Chapter One

Introduction

1.1 General Review

Consideration of land value and terrain should continue to play a role in the development and application of any new cadastral survey standards.

The fields of land surveying and mapping have benefited from technology innovations.

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. We use geographic information system (GIS) technology to research, develop, implement, and adjustment of their maps. GIS provides planners, surveyors, and engineers with the tools they need to design and map their neighborhoods and cities.

1.2 Problem Statment

The process of demarcation of parcel's boundaries depends on traditional method. Parcels are demarcated by ground marks had been previously monumented on the ground such as: constructed concrete control points, block corners stones and parcels' corners wooden pegs.

Torrens system is a fixed boundaries cadastral system which needs a precise demarcation of boundaries. Many problems of boundaries in residential areas had been accounted such as: removal, displacement, buried underground and difficulty of demarcation or identification.

The fields of land surveying and mapping have benefited from technology innovations in personal computer, total station instruments, and global positioning system (GPS) equipment, to name just a few. New tools for rapid acquisition of measured data are continually being developed and refined, and the Internet has provided the means to share such data with people worldwide.

We have turned to technology, specifically Geographic Information Systems (GIS), as an aid to make complex management decisions about lands and for saved and generalized data. For mapping and GIS purposes the primary concern may be the positional accuracy of the corner locations.

1.3 Research Objectives

The objective of this study is to evaluate the positioning accuracy of the cadastral maps.

1.4 Previous Studies

Barnes Grenville, Chaplin Bruce, Moyer D. David they said in our paper Accurate coordinates of corner's parcel ,Clear marking of parcel boundaries helps assure that owners and their neighbors have common understanding of GPS would be used to provide control for surveying specific parcel details that are required to be mapped. It has location of each land parcel. (Barnes Grenville, Chaplin Bruce, Moyer D. David, 1998)

Damon Anderson, Mitch Blank, Diann Danielsen, Todd Halvorson, Scott Hameister, Steven Jarocki, Ted Koch, Chair, Janet Krucky, David Levine, Rick Pauls, Marty Pingel, Louis Rada, Karen Sylvester, Thomas Tym, Ruekert & Mielke, Inc.Gus VanderWegen, Strand Associates, Paul Vastag, Peggy Wilson, JE & Associates they said in our paper For cadastral parcel maps the position of the parcel corners will be determined from coordinate geometry based on parcel descriptions, or from field survey procedures. All cadastral parcel maps will report the document source for the parcel descriptions.

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 Georeferencing 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(V. V.Govind Kumar, K. Venkata Reddy, Deva Pratap April 2013).

1.5 Thesis layout

This research work contains of six chapters. Chapter One introduces the researech problem and objectives. Chapter Two reviews Geographic Information Systems. Chapter Three explains the Cadastral Mapping System. Chapter Four illustrateS the methodology used to resolve the researech problem. Chapter Five summaries results, analysis, conclusion and recommendations.

Chapter Two

Geographic Information Systems

2.1 Introduction

Geographic information systems are an important product of the revolution of information technology. Which allow us to use and analyze spatial information in conjunction with connected socio-economic information, and therefore it's an ideal basis for the planning and management. There are many definitions for GIS depending on its components and functions. The U.S Federal Interagency Coordinating Committee (1988) definition stated that a GIS is a system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modularity and display of spatially referenced data for solving complex planning and management problems. (Shoba and Ra sappan, 2013) also describe GIS as: A computer tool for capturing, storing, querying, analyzing and displaying spatial data from the real world for a particular set of purposes. GIS has capability of efficient storage, retrieval, integration, manipulation, updating and changing, managing and exchanging, combining, analyzing, and presenting of geographical and non-geographical information. GIS technology can be used for scientific investigations, resources management, asset management, environmental impact assessment, urban planning, cartography, criminology, history, sales, marketing, and logistics, etc. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations.

2.2 Components of GIS

Actually GIS is quoting its power and comprehensiveness from its strong components, mainly it's have five components, which are: hardware, software, data, people, and procedures.

2.2.1 Hardware

GIS needs many types of hardware to satisfy some of its main functions such as data collection, storage, manipulation, and presentation. The heart of GIS is the computer which can be a personal computer (PC) or a workstation depending on the volume of the GIS projects and the organization. Input units mainly the keyboard and the mouse, the output units such as the monitor. Many types of devices are attached to the computer as input devices such as scanners, cameras, digitizers, and many others. Also printers and plotters of different sizes are attached to the computer as output devices. Networks hardwares, such as modems, cables, hubs, bridges and other networks devices, are utilized in GIS to share data, software, and hardware.

2.2.2 Software

Several comprehensive software systems are developed and fully support GIS applications. GIS has benefited greatly from the rapid, continuous development in the software systems, Many organizations and companies concerned with GIS had developed softwares to satisfy different functions of GIS such as those developed by The Environmental Systems Research Institute (ESRI): Arcview, Arcinfo and ArcGis. ArcGis is composed of many modules such as ArcMap, ArcCatalogue, ArcToolbox, ArcReader, ArcGlobe, and ArcScene. These modules are functioning in a integrating manner for capturing, managing, manipulating, displaying, and analyzing spatial data. There are many other GIS softwares such as IDRISI which had been developed by the Graduate School of Geography at Clark University, Geographic Resources Analysis Support System (GRASS) which had been developed by U.S Army Construction Engineering Research Laboratories (USACERL). Also Intergraph's Modular GIS Environment (MGE) and many other systems.

2.2.3 Data

The efficiency of any GIS scheme depends on the quantity and the quality of data. The expected results of analysis are affected directly by the availability, accessibility, reliability, validity, integrity, and completeness of data. Data must be classified in several classes and all data of a particular level of classification, such as roads or vegetation type are grouped into layers or coverages. Layers can be combined to each other in various ways to create new layers that are a function of individual ones.Data collection and processing is the most expensive part of GIS. There are two main types of GIS data: spatial or geographical data and non-spatial data or attributes.

2.2.3.1 Geospatial Data

Spatial data describes the absolute or relative location of geographic features, it is the graphical representation of the geographic locations in a digital form, and it can be classified into two basic data models: raster data model and vector data model. Raster data model, known also as a grid model is: a mathematical model. it is a set of grid of uniform, regular cells. The cell is called pixel which refers to a picture element usually it is rectangular or square but it may be triangular or hexagonal. The main sources of raster data models are satellite imageries, aerial photographs and digital image scan of existed maps. Vector data model is: representation of the geographical phenomena in terms of the spatial components, consisting of points, lines, areas, surfaces and volumes and each layer in the vector data model must be composed of only one component. The point is an object of zero dimensions called node or vertex. Line is the link between two points which has one dimension called link or arc, while area has two dimensions and composed of at least two arcs called polygon or face. The geometrical relationships and connections between objects are controlled by Topology independent of their coordinates. Topology model is based on mathematical graph theory that deals with the geometrical properties and employs nodes and links.

2.2.3.2 Attributes

Attributes are non-graphic data that describe properties of the geographic features or elements represented on the map. Attributes are stored in a table in a manner that each record or row in the table corresponds to geographic object on the map, whereas each property is stored in a column or a field. Each object must have an identity (ID) or access key. The number of columns representing the properties is not limited, but is optionally selected due to the available attributes. The number of columns may be extended by joining several tables automatically using a common field. The first line or row in the attributes table contains the name of the field which must not exceed ten characters, the data of each field must be of the same type of characters and the type can be short integer, long integer, float, double, text and date.

2.2.4 Users

Different levels of people from different disciplines are involved to establish GIS project or organization. People involved in GIS team depend on the capacity of the organization and the nature of the GIS project, GIS team may include GIS experts, who advise and solve problems for end users, cartographers, system analysts, computer specialists and people specialized in the field of the project in question e.g. geologists, agriculturists, engineers. GIS team also include end users, who seek problem solutions and see final products only in the form of maps and reports, GIS operators of low level of experience who understand the functions of specific system so as to manipulate data and data compilers, who understand the data but not the system.

2.2.5 Procedures

Procedures include how the data will be retrieved, input into the system, stored, managed, transformed, analyzed, and finally presented in a final output. The procedures are the step taken to answer the question needs to be resolved. The ability of a GIS to perform spatial analysis and answer these questions is what differentiates this type of system from any other information systems. The transformation processes includes such tasks as adjusting the coordinate system, setting a projection, correcting any digitized errors in a data set, and converting data from vector to raster or raster to vector.

2.3 Functionality of GIS

Most GIS packages provide functions and tools to enable the execution of different operations necessary for GIS project.

2.3.1 Data Acquisition

All data that needed for GIS project must be transferred from their original source form to the digital form to satisfy the basic requirements of GIS. Data can be obtained from primary data acquisition techniques such as direct ground survey techniques, whetherin a digital form or in a hard copy form. Data in hard copy maps which are secondary data acquisition sources are transformed to the digital form by digitization or scanning and the resulting format depends on the employed technique. Satellite imageries and aerial photographs are important source of spatial data which can be obtained directly in digital form or scanned from hard copies. Aerial photographs provide spatial data of high accuracy which is suitable for creation and updating of large scale topographic maps while the accuracy of the spatial data obtained from remote sensing depend on the ground resolution. Data acquisition is a critical, time consuming and expensive stage in many geographical information tasks.

2.3.2 Preliminary Data Processing

Preliminary data processing includes creating topologically structured data, classification of remotely sensed data, change of structure of data, coordinate systems and map projections transformation and conversion from raster to vector or vice versa according to the type of analysis tools. The required conversion to a raster data model from a vector data model can be done straight forward by rasterization algorithms while vectorization of raster data is more complicated. Data of unknown coordinate system can be forced by rubber sheet transformation to fit into known coordinate system data of the same location. Data processing involves the creation of surface models by interpolation techniques to generate contour maps, triangular irregular network (TIN) or any other relief representation method. Acquiring data from different sources may cause the problem of using two or more classification or coding referring to the same phenomenon, re-coding must be applied to solve this problem by reclassification to combine several classes to form a generalized less-detailed class.

2.3.3 Data Storage and Retrieval

The manner by which the data is stored depends on the data model. The storage of vector data model consist of the spatial data or the map and the attributes tables, where every record in the attributes table corresponds to a spatial object or a feature in the map and the fields of the table are the attributes of these spatial objects. Each spatial object must have a unique identifier or access key to link the spatial object to its attributes in the table.

The raster data is saved in the computer memory in the form of two dimensional arrays, the coordinates of grid cells, or pixels, are implicit within the row and column ordering of the matrix. The property of this type of storage from a retrieval point of view, that each element can be referred to or addressed directly in terms of the row number and the column number.

2.3.4 Spatial Search and Analysis

The objective of any GIS project is to use the stored data to make decisions and to solve problems in a particular application. GIS has utilizes of many functions to carry out searches and analysis to satisfy these objectives.

2.3.4.1 Containment Search within a Spatial Region

This is a straight forward spatial analysis to find features or part of features that lie within a given region of space. A rectangular window can be defined to find spatial objects that lie within it.

2.3.4.2 Proximal Search

There are many types of proximal search. One of them may be regarded as an extension of the spatial containment search, where a zone of specified distance from a particular object is defined. This object can be point, line or area and this zone is called buffer in the case of vector model and spread in raster based systems.

2.3.4.3 Phenomenon Based Search and Overlay Processing

This type of search may be based on a single phenomenon irrespective of other phenomena or a search for regions that are defined by combinations of phenomena.

2.3.4.4 Interpolation and Surface Modeling

Interpolation functions are performed in sample points taken in a regular distance interval forming a regular grid, the values of the known sample points are used to estimate the unknown values by analysis of the correlation function between the sample values and the distance.

2.3.4.5 Best Path Analysis and Routing

Network data models or raster data models are used to find the best route in terms of cost, length or other criteria. Network data models are used to select a path from already existed paths such as roads and rivers while raster data models are used when the problem is to find a path across terrain that may not have any predefined path.

2.3.4.6 Spatial Interaction Modeling

Spatial interaction modeling is used for identifying optimal locations of facilities that satisfy particular requirements or criterion.

2.3.4.7 Correlations, Associations, Patterns and Trends

GIS analysis is useful to integrate information within spatial region to search for links between events. This type of analysis can be applied to find factors that cause a certain phenomena for example to find correlation between environmental factors and diseases.

2.3.4.8 Map Algebra with Gridded Data

GIS analysis is useful to integrate information within spatial region to search for links between events. This type of analysis can be applied to find factors that cause a certain phenomena for example to find correlation between environmental factors and diseases.

2.3.5 Graphical Display and Interaction

GIS has the capability to represent the results of analysis and queries on maps, for example by choosing each country which its area is less than one million squared kilometers and its population is more than 100 million from the layer of world countries. Many cartographic facilities are available to modify map features and change the graphical variables of map symbols and text such as color, shape, size, patterns, orientation, font size and orientation of text. Many GIS packages also include facilities for changing datums and map projections for example by changing the datum of a particular layer by using define projection in the data management tools of Arc Toolbox. Animation facilities also are provided by some GIS packages for the presentation of maps to show changes over time. An important facility for some GIS applications is the capacity to view three dimensional (3D) scenes from different viewpoints in order to evaluate aspects of the landscape with regard to their appearance and their visibility from different locations.

2.4 Spatial Analysis

The strongest capability of GIS which differentiate it from other spatial technologies is the advanced spatial analysis. Spatial analysis is a general term to encompass the manipulation of spatial data to examine the location, attributes, and relationships of geographic features to gain information. the purpose of geographic inquiry is to examine relationships between geographic features collectively and to use the relationships to describe the real-world phenomena that map features represent." (Clarke, 2001).There is three types of spatial relations: Proximity, Directional and Topological. Also, there are three Fundamental Questions Regarding Spatial Relationships; how can two (or more) spatial distributions be compared with each other? How can variations in geographic properties over a single area or data set be described and/or analyzed? How can we use what we have learned from an analysis(es) to predict future spatial distributions? Spatial Analysis can cover the spectrum implied by these questions.

For mapping and GIS purposes the primary concern may be the positional accuracy of the corner locations.

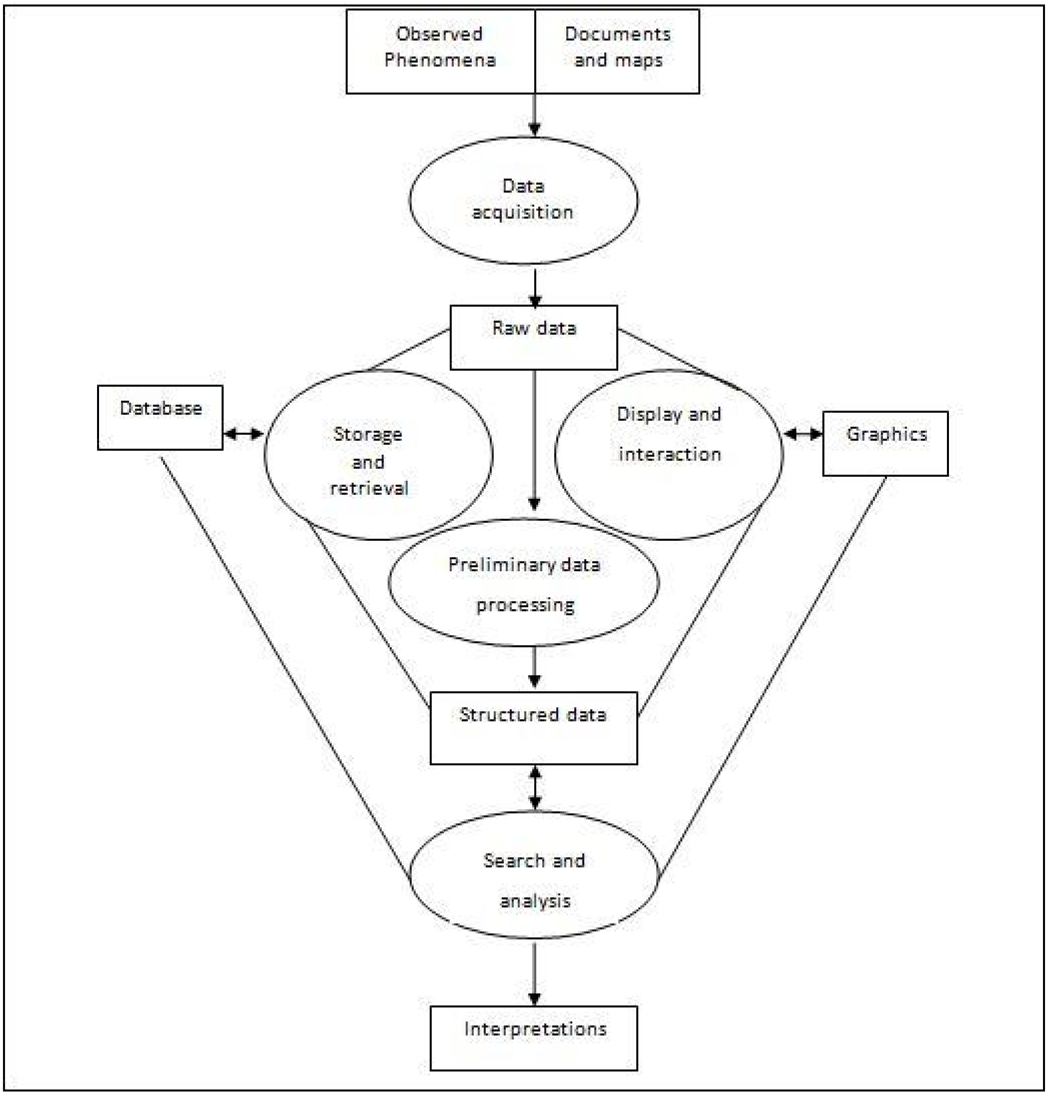

Figure 2.1: Relationship between GIS functions

(Christopher B. Johns 1988)

2.5 Working with CAD Data

GIS workflows often rely on CAD datasets generated by outside survey, engineering, and architectural sources. Integrating this data with your GIS can be a critical step in streamlining design processes and using your GIS as a central repository for spatial data. Choosing how to integrate CAD data depends on your specific requirements. You can perform a variety of common tasks out of the box or adapt them to complement existing workflows.

Examples of how you can use CAD data in ArcGIS for Desktop include the following:

1. Apply a unique symbol to CAD point features.
2. Use CAD features with proximity tools such as the Buffer tool.
3. Isolate CAD polylines on different drawing layers such as Roads and Railways and use them as input to the Intersect tool to create points for additional analyses.
4. Load CAD parcel geometry into a geodatabase and create a topology.

Whether your goal is to load CAD data into a geodatabase or to simply overlay it with existing spatial data, all CAD integration workflows start with a common task sequence: define a spatial reference, add the data to the map.

Geoprocessing tools and data loaders can be chosen to load CAD data into a geodatabase.

In ArcGIS for Desktop never working directly with actual CAD data. Had been translated from data in the source file. As a result, modify and clean up the data before loading it into your production geodatabase.

2.6 Spatial Adjustment

GIS data often comes from many sources. Inconsistencies between data sources sometimes require you to perform additional work to integrate a new dataset with the rest of your data. Some data is geometrically distorted or rotated with respect to your base data.

Within the editing environment, the spatial adjustment tools provide interactive methods to align and integrate your data. Spatial adjustment supports a variety of adjustment methods and will adjust all editable data sources. It's often used when you've imported data from another source, such as a CAD drawing. Some of the tasks you can perform include converting data from one coordinate system to another, correcting geometric distortions, aligning features along the edge of one layer to features of an adjoining layer, and copying attributes between layers. Since spatial adjustment operates within an edit session, you can use existing editing functionality, such as snapping, to enhance your adjustments.

Spatial Adjustment Can be defined as the process of transforming the unadjusted map into another (map coordinate system) using method such as affine, similarity, rubber sheet ….For Spatial Adjustment the cadastral map, sufficient number of Ground Control Points (GCP’s)with real world coordinates is required.

Transformations move or shift data within a coordinate system .They are often used to convert data from unknown digitizer or scanner units to real-world coordinates. Transformations can also be used to convert units within a coordinate system, such as converting feet to meters. To convert data between coordinate systems, such as geographic to projection, you should project the data instead.

The transformation functions are based on the comparison of the coordinates of source and destination points, also called control points, in special graphic elements called displacement links. For transformations, the from and to locations of links are used to construct the transformation formulae. You can create these links interactively, pointing at known source and destination locations, or by loading a link text file or control points file.

2.5.1 Similarity Transformation

The similarity transformation scales, rotates, and translates the data. It will not independently scale the axes, nor will it introduce any skew. It maintains the aspect ratio of the features transformed, which is important if you want to maintain the relative shape of features. The similarity transform function is

$$x' = Ax + By + Cy' = -Bx + Ay + F \longrightarrow (2.1)$$

Where

$A = s * \cos t$

$B = s * \sin t$

C = translation in x direction

F = translation in y direction

s = scale change (same in x and y directions)

t = rotation angle, measured counterclockwise from the x-axis

A similarity transformation requires a minimum of two displacement links. However, three or more links are needed to produce a root mean square (RMS) error.

After chosen which data to adjust, selected an adjustment method, set the adjustment properties, created links, and previewed the result, perform the adjustment. Clicking the Adjust command executes the spatial adjustment. Displacement links are removed from the document. An adjustment can be undo to return to the original state if the results are not what you intended. And save links to a text file through the link table.

Having more points and evenness in distribution, its Spatial Adjustment is precise than the previous having little points. 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 neighbor and 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.

Chapter Three

The Cadastral Mapping

Cadastral Is a parcel based, and up-to-date land information system containing a record of properties in land (Raghavendran, 2002).

Cadastral is an official register of the quantity, value, and ownership of real estate; used in determining property value. (Florida Department of Revenue Property Tax Administration Mapping & GIS Section,1988).

Cadastral is a record of interests in land, encompassing both the nature and extent of these interests (McLaughlin 1975, p. 60).

Cadastral is an information system, based on parcels containing information about the ownership, use, and value of these parcels (McLaughlin 1975, p. 60).

Cadastral is a fundamental source of data in disputes and lawsuits between landowners.

3.1 Cadastral Map

A map showing the boundaries of subdivisions of land for the purposes of describing and recording ownership to be used in determining property value(V. V.Govind Kumar, K. Venkata Reddy, Deva Pratap April 2013).

It commonly includes details of the ownership, the tenure, the precise location (some include GPS coordinates), the dimensions (and area), the cultivations if rural, and the value of individual parcels of land.

It shows the boundaries of all land parcels on large scale maps together with the village registers which contains the ownership, land use and area details.

Or shows the relative location of all parcels in a given village or district. They are commonly range from scales of 1:500 to 1:5000.

Cadastral maps are indispensable tool for the administration in dealing with day to day revenue and development activities in the district.

3.2 Parcel System

Parcel is a single discrete piece of land having defined physical boundaries and capable of being separately conveyed (V. V.Govind Kumar, K. Venkata Reddy, Deva Pratap April 2013) (Figure 3.1).

Figure 3.1: Parcel

In most countries, legal systems have developed around the original administrative systems and use the cadastral to define the dimensions and location of land parcels described in legal documentation.

Cadastral surveys document the boundaries of land ownership, by the production of documents, diagrams, sketches, plans (plats in USA), charts, and maps. They were originally used to ensure reliable facts for land valuation and taxation. An example from early England is the Domesday Book in 1086. Napoleon established a comprehensive cadastral system for France that is regarded as the forerunner of most modern versions.

3.3 Boundary (Real Estate)

A unit of real estate or immovable property is limited by a legal boundary. The boundary (in Latin: limes) may appear as a discontinuation in the terrain: a ditch, a bank, a hedge, a wall, or similar, but essentially, a legal boundary is a conceptual entity, a social construct, adjunct to the likewise abstract entity of property rights.

A Private property line plaque separating the private property and the public right of way on a sidewalk in New York City. It declares that the public may utilize the space inside the private property by a revocable license, to prevent it to become a prescriptive easement.

Property line describes the legal boundary of a parcel of land. The boundary is established by a professional surveyor using a transit and or modern Global Positioning System (GPS) technology. The coordinates of the property line are often described on a drawing called a "plot plan" or "plat" by indicating the length of the boundary along a specific compass bearing in relation to a verifiable "point of beginning". The metes and bounds method is also used to provide a legal description of a property.

3.3.1 Type of Boundary

One significant advantage of a general (versus fixed) boundary system is that a physical boundary (hedge, fence, canal, etc.) is usually easier to locate than a boundary marker (fixed) planted at the parcel corners.

As time has passed, populations have increased in size, societies have become more complex, and the value of land and the need to manage it wisely have increased. These changes have increased the need for information about land, and consequently the value of land information.

During the last 20 to 30 years, there has also been an explosion in technology that can serve as the basis for meeting the increased need for land information. These technology changes have included computers (ranging from personal computers (to large mainframe machines), digital Mapping, orthophotography, and high quality, automated cartographic product production processes.

3.4 Torrens Title

Is a system of land title in which a register of land holdings maintained by the state guarantees an indefeasible title to those included in the register. Land ownership is transferred through registration of title instead of using deeds. Its main purpose is to simplify land transactions and to certify to the ownership of an absolute title to realty. It has become pervasive around the countries strongly influenced by Britain, especially those in the Commonwealth of Nations.

It was enacted on 7 July 2004. The proposed TRS will transform the present system of deeds registration into a system of title registration. Under the proposed system, once a person is registered in the title register as the owner, he is recognized as the true owner. Title registration system has been operating in other overseas common law jurisdictions like Australia, New

Zealand, England, Canada and Singapore, and is generally recognized to be the most efficient and secure system for registration of ownership of land.

The Torrens system works on three principles:

1. Mirror principle – the register (Certificate of Title) reflects (mirrors) accurately and completely the current facts about a person's title. This means that, if a person sells an estate, the new title has to be identical to the old one in terms of description of lands, except for the owner's name.
2. Curtain principle – one does not need to go behind the Certificate of Title as it contains all the information about the title. This means that ownership need not be proved by long complicated documents that are kept by the owner, as in the Private Conveyancing system. All of the necessary information regarding ownership is on the Certificate of Title.
3. Indemnity principle – provides for compensation of loss if there are errors made by the Registrar of Titles.

Australian colonies introduced the Torrens system between 1857 and 1875. The Torrens title system was introduced first in South Australia by Sir Robert Richard Torrens, the Registrar-General of Deeds through the Real Property Act 1858.[10] Later in Victoria under the Real Property Act of 1862, and in New South Wales on 1 January 1863, with the commencement of that colony's own Real Property Act of 1862.

3.5 The Relation between Cadastre and GIS

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.

Presently, the cadastral maps are being updated with high resolution remotely sensed imageries using Geographical Information Systems (GIS) and Global Positioning System (GPS).

Based on the above research studies an attempt has been made to create,

Vectored cadastral map is prepared in the GIS environment of the study area and registered and the layer of Ground Control Points (GCPs) collected from GPS instrument. The features of cadastral map are adjusted by layer of Ground Control Points. The accuracy assessment of the vectored cadastral map has been carried out.

The cadastral maps have to be exported to convert to vector format in ArcGIS 10.0 environment. Vector cadastral maps have to be combined with attribute data calculate coordinates (E, N).Ground control points have to be collected using GPS instrument and add to ArcGIS. Cadastral map has to be adjusted by Ground control points. Then accuracy assessment of the vectored cadastral map has been carried out.

For Spatial Adjustment the cadastral map, sufficient number of GCP's with real world coordinates is required .Which uses geodetic coordinate system based on WGS 84 Ellipsoid.

The GCP's are identified on the cadastral maps and corresponding geodetic coordinates are derived using the GPS observation for generating a transformation model. As a matter of correct spatial adjustment more points and evenness in distribution over the area is considered.

3.6 Accuracy Assessment of Adjusting of Cadastral Maps

The accuracy of any map may be tested by comparing the position of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.

The Accuracy assessment is carried out for the task of vectorisation and Adjustment of cadastral map.

Chapter Four

Methodology

4.1 Study area

Block78_ Althora _ Karari Discrete _ Khartoum State_ Sudan was selected as a study area for this research (Figure 4.1). The area lies between longitudes 32° 29′ 38′′E and 32° 29′ 55.43 ′′ E and latitudes 15° 44 ′ 13.33 ′′ N and 15° 43 ′ 39.23 ′′N. It is a flat area and contains a few buildings only.

Figure 4.1: The Location Map of the Study Area

Figure 4.2: Study Area

4.2 Test Data

Vector data drawn by AutoCAD (Cartesian coordinate system). Easting and Northing ground control and check points observed by GPS based on UTM Projection and WGS1984 Datum, Reference Control Point is a concrete control point and placed at Sudanese Survey Authority by Sudanese National Survey Corporation.

4.3 Hardware and Software

Two Trimble 5800 GPS (reference and rover).

4.3.1 ArcGIS

In January 1997, Esri decided to revamp its GIS software platform, creating single integrated software architecture. ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used to spatial adjustment and design attribute data which is ready to use for storage, analyses and editing at any time.

4.3.2 Computer-Aided Design (CAD)

A computer software system designed mainly for drawing, drafting, and related graphic processing. CAD has limited capabilities for handling tabular data linked to map features or for complex geographic analysis, and it cannot support topologic analysis. It has been worked with Cartesian coordinate system. [6]

4.4 Procedures

The test consists of three phases (Figure 4.3). In phase one the coordinates of the control and check points have been driven from the cadastral map. Phase two is concerning with the field work carried out to observe the coordinates of the same set of points. Phase three is the cove phase where residual values in easting, northing and residual have been computed and evaluated.

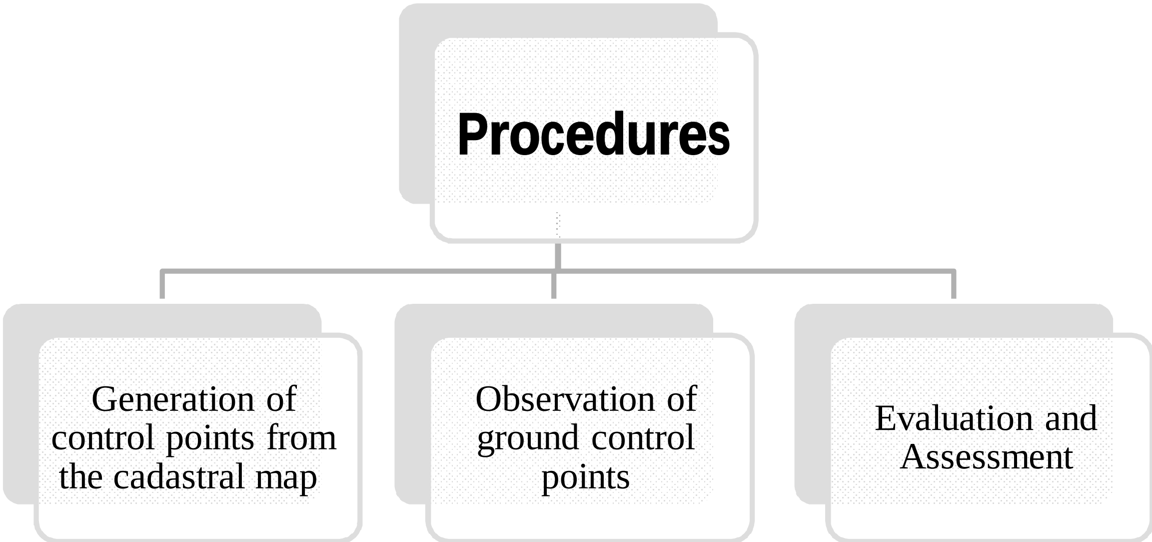

Figure 4.3: Three phases

4.4.1 Generation of Control points From the Cadastral Map

Vector data drawn by AutoCAD had been exported to Arc GIS environment. File Geodatabase had been contains all the feature classes of layers (vertices points) which have been exported**.**

4.4.2 Observation of ground control points

The reference GPS had been set at the control point. The four corners of the block 78 had been observed by rover plus ten additional points for check inside the block to be used to calculate the accuracy of coordinate of digital map after transformation of map coordinates to the ground control points by spatial adjustment tool. It had been utilized for transformation of coordinates using projection method, similarity and link file.

The link had been form from the coordinates of corners of parcels from digital map, the coordinates of the same corners which had been observed by Global Positioning system (GPS) from field and the residual error.

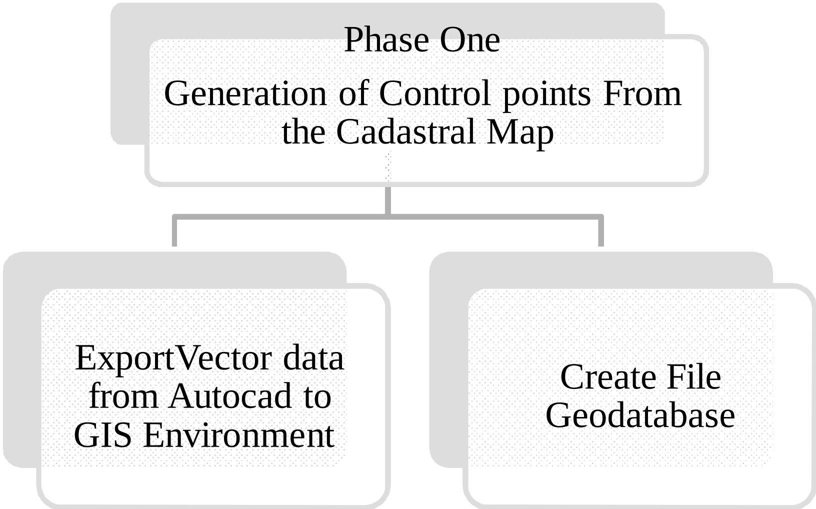

Figure 4.4: phase One(Generation of Control points From the Cadastral Map)

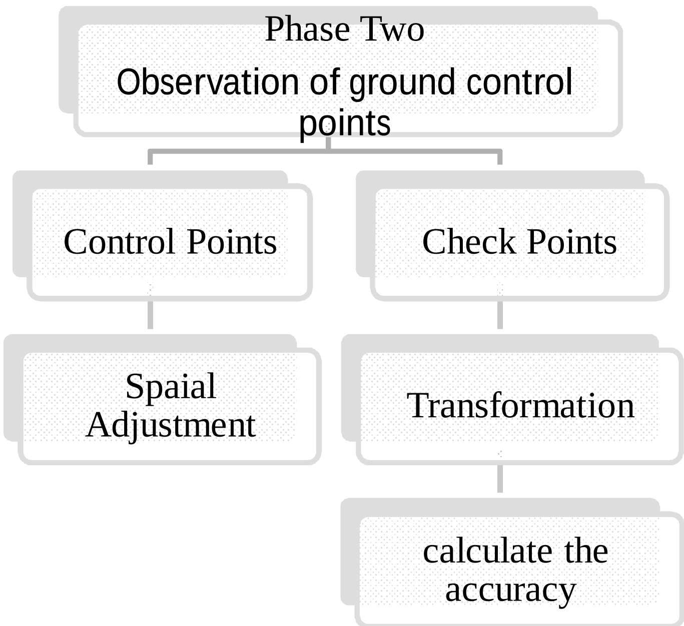

Figure 4.5: phase Two(Observation of ground control points)

4.4.3 Evaluation and Assessment

The accuracy of cadastral map may be tested by comparing the position of points with corresponding positions as determined by surveys of higher accuracy.

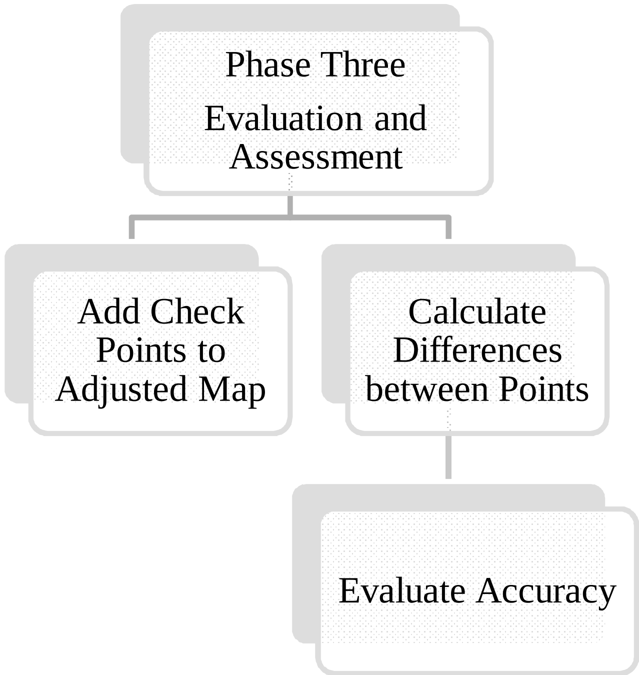

Figure 4.6: phase Three (Evaluation and Assessment)

Chapter Five

Results and Conclusion

5.1 Results and Analysis

Tables of ground control points which have been observed by GPS, as have shown in table (5.1) and (5.2).

Table 5.1: Coordinates of Control Points (corners of the block)

Point	Parcel no	corner	E(m)	N(m)
1	12	NW	446625.689332	1739636.40026
2	1	NE	446303.35036	1739770.91944
3	414	SE	446284.096138	1738787.92962
4	395	SW	445997.259523	445997.259523

Table 5.2: coordinates of check points

point	Parcel no	corner	E(m)	N(m)
1	29	NE	446411.8779	1739652.7153
2	37	SE	446580.6771	1739524.8042
3	67	SW	446313.3624	1739563.633
4	87	NE	446425.4723	1739504.4686
5	181	NW	446159.2807	1739396.9422
6	193	NE	446476.5817	1739266.199
7	245	NE	446216.7832	1739230.6081
8	282	NE	446254.0829	1739143.9158
9	357	SE	446154.4791	1738983.9683
10	375	NE	446266.1661	1738924.9907

Coordinates of ten check points had been calculated and edited in the attribute table of the transformed vertices layer as shown in table (5.3).

Table 5.3: Observed and calculated coordinates of the check points

Point	parcel no	E observed (m)	N observed (m)	E converted map(m)	N converted map(m)
1	29	446412.0358	1739652.749	446411.8779	1739652.715
2	67	446313.5004	1739563.513	446313.3624	1739563.633
3	87	446425.6387	1739504.321	446425.4723	1739504.469
4	37	446580.6137	1739524.506	446580.6771	1739524.804
5	193	446476.3482	1739266.195	446476.5817	1739266.199
6	181	446159.3409	1739396.873	446159.2807	1739396.942
7	245	446216.8121	1739230.528	446216.7832	1739230.608
8	282	446253.9415	1739143.842	446254.0829	1739143.916
9	357	446154.1261	1738983.944	446154.4791	1738983.968
10	375	446266.0019	1738925.061	446266.1661	1738924.991

According to the measurements carried out on the block map, results were obtained for accuracy.

The differences between actual ground coordinates of the check points (from GPS) and their measured coordinates (from adjusted map) were computed. The linear errors for any points were computed using the following equation (Root Mean Squire :

$$\text{Linear error} = \sqrt{\Delta E^2 + \Delta N^2} \longrightarrow \quad (5.1)$$

Where,

ΔE= measured coordinate –actual grand coordinate $\longrightarrow$ (5.2)

ΔN=measured coordinate –actual grand coordinate $\longrightarrow$ (5.3)

Tables below illustrate the results of difference.

Table 5.4: Difference in E and N coordinate

Point	parcel no	ΔE(m)	ΔN(m)	ΔE^2(m)	ΔN^2(m)
1	29	-0.1579	-0.03371	0.024931	0.001136
2	67	-0.138	0.11996	0.019043	0.014390
3	87	-0.16637	0.14806	0.02768	0.021922
4	37	0.063399	0.2978	0.004019	0.088685
5	193	0.233464	0.00429	0.054505	0.000018
6	181	-0.0602	0.06964	0.003624	0.004849
7	245	-0.02887	0.08042	0.000834	0.006467
8	282	0.141379	0.07358	0.019988	0.005414
9	357	0.352962	0.02399	0.124582	0.000576
10	375	0.16419	-0.07024	0.026958	0.004934

Table 5.5: mean of Difference in E and N coordinate, and linear error

Point	ΔE^2(m)	ΔN^2(m)
sum	0.306166	0.148392
mean	0.030617	0.014839
square	0.0009	0.000196

Linear error = $\sqrt{0.0009 + 0.000196}$

Linear error = $\sqrt{0.001096}$

Linear error = 0.033106 m

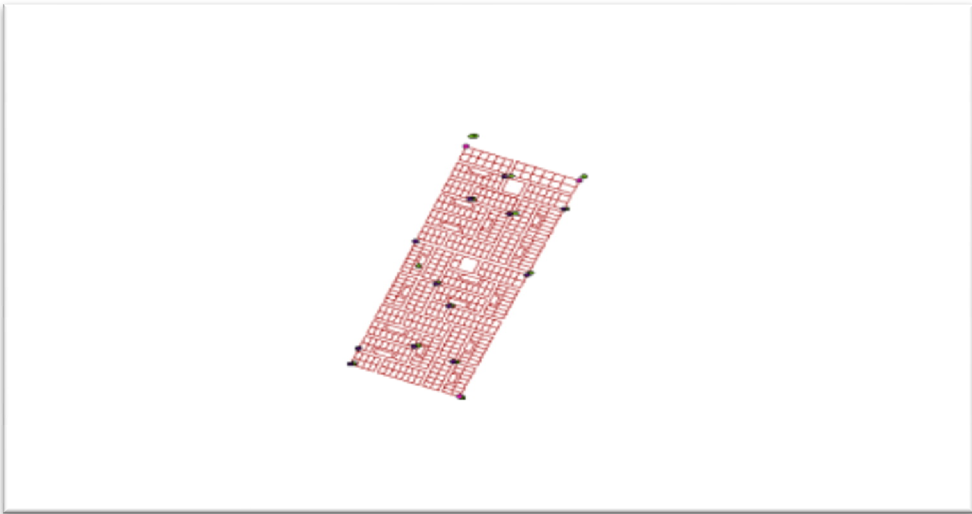

Figure 5.1: Adjusted map

5.2 Conclusion

According to the test carried out in this study it can be conducted that:

1. Evaluation the horizontal positional accuracy of the cadastral maps had been improved to 0.033 meters.
2. The coordinates of the digital cadastral map can be used for the demarcation of the boundaries of the residential parcels using GPS or smart station.
3. The achieved horizontal positional accuracy is quite suitable for cadastral surveys (scale 1:1000).

5.3 Recommendations

The following recommendations are suggested for further studies in the same field:

1. Design digital cadastral systems for the management of the cadastral system.
2. Test the positional accuracy for wide residential area (many blocks) using the same number of control points.

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