of character or mode of use of land, which will degrade the local environment and its surroundings [Section 10(5)].

A cluster of three mouzas under Sonarpur police station in 24 Parganas South have been studied to overlay the respective mouza maps on GeoEye-1 PAN images on mouza scale i.e. 1:3960 scale. The approximate extents of the current study area is as follows

Upper Left : 88d 24' 03.65"E, 22d 29' 49.02"N
Lower Right : 88d 27' 13.28"E, 22d 26' 49.37"N

4. Material

The data used for the study include:
1. GeoEye-1 PAN image of 2011

The image has the following information:
Satellite : Earth observation satellite launched in September 2008
Sensor name : GeoEye-1

Image type : PAN
Processing level : Standard Geometrically Corrected
Projection : UTM
Datum : WGS84
Pixel size : 0.5 meters

2. Mouza maps on 1:3960 scale collected from Land and Land Reforms Department, Government of West Bengal
3. The ancillary cadastral information from Land and Land Reforms Department, Government of West Bengal

5. Methodology

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 mouza map, sufficient number of GCP's (Ground Control Point) 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 (Global Positioning System). The secondary sources consist of aerial images or high-resolution satellite images. Transformation models are used to transform coordinates from one system to another system (Murthy et al., 2003). In this case second source is adopted.

In geo-referencing, same points both on GeoEye-1 PAN satellite image and in mouza map are considered. As GeoEye-1 PAN satellite image is geometrically correct, the mouza maps are geo-referenced using that image. For this study, 2^{nd} order polynomial is considered. 30 to 35 GCPs are taken for geo-referencing a mouza map depending on its size and total RMS error is kept within 0.5 m i.e. within 1 pixel.

Initially, the mouza maps of the study area were scanned at 200 dpi. The next task involved the parcel matching of each mouza maps with respect to the high resolution ortho-rectified images (GeoEye-1 PAN). Thus each individual mouza sheet/map gets properly referenced and then cadastral rasters are mosaiced and converted to vector format by onscreen digitization as they are spatially contiguous.

The major problem encountered during the mosaic procedure is the "edge-matching" error which is obvious. Minor differences or mismatches between adjacent maps / sheets are resolved and created a seamless join by edge-matching. Edge-matching error gets accumulated to the adjacent plots of adjacent maps / sheets.

After drawing each and every parcel boundaries in polygon layer, it was overlaid on the satellite image.

Rao et al. (1996) used Survey of India topomap as a reference for co-registration among the cadastral, IRS-1C PAN and LISS-III data and the error for image to cadastral registration was of the order of less than a pixel in general. Kumar et al. (2013) have done geo-referencing of cadastral map using Google Earth image which was first georeferenced by topographic map. The residual error was at an average 1.621 m (x-direction) and 1.682 m (y-direction) for satellite data and the total RMS error was 2.508 m.

6. Results and discussions

6.1 Study area

Three spatially contiguous mouzas under Sonarpur police station in 24 Parganas South are selected as study area. These mouza maps were made in 1954-58 under the West Bengal Estate Acquisition Act, 1953 (Act 1 of 1954) on the basis of Revenue Survey (RS) made in 1926-29. The names of these mouzas are Atghara, Jurisdiction List Number (J.L. No.) 5, Ranabhutia, J.L. No. 6, and Kantipota, J.L. No. 7. These three mouzas consist of 3 mouza sheet. This list of mouza maps involved in these three mouzas of EKW area is shown in Table 1 and a part of mouza map of Atghara, J.L. No. 5, Ranabhutia, J.L. No. 6 and Kantipota, J.L. No. 7 are shown in Figure 1a, Figure 1b and Figure 1c respectively.

Table 1: Details of mouza maps used in the study

Sl. No.	Mouza name, J.L. No.	No. of maps /sheets	Total plots	Area (Acre)
1	Atghara, 5	1	176	197.38
2	Ranabhutia, 6	1	272	369.44
3	Kantipota, 7	1	344	296.29

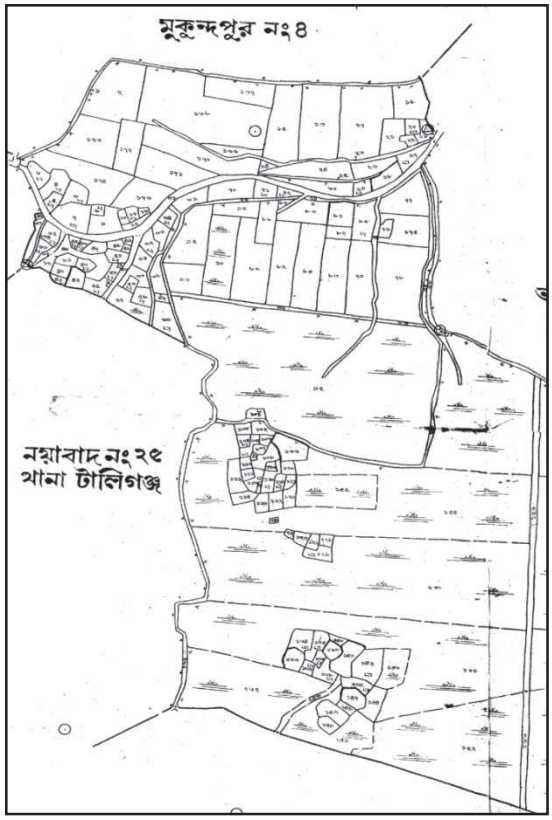

Figure 1a: Part of mouza Atghara, J.L. No. 5

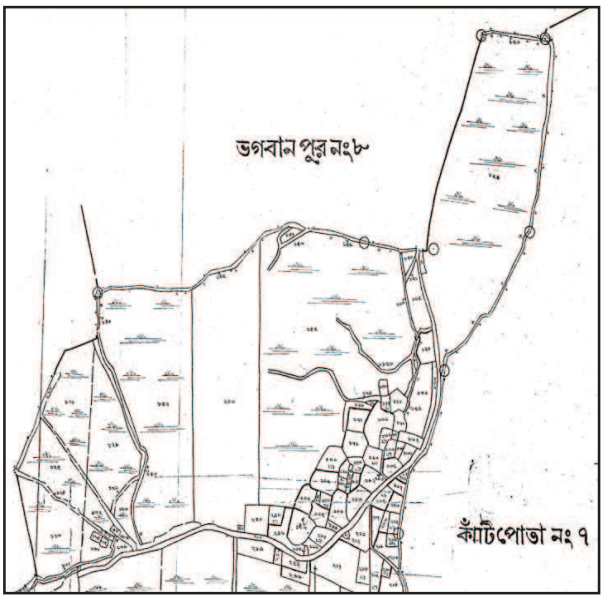

Figure 1b: Part of mouza Ranabhutia, J.L. No. 6

Figure 1c: Part of mouza Kantipota, J.L. No. 7

6.2 Accuracy assessment of geo-referenced mouza maps

For this study second order polynomial model and cubic convolution interpolation resampling mode were adopted. Based on the area and number of plots depicted on the RS mouza map, 30 GCPs were taken for mouza Atghara, J.L. No. 5 and mouza Kantipota, J.L. No. 7 and 35 GCPs were taken for mouza Ranabhutia, J.L. No. 6 for geo-referencing. By transformation matrix, reference GCP coordinates to coordinates for the same point in the input coordinate system are calculated. The corresponding reference GCPs are retransformed to the input coordinate system using the reference-to-input transformation matrix. The distance between the input GCP coordinates and those retransformed coordinates is the root mean square (RMS) error. Distances between the input and retransformed coordinates in one are called residuals. X residual is the distance between the source X coordinate and the retransformed X coordinate and Y residual is the distance between the source Y coordinate and the retransformed Y coordinate. From the residuals, the total RMS error, and the X RMS error and Y RMS error are calculated by using the following formula

$$R_x = \sqrt{\frac{1}{n}\sum_{i=1}^{n} XR_i^2}$$

$$R_y = \sqrt{\frac{1}{n}\sum_{i=1}^{n} YR_i^2}$$

$$T = \sqrt{R_x^2 + R_y^2} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} XR_i^2 + YR_i^2}$$

where:
R_x = X RMS error
R_y = Y RMS error
T= total RMS error
n = number of GCPs
i = GCP number
XR_i = the X Residual for GCP_i
YR_i = the Y Residual for GCP_i
The X RMS error, Y RMS error and total RMS error of three maps are shown in table 2.

Table 2: RMS errors in X and Y direction and total RMS error

Mouza name, J.L. No.	X RMS error (pixel)	Y RMS error (pixel)	Total RMS error (pixel)	Total RMS error (m)
Atghara, 5	0.46	0.38	0.60	0.30
Ranabhutia, 6	0.48	0.33	0.58	0.29
Kantipota, 7	0.36	0.41	0.55	0.28

The RMS error in X-direction ranges from 0.36 pixel to 0.48 pixel and in Y-direction ranges from 0.33 pixel to 0.41 pixel and the total value of total RMS error varies from 0.55 pixel to 0.60 pixel which is less than 0.5m, indicates that the RMS error in rectification of the mouza map is better than a pixel.

The results indicate that the image distortion due to registration is very less, signifying the fact that the geo-referencing is very stable. The transformation model of one of the geo-referencing processes is presented in the following Table 3.

Table 3: Transformation model of one of the geo-referencing processes

GCP ID	Ground Coordinate System (Satellite Image)		Raw Image Coordinates (Mouza Maps)		Residual (in pixel)		RMS Error (in pixel)
	X	Y	X	Y	X	Y	
1	646450.3999	2486884.474	3532.5000	2711.5000	0.87	0.41	0.96
2	645439.8367	2486333.794	0597.5000	4434.5000	0.02	0.07	0.08
3	647314.9375	2487562.063	6045.9646	0616.6165	0.48	-0.26	0.55
4	647049.8213	2486666.129	5313.5000	3308.5000	0.35	-0.02	0.35
5	646778.1250	2487167.625	4479.2500	1840.7500	-0.81	0.43	0.91
6	647112.6719	2486150.266	5531.3750	4838.1250	0.37	-0.50	0.62
7	646260.1364	2486676.286	2986.5000	3345.5000	0.05	-0.01	0.05
8	646861.0550	2486791.353	4749.5000	2951.5000	0.01	-0.00	0.01
9	645570.6250	2486542.125	963.25000	3807.7500	0.92	0.32	0.98
10	646250.1930	2486584.424	2965.5000	3618.5000	0.74	0.03	0.74
11	646142.7599	2486281.838	2674.5000	4523.5000	0.01	-0.06	0.06
12	646997.4375	2486829.188	5149.2500	2827.2500	0.51	-0.37	0.63
13	647239.7150	2486388.449	5887.5000	4121.5000	-0.35	0.75	0.83
14	646604.4754	2487091.837	3971.5000	2081.5000	-0.31	-0.01	0.31
15	645853.7406	2486385.354	1813.5000	4243.5000	-0.10	0.29	0.30
16	646533.3621	2486146.771	3833.5000	4891.5000	-0.18	-0.14	0.23
17	647107.9143	2486562.086	5490.5000	3613.5000	0.10	-0.10	0.14
18	647157.4648	2486441.276	5643.5000	3969.5000	0.09	0.05	0.10
19	646502.5374	2486973.364	3678.5000	2442.5000	-0.52	-0.11	0.53
20	646283.0625	2486386.063	3078.6250	4203.1250	0.33	0.10	0.34
21	646834.4161	2486174.261	4714.5000	4787.5000	0.11	0.27	0.30
22	646960.8100	2486390.207	5069.7500	4136.2500	-0.04	0.18	0.19
23	647205.8750	2486932.375	5755.7500	2503.7500	-0.64	0.43	0.77
24	645719.3259	2486355.418	1419.5000	4343.5000	-0.60	-0.55	0.82
25	646293.9691	2486627.606	3090.5000	3486.5000	0.24	-0.15	0.28
26	645749.1546	2486825.727	1462.5000	2952.5000	-0.44	-0.01	0.44
27	645752.7031	2486673.766	1487.5000	3400.5000	-0.28	-0.46	0.54
28	646196.2032	2486040.481	2852.5000	5233.5000	-0.76	0.29	0.82
29	645518.3534	2486169.762	0846.5000	4910.5000	-0.01	0.11	0.11
30	646639.5097	2486171.943	4143.5000	4808.5000	0.42	-0.28	0.50
31	646693.0910	2486765.187	4256.5000	3043.5000	0.11	-0.04	0.12
32	647098.3750	2486758.875	5449.5000	3028.5000	-0.69	-0.14	0.70
33	647142.2579	2486717.203	5581.5000	3148.5000	-0.28	-0.71	0.76
34	647210.2756	2487225.261	5753.5000	1630.5000	0.28	0.20	0.35
35	647435.4504	2487550.523	6402.5000	0640.5000	0.01	-0.01	0.01

6.3 Vectorisation of mouza maps

After geo-referencing of mouza maps cadastral rasters were mosaiced and converted to vector format by onscreen digitization. The vectorisation of mouza maps involved drawing of each and every parcel boundary in polygon layer and attribute updation. When the vector layer was not exactly matched with the parcel boundaries in the satellite data, the spatial adjustment concept was used. The accuracy of digital conversion is assessed through one-to-one matching of the vectorised mouza maps with the original analog map, attribute data assessment, assessment of parcels area in vectorised map with respect to the area of parcels mentioned in revenue records. The digital vector layer overlaid on Geo-Eye-1 PAN images is shown in Figure 2.

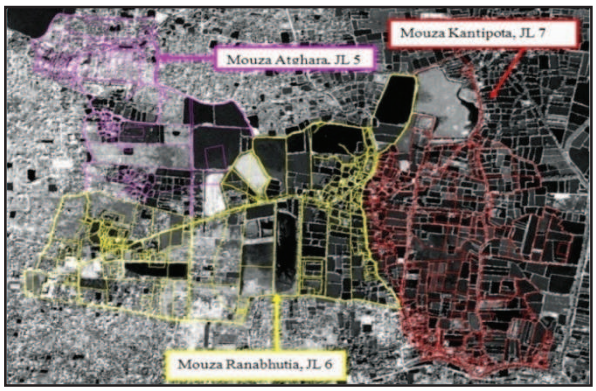

Figure 2: Vector layer overlaid on GeoEye-1 PAN images

7. Conclusions

Present study introduces the use of GeoEye panchromatic imagery to develop a method for overlaying vectorized mouza maps on rectified high resolution remotely sensed imageries and suggests that mouza maps can be updated with good accuracy. Further, it reveals that the cadastral information in the form of maps and records can be updated in vectorized map with medium to high accuracy.

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