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Developing Cost Effective Approach to Integrate Cadastral Map and Land Parcel Data Using RS & GIS Technologies

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Abstract

Land is an important resource to human and it has direct or indirect role for their food, shelter and living. Land management system plays a vital role in keeping related records to facilitate the act of timely decision for better wellbeing of any society. In Pakistan, the existing land management system is in manual form resulting a lot of social problems in the form of land disputes and also arising as a serious hurdle in the economic growth of the country. In this study, a new technique is developed for land management system in Pakistan using remote sensing and GIS technologies. The relevant data of land parcels from land register and cadastral map were integrated using high resolution satellite imagery through GIS technology. The methodology showed positive results with more precise, manageable, updatable, and future friendly output as compared to the existing manual techniques. This also proved that satellite imagery can be effectively used an alternative for field surveys to prepare cadastral maps with less time and cost.

Keywords: land management system, GIS, remote sensing, cadastral map, land register

1. Introduction

Land is the ultimate source for sustaining life (UN-ECE, 1996). The word land has different meanings to different people depending on their interests. It is one of the most important dimensions of human security in any state. One of the important functions of a state is to provide security of assets to its citizens. Like rest of the world, in Pakistan too, land is one of the most important assets for citizens both in rural and urban areas (Qazi, M. U., 2006). Over the globe, various systems are used in order to manage land records. In Pakistan, land records are kept in an antiquated paper based system whose complication and control of the state representatives over its access has given rise to dispossession of the weaker sections of society. All these records are prepared and maintained in a manual form (Zahir Ali, 2013). Similar to many other developing countries, the cadastral and land registry systems are one of the weak sectors in Pakistan. Strengthening these systems is a basic necessity and a way of stimulating development (Zahir Ali & M. Shakir, 2012).

The uncontrolled increase in population, intensity in land usage and cascading division of land lead to high degree of complexity in land information. Moreover, keeping in view the demands of modern era, manual methods of sustaining land information must adopt new methods with faster processing and high degree of accuracy (Juppenlatz, M., 1991). Therefore, it is a sole option to utilize new technologies for managing this precious resource.

The International agencies like World Bank and United Nations have recognized the importance of an effective land information system. Land information system has two pillars i.e. the cadastral one which includes all

ground measurements and the administrative one which mostly concerns the land owner, economic value of land and crop types (Dale, P. F. & McLaughlin, J. D., 1988). The intentions of this study are to put emphasis on the advantages of Geographic Information System (GIS) remote sensing technologies for upgrading the old land information system into a new digital land information system to meet the current and future demands.

2. The Pakistan Scenario

After the partition of subcontinent in 1947, the British handover the power to their respective states but leave its ruling customs in which land administration ranks at the top. As the colonial system was the result of invasion, their thought of power also flourishes from their system in which one-way accountability (servant is accountable to his officer) is kept in mind. The present land legislation system is mainly constituted of the Land revenue act 1967 and Registration act 1908. This system might have worked well in the first decade after the creation when the land records were manageable.

In Pakistan, the land record data is kept in the form of land registers and the cadastral maps are drawn on paper sheet in manual form. The record of one land parcel is written in 17 different registers having its own attributes (Qazi, M. U., 2006; Dale, P. F. & McLaughlin, J. D., 1988). Handling and regular updating of these records is a huge task. Normally, these updates are taking place once every four years.

With the advancement in the Remote Sensing (RS) and Geographic Information System (GIS) technologies, it is now possible to perform different task more efficiently, cost effectively, and precisely (Zahir Ali, 2012; Adeel, M., 2010).

3. Methodology and Data Used

The methodology followed in this research can be divided in to three broad steps. The first step is desk research which includes in depth review of literature to get full background knowledge of the land administration system in the study area for highlighting the problems in the existing system. A case study approach is used in the second step for collecting the data and suggesting proper solution to the problem faced during data collection. Processing of the data and computerization of the land records is carried out in the third step. The methodological framework is shown in the Figure 1.

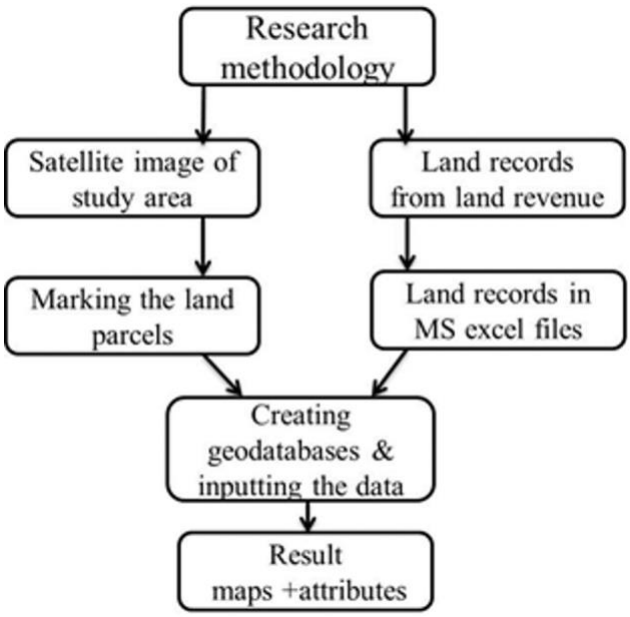

Figure 1. Methodological framework

3.1 Desk Research

This method is completely based on literature review of the land administration system in Pakistan. The main purpose of this step is to highlight the successes and failures of the Land Administration System (LAS) of the study area and its relationship to other departments. This step was necessary to trace the problems in the existing system.

3.2 Case Study Approach

Case study methodology is the most frequently used in the field of cadastre because this system mostly deals with humans and institutions (Silva, M.A., & Stubkjær, E., 2002). The land administration system of Khyber Pakhtunkhwa (KP) province has been studied in detail in hierarchical order starting from higher position (Senior Member) to lower position (Patwari) of the Board of Revenue (BOR).

3.3 Geographic Information Technologies

With the help of remote sensing and geographic information system technologies, satellite image of the study area was acquired and land parcels were marked. The data were collected from BOR pertaining land owner information, tax paid, land area and source of irrigation. These information were then organized and maintained in a geodatabase. All the information pertaining to each land parcel were linked and visualized in the developed land information system.

4. Study Area

Tarakai Moza of district Swabi, KP province which lies between 34°9'38.78"N to 34°11'36.55"N latitude and 72°18'51.95"E to 72°23'21.37"E longitude with area of 1700 acres was selected as study area as shown in Figure 2. The study area contains small villages with more concentration of agricultural field irrigated by canals.

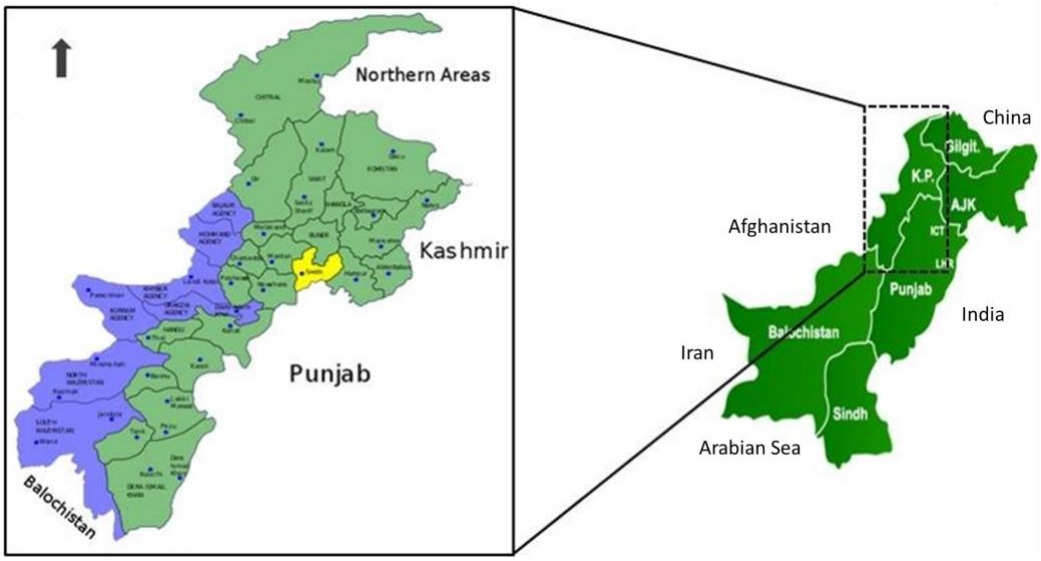

Figure 2. Study area location (in yellow color) on provincial map

5. Digitizing Cadastral Map

The data collected from BOR office and satellite imagery from Google Earth was analyzed. The satellite imagery was Ortho-rectified in order to accurately register imagery to ground coordinates and to remove image distortions. After performing the essential pre-processing of RS imagery, the use of RS imagery was assessed in cadastral map digitization.

5.1 Digitizing Study Area Boundary

The first step was the digitize study area boundary on satellite image. The map acquired from BOR was taken as reference map. The handmade map did not contain any coordinates. The map has its own legends and annotations which can be only recognized with the help of Patwari (local land manager). Some part of the boundary was easily marked on the satellite image as most of the boundary was along the natural pathways, roads, canals. However, in settlements it was difficult to mark the boundary correctly for which field survey was carried out with the help of local land manager and GPS.

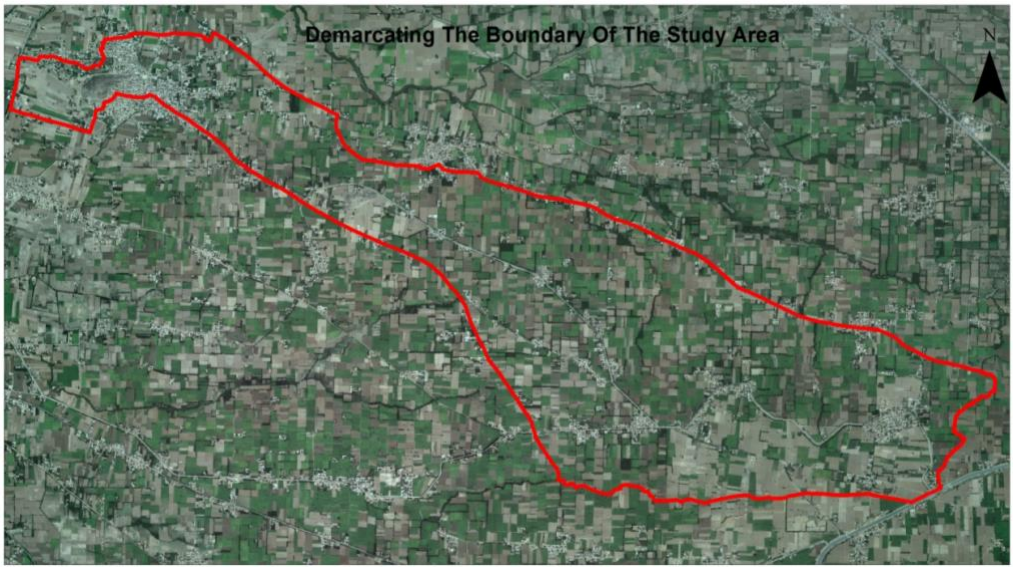

Figure 3. Demarcation of the study area boundary

5.2 Digitizing Land Parcels Boundaries

It's the lengthiest and critical step in the whole study after demarcating the boundary each land parcel should be demarcated with the help of satellite imagery because it is our region of interest. Normally demarcating land parcels boundaries looks easy but in practice it was not the case with the whole Moza. The study area has a small size of land parcels which is due to the reason of high rise in the population that caused repeated division of land parcels within the family members which resulted in the small and complex land parcels size, making the digitizing land parcels more challenging. To avoid the misplacement of land parcels the available map from the office was geo-referenced with the satellite image of the study area. The acquired map was of the year 1990 which shows the fields of that time while now on satellite imagery there are much more land parcels than the available on the map which shows the lacking of updating facility Field survey was carried out several times on ambiguous land parcel boundaries in order to make the boundaries more trusted for supporting the forthcoming LIS. Each land parcel is marked and given the same name (parcel id) which is a unique character for each field, as that in the map of the BOR in order to make it easy for generating its record in the further steps.

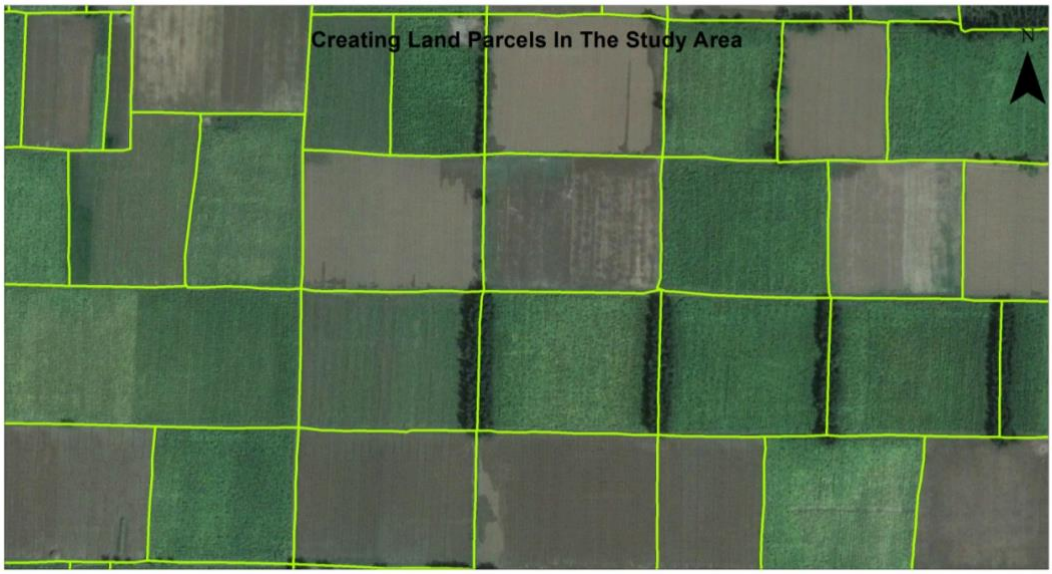

Figure 4. Digitized Land parcels boundaries in the study area

5.3 Digitizing Settlements & Graveyards

The settlements were marked in groups as it appears in the map of BOR due to relying on the data of the BOR which have no data in registers about them. On the map settlements were differentiated from the other features only on the basis of color as they appeared yellow (the same color as they are on local map). Another feature on the map of the BOR drawn in the shape of polygons which constituent the graveyards. They have no available data on parcel based as in the case of land parcels and nor they are included in agricultural land. The same procedure was applied to graveyard differentiating them with light brown color from other map features. The main objective of differentiating these features is that they have no part in agricultural production so for making the land information system more refine in order to estimate the yield of specific crop with accurate parcel area and in result the tax that should be paid in term of irrigation water tax and others.

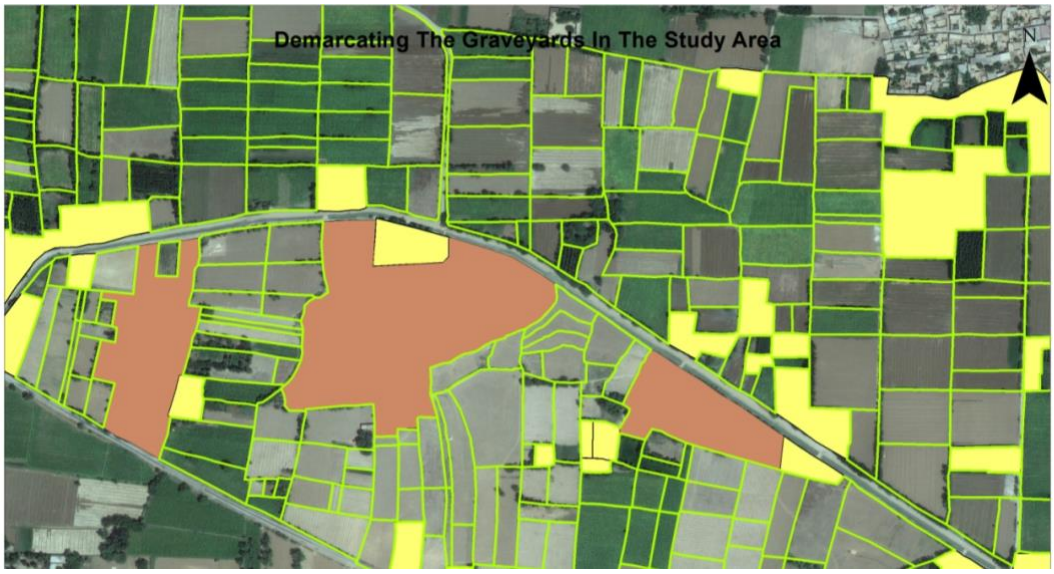

Figure 5. The settlements (yellow color) and graveyard (light brown)

5.4 Digitizing Linear Features

The study area contains some kilometers of roads, un-metaled paths leading towards other villages called pathways, and canals which are running in most part of the area for irrigation purposes. These features are easier to mark on satellite image as they exhibit a pattern which is easy to follow as compared to land parcels and settlements having complex shapes. In some cases, these linear features are used as reference point (because of their linear structure expanding on a long thread of area) in order to point out a land parcel or group of parcels.

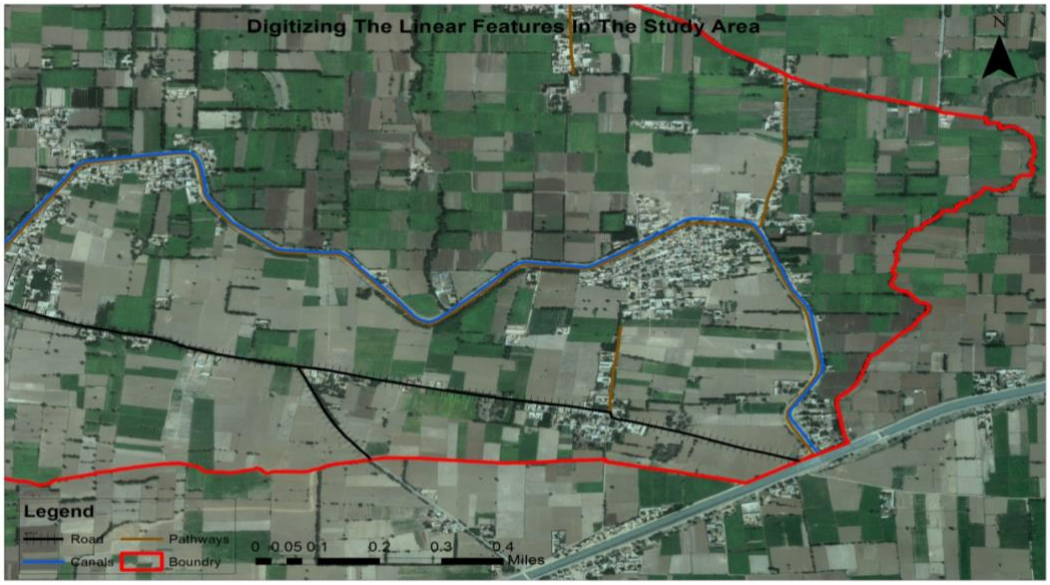

Figure 6. The canal (blue color), pathways (brown color), road (black color) and study area boundary (red color)

6. Organizing Land Parcel Data

After creating all the features within the study area, the next step was the management of land parcels records acquired from the BOR and putting it in such environment that it can be easily connected to its specific land parcel on map which can be easily manageable, updateable and so on.

For this purpose, data was put in excel sheets under the same titles as that is in the register of land manager. The specific register from which we took the data about the land ownership, area of the land, type of irrigation, name of the farmer and so on in local system the name of this register is called register Haqdaran-e-Zameen, means that the register contains the land owner name. A sample of page from the same register is given below.

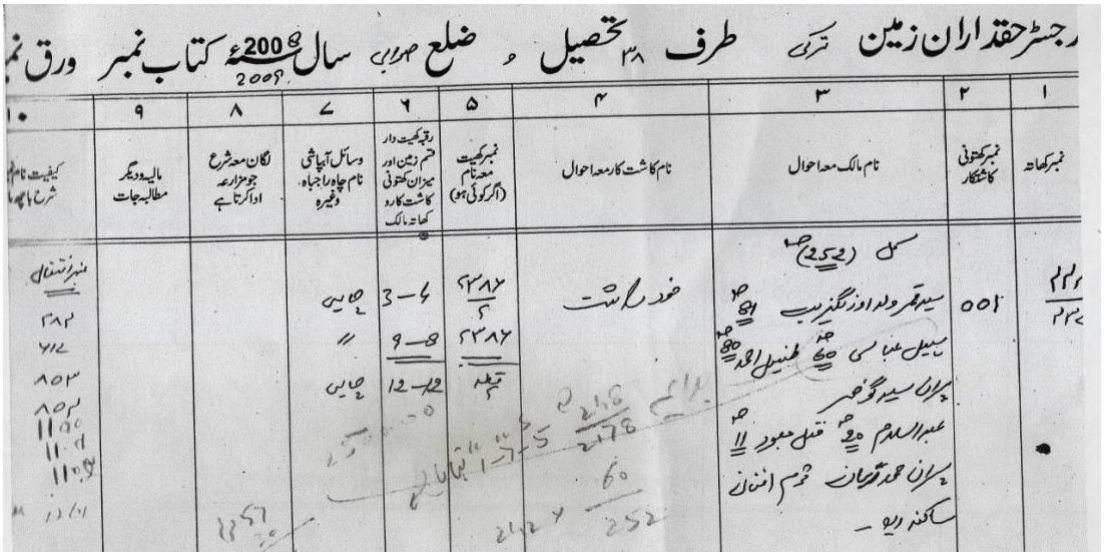

Figure 7. Page from the register Haqdaran-e-Zameen showing land titles

All of the above information was recorded in excel sheets and then to configure both the map and the parcel data we take the help of GIS by making Geo-database in order to make both the features in coordination.

7. Integrating Land Parcel Map & Register Data

The land parcel data has been put in excel sheets in their respective columns as given in the Figure above, and then organized for taking it in a Geo-database environment with the help of freely available Quantum GIS software. Each land parcel has a unique identifier called Parcel ID (PID) called in database term primary key Each parcel has given its respective PID as present in the register which will be used to recognize and differentiate it in the field from other parcel. On other hand each land parcel created have also the same column named PID which is also unique identifier (primary key) for each land parcel on map. The land parcels digitized have given the same PID as that present on the map of BOR which on joining in the GIS environment connect to its respective Land parcels showing its related data that was taken from land registers. On the basis of this field the data of the register was connected with land parcels on map with no redundancy due to its uniqueness resulting in a fully integrated land information system which can be queried, displayed, edited and updated anytime.

8. Results and Discussions

After processing the whole data on the followed procedure, it is now possible to get a land management system having all the qualities of a computerized land information system which exist there plus some more unique characters which are most important in nowadays land information system.

Each land parcel has its own related data linked with it shown in Figure 8 below. The advantage of this type of land information system is that we have both the attributes of the system i.e. map and related data called register information in one compact environment which ease the work in the reference of time, accuracy and expertise. This will be explained in the coming lines.

As we have all the data in digital time so it's quite fast to query information about land parcels, updating the information and so on.

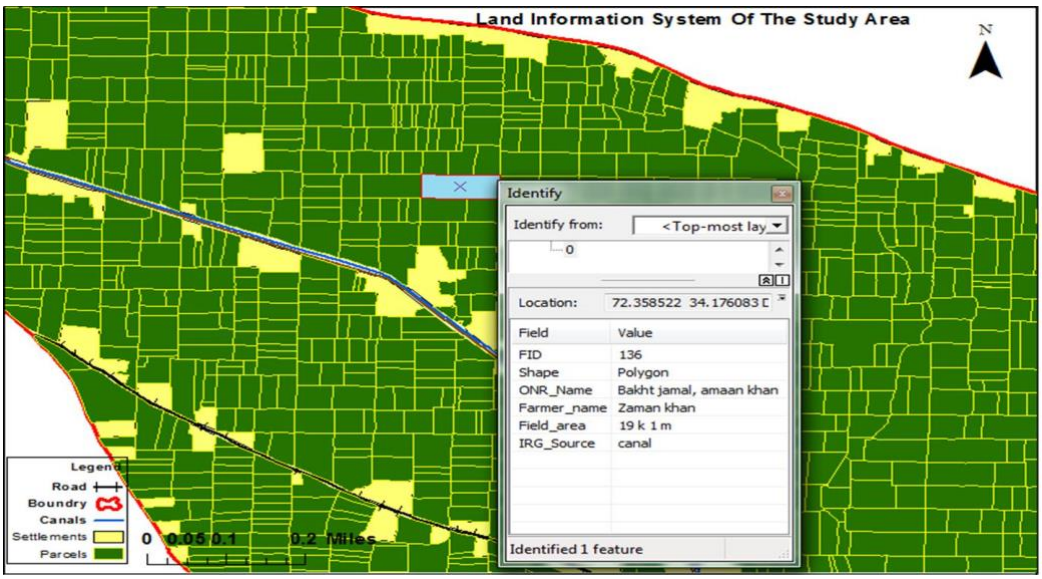

Figure 8. Map of the study area with all the available parcel information

As already been discussed about the methodology that is in use and also the flaws in that are discussed in detail in the above chapters but some more and the difference between the both will be discussed in the following lines in more detail.

The following table describes the time taken by each step of the methodology used for the collection of field data.

Table 1. Time taken by field data collection

S. No.	Field data collection procedure	Time (days)
1	Meeting with Provincial Officials SMBR/DLR	28
2	Meetings with DRO/ Tehsildar /Land Manager	40
3	Copying the relevant data from record books	15
4	Boundary demarcation on ground	10

During the meetings with BOR officials, an interview was conducted about the existing situation of LAS such as the process of updating, data collection and so on. The answer from every official was “land manager is responsible for every type of work from management of land records in each Moza”.

The procedure of updating the land records is such that these records are updated only in registers like after the death of the father the land ownership is transferred to their sons and daughters while on map it remains the same as already proved from the acquired Lattah map of the study area which is of the year 1990. Normally it is done in three months of time from March to May. The records book then forwarded to the office of district revenue office to be updated in the district records book.

After acquiring the data from the field, the next step was to analyze that data on the described methodology to acquire the projected output. The Table 2 shows each step of data processing and the time taken in terms of days.

Table 2. Time taken by data processing

S. No.	Data processing and analysis	Time (days)
1	preprocessing satellite imagery	5
2	putting the acquired data in fields	7
3	Creating land parcels on Imagery	13
4	Creating other features on imagery	9

5	Field survey on some ambiguous land parcels	6
6	Connecting the data with land parcels	2
7	Total number of days	42

Each and every step of the methodology was measured in terms of time which is ultimately the money. The main target for predicting the cost effectiveness of this methodology was to compare it with the methodology in use and to gather the information about the persons involved their monthly salary and then compare it with the one that we developed but unfortunately that data was not collected because of the procedure of updating the records is so ambiguous that even the official hesitate to tell us about that.

For surveying the land parcels, the district office organized two types of surveying in which one is to make the records clearer and up to date (Istemal) while the other is to enhance the management of the land records more efficient (Bandobast). Comparison of the methodology adopted in this study and the methodology used by BOR for updating the land records is shown in the Table 3 below.

Table 3. BOR practices for updating land/map & register data for a single Moza

S. No.	**Activity**	**Frequency**	**No of employ**	**Time (days)**	**Cost (PKR)**
1	Updating records in books (only)	Once in 4 years	2	120	160000
2	Updating cadastral maps/Istemal	Once in 20 years	12	180	1200000
3	Bandobast	No specified time	20	200+	1800000
4	Our methodology	Anytime/any season	1	42	30000

This Table shows the newly formed method more cost effective that of the old one. The information has been taken from an authentic 56 pages' book in the field of BOR named as "Hidayat Rehnumaye Amalae Bandobast" where most of the basic information are given about the updating procedures.

9. Conclusion

In this study, a digital land information system has been developed from the scratch that can be checked whether it is practicable or not in our society and how it can be made more cost effective and easily available to the end users.

Using RS images of 0.5 meter resolution showed a significant approach towards digital cadastral map design and already work has done with acceptable results (M. Gianinetto, A. Giussani, G.M. Lechi & Scaioni, M., 2004). Moreover, the advancement in digital image analysis like the use of digital elevation model for ortho-rectification can help allot to mark boundaries on its original position. Using very high-resolution imagery and surveying instruments will add a new approach to study to check the effectiveness of very high-resolution satellite imagery and high-level survey instruments in demarcating land parcel.

For the prosper future of any country an active and well-functional land information system is needed which is not possible without being switching in to new technologies and also keeping up to date ourselves. After being on the way towards the digital information system the next step is to connect this system with other governments organization's which directly or may indirectly using this data in order to make the system faster. As in the case of judicial system, if the land information system is connected with judicial system and the judiciary can become able to connect with the data so there will be no delay in the processing of the land related cases.

The next option is to connect the system with irrigation system which will be easier to manage the water for irrigation system more accurately and with less time.

The system should become online in order to make sure the land related data in the reach of common people and to reduce the interaction of the officials which will decrease the work load of on the system as a whole and also ensure the on-time delivery of the data to the end users.

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