BE CIVIL ENGINEERING
FINAL YEAR PROJECT

GEOMAPPING AND DIGITIZATION OF CADASTRE MAPS USING GIS TOOLS, AND SELECTIVE EARTH TRUTHING OF MINERAL TITLES IN KP

Project submitted in partial fulfilment of the requirements for the degree of **BE Civil Engineering**

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This is to certify that

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Final Year Project entitled

GEOMAPPING AND DIGITIZATION OF CADASTRE MAPS USING GIS TOOLS, AND SELECTIVE EARTH TRUTHING OF MINERAL TITLES IN KP

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ABSTRACT

The mineral resources of Pakistan are in vast quantities as compared to most countries of the world. But this fact itself has not led our economy towards any growth due to insufficient capital and infrastructure to convert the raw mineral into finished material. For this we require foreign investments and in order to ensure that we must have a transparent digital mining cadastre system which will attract foreign mining companies to Pakistan and set up their exploration sites. This system needs the datum to match WGS84 so that uniformity can be achieved. This project undertaken by SAGE, MCE will make our cadastre system compatible with the rest of the world.

DEDICATION

To our beloved Parents whose prayers, best wishes and support always accompanied us during the execution of this project

AND

Dedicated teachers whose sincere, selfless support and guidance paved our path towards the completion of this project as well as our degree.

All Syndicate Members

ACKNOWLEDGEMENT

Beginning with the name of ALLAH Who is the most Merciful and the most Beneficent, it is a great privilege for us to present our civil engineering knowledge in its practical form. Utmost thanks to **ALMIGHTY ALLAH** for impowering us with the strength and courage for the completion of this project.

After that, our sincere gratitude to our project advisor **Lt Col Dr. Hamid Ashraf** for supporting, encouraging and guiding us through his lifetime knowledge and experience in the field of Geotechnical department. We are also grateful to all other faculty members including Mr. Sarmad, Engr Adil for their guidance and patience in our hour of needs.

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CHAPTER 1

INTRODUCTION

1.1 General

The business model of Pakistan's mineral sector is relatively outdated and has a relegated regulatory regime as compared to leading mineral-led economies of the world. Mineral based investment is invariably driven by assurance in security of tenure and return of investments. Investors always gauge a country's mineral by its attractiveness and transparency in the mineral title acquisition system. Therefore, it is important to implement a transparent and corruption free mineral title management system, one that is based on the world leading practice and acceptance to most of the leading mining corporations of the world.

The situation in Pakistan is not different than most of the third world developing countries, where all the records are on paper and susceptible to loss and change in its contents bearing corrupt factors. The mining contractual/management system is similar, and in need of certain advancement and reforms. 21st century is the place of digitization and innovation and our world is fast moving towards digit globalization. Most of our data and information nowadays is digitized and readily available to us with the touch of our fingertips. If the same were the case for our mining system, and we could have it all with us in binary form then that would be very useful and more importantly, more effective.

Hence the mining industry has introduced a Mining Cadastre System for the day-to-day operation of the mining business for the government as well as the corporations. A cadastre system has help reform both the commercial and government owned mining related businesses/ projects.

Pakistan is bestowed with substantial amount of mineral resources. These resources can be utilized for the greater good of the society and its populace. However, the benefits from these mineral resources can only be extracted if the sector is capable of extracting mineral-based large-scale foreign investment. Foreign investor sees transparency and corruption free mineral license granting system as the corner stone for investment in a particular country. A system that can ensure security of tenure

and return of capital, i.e. a mining cadastre system. Taking the lead from the 21st century mineral advancement and governments' will for mineral development, KP has taken the lead to implement a world leading mining cadastre system.

During the implementation of the project by Military College of Engineering (MCE), NUST, the Landfolio team (world-leading mining cadastre system company) identified a bottle neck in the project. The paper-based data for licenses of KP were required to be digitized and confirmed on ground before it could be incorporated in the system.

1.2 Problem Statement

The license data coordinates were in yards and the Landfolio mining cadastre system used coordinates in meters, hence all the coordinates were required to be transformed to metric coordinate system. Also, the coordinates were required to be plotted into the GIS system by constructing polygons for each set of coordinates of each license. Then once the conversion of data and polygon construction/ plotting is complete, these points were required to be confirmed on ground by the process of Ground Truthing.

1.3 Scope

The project specifically attempts to rectify and implement following: -

- Stocktaking/ audit if mineral title boundaries and marking scheme;
- Conversion of paper-based record to computer-GIS -based record; and
- Thereby implementing a procedure to automatically record and update old/ new records.

When completed, the project will provide with

- A spatially geo-referenced mining cadastre system
- A system coherent with the modern mapping standards
- The ability to analyze, manipulate and handle large amounts of related data flow into the system.

1.4 Objectives

- To audit/ stock take all mineral titles data of Mineral Development Department, KP, that is to be implemented through newly developed mining cadastre system; and
- To digitize this collected data using ArcGIS and form a digitized mining cadastre system of KP.

1.5 Organization of the Report

The following layout of thesis will be followed:

- Chapter 1 - Introduction – provides a brief overview of the entire project including problem statement and scope.
- Chapter 2 - Literature review – provides the background and detailed study of all topics involved in the project.
- Chapter 3 – Methodology – explains the overall concept of project, and steps of the process of digitizing.
- Chapter 4 - Analysis and Results – explains the several issues faced during working of methodology.
- Chapter 5 – Conclusion and Recommendations – summary of the outcome of this project along with recommendations for future implementation.

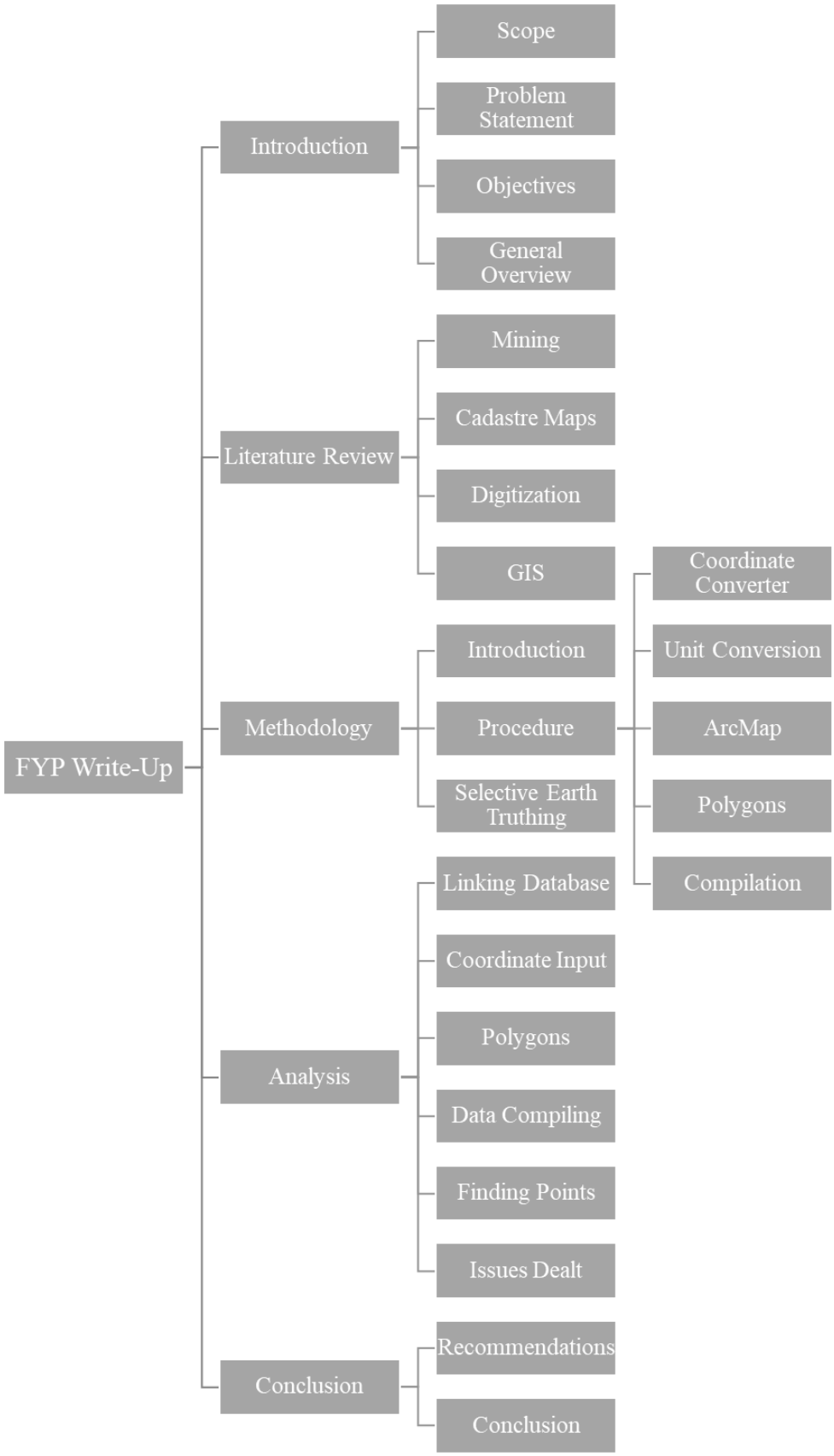


Figure 1 **Work Breakdown Structure (WBS)** of Write-up

1.6 Digitization

Digitization is the method or process of converting analogue data or information into digital format. In this process the data is organized in the form of bits. Digitized data is in the form of binary numbers i.e. 0 and 1 and is processed by the computers in the form of digital image, sound or document. The process of digitization is very important in terms of data processing, storage and transmission, because it supports information of all kinds and formats. Although analog data and physical data is typically more sound, digital data can more easily be shared and accessed and can be stored.

1.7 Geo Mapping

Geo mapping is a technique to anticipate raw data from different contexts or specific geographic points and turn it into a geo map. By anticipating location data in this way, we can easily understand information. There are many types of geo maps, each serving a different purpose.

Geo mapping can also be defined as a technique of surveying of land and sub surface bye the use of GPS that shows a view of a site and the surrounding area that includes buildings roads mines etc. The ability to precisely locate mines location and area by giving us coordinates should be the main goal of this process in our study.

Geo maps are of different types each having its own function and purpose. Some of the geo maps are following: -

- Political maps
- Climate maps
- Road maps
- Physical maps
- Terrain maps
- Cadastral maps

1.8 Cadastre system

A cadastre system is the land recording of the property ownership and real estate of a country. It includes information and details of the precise location, the area and dimensions.

The roman emperors were the first to introduce cadastres to recover state owned land.

In order to have complete dimensions and boundaries of land, diagrams, sketches and plan cadastre surveys are performed to document the boundaries of land.

In our project we would obtain data of mineral titles of Khyber Pakhtunkhwa, in the form of coordinates which is analogue data from the techniques of surveys and ground truthing and then digitizing that data in Arc GIS to provide a digitized data for incorporation in mining cadastre system of Khyber Pakhtunkhwa.

The technique will help to locate mines of Khyber Pakhtunkhwa easily by just putting coordinates in the system and would bring a great transparency in the mining licenses.

The process starts with obtaining data which is in the form of analogue. Taking those analogue data and converting it into the required specified units and linking that coordinates with Arc GIS where a polygon of the given coordinates will be formed, and a digitized mapping system of Khyber Pakhtunkhwa will be obtained.

1.9 Khyber Pakhtunkhwa (KP) – The Province and its Mineral Resources

KP occupies an area of 101,741 square kilometers. It has almost all varieties of mineral resources.

Some minerals found are:-

I. Gemstones i.e. peridote, tourmaline, aquamarine, emaralds and other semi-precious stones.
II. Energy Minerals i.e. Coal.
III. Minor Minerals i.e. Sand, gravels, ordinary stones, pebbles and cobbles for use in construction and civil work.
IV. Metallic minerals i.e. gold, silver and base metals lead, zinc, copper,

antimony etc.

V. Dimension stones i.e. marble, granite and other decorative stones.

According to KP Mining Concession Rules 2005, the exploration licenses of mineral titles can be transferred. Mining of minerals and its processing to profitable commodities for usage in the manufacturing industries is known in this region.

It is to be noted that the mining system in Pakistan is based entirely on old traditional system of land records and registers that are complex, complicated, outdated, and incompatible to new developments in the modern digitized world. In addition to be quite inefficient, the system in Pakistan has many discrepancies that have created difficulties in the development process of digitized system.

The government has declared the National Mineral Policy (NMP-2013) to ease for expansion of the mining industry and improvement. This new policy describes a detailed representation of country's objective of improving the mineral sector. The NMP-2013 provide basis for addressing difficulties faced by the sector and respond to important government priorities and commitments. The NMP provides decision-making tools that will help to improve mineral industry. The Policy addresses the following main challenges, which usually revolve around following four themes to ensure:

I. Enhanced economic contribution of the mining sector to Pakistan's economy
II. Competitive economic environment to attract foreign investment
III. To ensure the implementation of the legislative regime for the mining sector by effective coordination between provincial and federal institutions
IV. Production and exploration of Pakistan's mineral resources is environmentally sustainable.

CHAPTER 2

LITERATURE REVIEW

2.1 Mining History of Pakistan

Various valuable stones are dug and cleaned for domestic use just for trade. These incorporate actinolite, hessonite, agate, rutile, sea green/blue, jadeite, ruby, amazonite, serpentine, azurite, kyanite, Margaret, spinel, emerald, moonstone, topaz, potash, Horoscopes, tourmalines, onyx peridot, turquoise, net, quartz (citrine, and so on.). In Pakistan, Mining is a perilous activity, particularly mining of coal, as security strategies are regularly disregarded, and mishaps are very normal. There is air contamination with no advanced security gear, for example, breathing hardware or ventilation. Almost all excavators have lung issues and many experiences the ill effects of carbon monoxide. Yet, the primary driver of death and injury are tumbles from precipices, being covered when mines breakdown and being hit by falling rocks. Following is the inside view of salt mines.

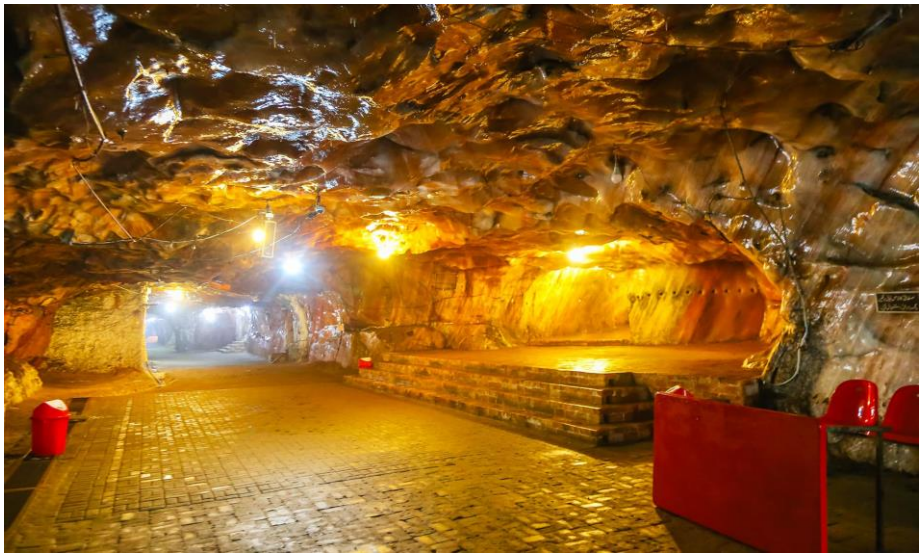


Figure 2 Inside view of salt mine, Khewra (Dawn, n.d.)

2.2 Cadastre Maps

Cadastre is an up-to-date land information system which contains a record of land interests. Land packages of geometric portrayal are incorporated in it, different records are linked to it portraying the idea of the ownership and interests.

The Financial Institution’s Group (FIG) Statement expresses that land packages are characterized by formal or casual limits denoting the degree of terrains held for restrictive uses by people and explicit gatherings of people (for example families, enterprises, and mutual gatherings). Every package is given a unique kind of code or bundle identifier, for example, a location, a co-ordinate, or much number appeared on an overview plan or guide.

Cadastre is a specialized term for records indicating the degree, worth and Ownership (or different reasons for usage or inhabitancy) of land. Carefully, a cadastre is record of zones and estimations of land and its owners that initially were arranged due to reasons of tax collection. An advanced cadastre typically comprises of a progression of enormous scope guides or designs and comparing registers. Cadastral guides normally go from sizes of 1:500 to 1:10,000. Enormous scope charts or guides demonstrating increasingly exact bundle measurements and highlights. For example, structures, water system units, and so on are frequently arranged by cadastral overviews for each bundle dependent on ground reviews and ethereal photography. Data in the literary or characteristic documents of the cadastre, for example, land worth, proprietorship, can be collected by these remarkable bundle codes appeared on the cadastral guide, therefore making a total cadastre. Both the plans and the registers might be put away in PCs, as discussed in the part "computerization of guides and registers". While the overview of the individual bundle of land has brought a "cadastral guide" in certain nations for that plot of land and may have been detached to any abutting land allocates. Genuine cadastral guide covers all packages inside a zone instead of disconnected plots. It can go about as a record for other land package overviews that show increasingly point by point data or can be of adequately enormous scope for the components of each plot to be reachable from the guide.

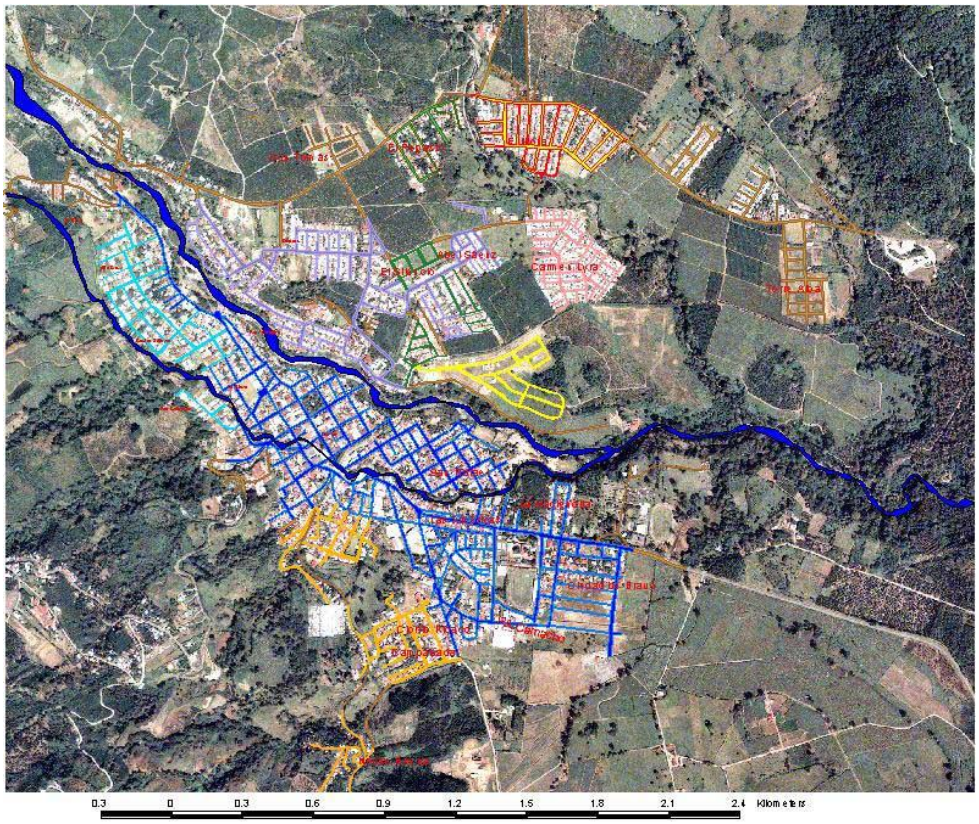


Figure 3 Satellite Imagery of cadastre map of KP. The different types of routes are depicted by coloured lines. The dark blue shows a water channel. (Wikipedia, Cadastre Maps, 2020)

Scale of cadastre Maps is vital. Since the objective is to give an exact depiction and distinguishing proof of the area, Scale must be big enough for each different part of the land which might be the subject of separate possession (helpfully called an "overview plot" or "land bundle") to show up as a conspicuous unit on the guide. At the point when map information is put away in a PC, they might be drawn practically at, any scale and this may give an impression of more prominent exactness than the nature of the review information may warrant.

Since the guide and the relating registers of a similar arrangement of depiction and recognizable proof, there must be some arrangement of cross referencing between what is shown on map and what is recorded in the registers. This shows that either names or numbers must be given to every unique and different land package.

References are known as property identifiers (PID) or kind of package reference numbers (UPRN). Different reference frameworks are created including:

- Grantor name of grantee name.
- Title numbers in sequence.
- The folio numbers and volume on which the plot is registered on.
- Ranch or territory’s name with an individual number of plots
- The registration block and individual plot number
- An address of post office.
- Index reference of parcel and street number
- A grid co-ordinate.

The reference picked should be straightforward and simple to recollect; simple to use for general population and by PCs. Reference should be long lasting, so it doesn't change with the offer of a property yet equipped for being refreshed when there is development of the land.

No two cadastral planning frameworks are equivalent, yet there are various fundamental parts in most frameworks. Since cadastral guides are inferred in various manners in various wards, there are a wide range of recognitions with respect to what establishes a cadastral guide. Because of authentic, social and social contrasts, cadastral guides assume altogether different jobs in various purviews extending from outlining or record guides till legitimating assurance of package limits.

It is necessary that when these names or numbers are drawn on the map that they don't highlight the details of map. The cadastral guide ought to show the limits of each land package and in certain wards may likewise show its territory and the genuine length and heading of every limit line. These contemplations may clearly request a scale fairly bigger than that required only to show each studied plot.

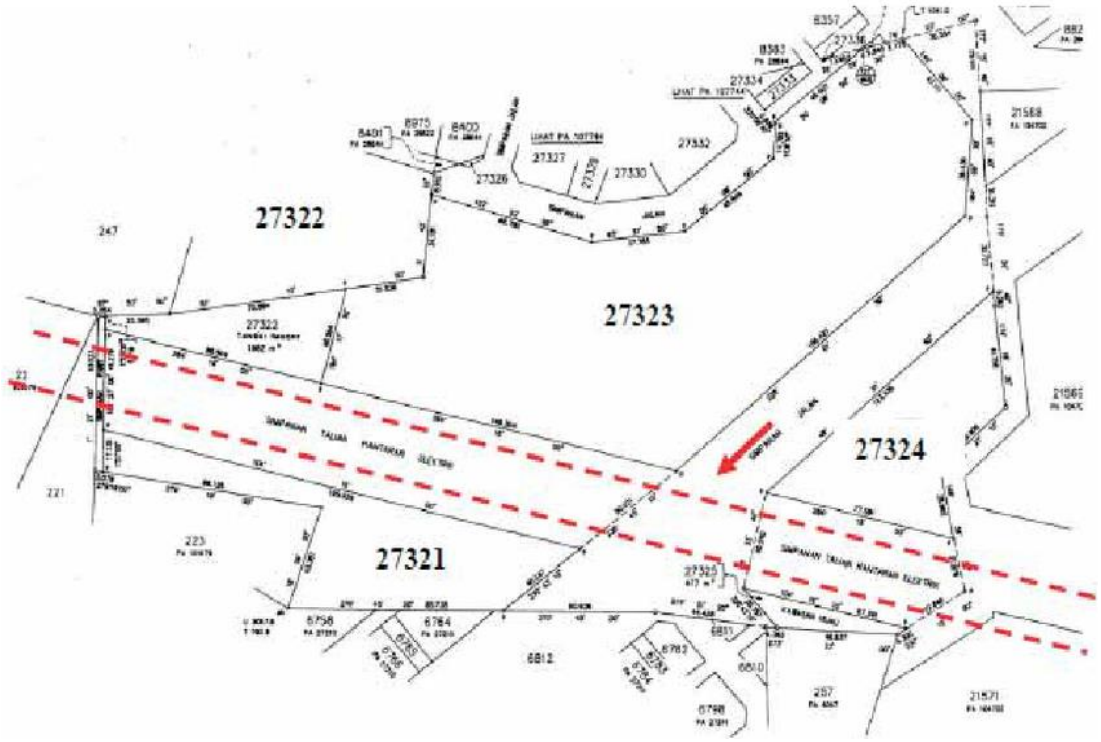


Figure 4 Cadastral map showing location of transmission lines. It is another form of a cadastre map (Choon, 2011)

The smallest agreeable scale relies fundamentally upon the territory of the smallest review plot liable to be met with and may consequently change enormously in various conditions. And a lot wider scope will be vital for cadastral guides of towns than for those of provincial regions.

In numerous nations it is likewise alluring that the material of which it is made ought not to be of a sort that energizes robbery. Since the imprints must be effectively unmistakable, they should be genuinely obvious on a superficial level however for significant focuses, for example, such as those used as control for surveys, there are preferences in enhancing surface imprints with marks that are set in concrete and covered underneath them.

The land bundle reference number can be utilized to recognize the plot. It very well may be cross-referenced both to the documents that contain progressively more thorough review data about the bundle, for example, its measurements, and to the information on proprietorship, worth and use. In majority of nations the records and

the information are stored separately. For example, the department of lands, justice ministry or it might be treasure of government.

New changes must be saved in order to save riots. Every invested individual must be advised promptly of any progressions that have occurred influencing land packages, for instance where there has been formal development, a cadastral guide needs to be updated regularly and efficiently. Following figure shows the overlay of land packages of cadastre map.

Figure 5 Cadastre map of KP (ssbacha, 2012)

2.2.1 Types of Cadastral Systems

Land organization in Pakistan isn't far reaching for entire nation rather it is independent for urban and provincial regions and exclusively urban territories. Additionally, in ancestral regions, individuals manage their own undertakings as per standard law of land rights, and the administration capacities through nearby innate middle people. According to USAID 2008 report hunching down and land capturing in Pakistan's urban regions is way too much. Shortage of lands causes problems like vagrants' constraint local settlements and free land capturing. One of the major

troublemakers “the land mafia” who claim and capture lands against the law and disposes that land.

Institutionally framework for land recording are set up in a way that has a hold of wide range of organizations. Board of Revenue (BOR), the Excise and Taxation Department (ETD), and the improvement specialists (DAs) are of important nature. Not even a single organization is of hold of all the land records. Inside this confounded institutional structure, The Board of Revenue (BOR) is the most significant organization for land organization. Within country zones the BOR's record get support from a multifaceted framework, which includes a few degrees of organization; the area, Tehsil, Kanungo circle, and Patwar circle.

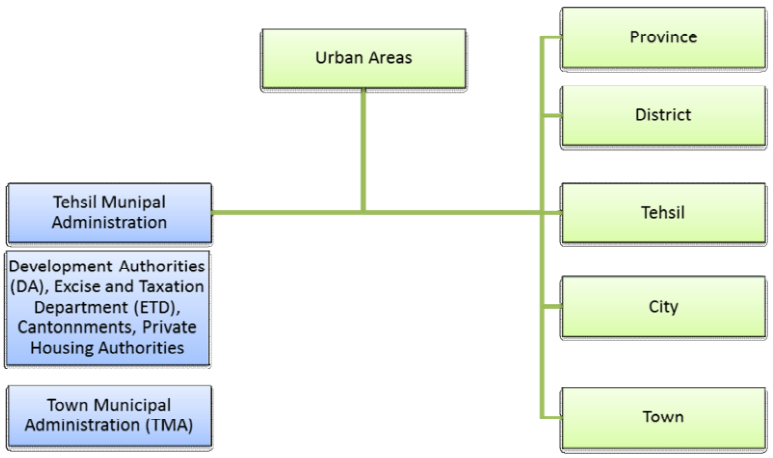


Figure 6 Administrative hierarchy for land administration in urban areas

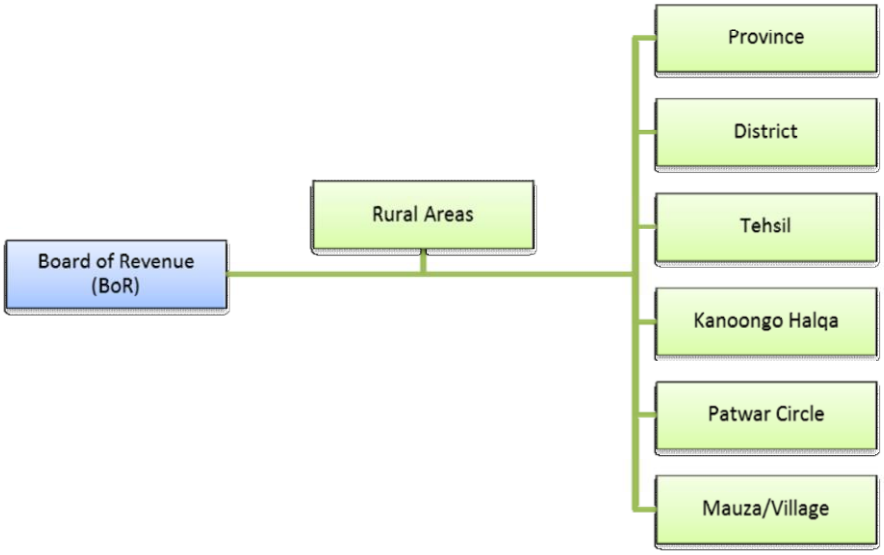


Figure 7 Administrative hierarchy for land administration in rural areas

2.2.2 Cadastral issues

The significant issues of existing cadastral framework are as per the following: -

I. **Policy Related Issues:** Lack of a far-reaching lawful structure overseeing land rights, nonappearance of normalized documentation and libraries of land rights, ineffectual proper contest goals frameworks, and the quality of numerous standard laws make instability of land residency for proprietors and likely buyers.

II. Obsolete and Opaque Cadastral System: The current manual arrangement of recording and upkeep, comprising of paper guides and registers has gotten out of date and hazy with the ever-expanding client-cooperation and measurement of land rights. In addition, Land records don't give either definitive evidence of possession nor are they connected to spatial information to impeccably distinguish the plot which offers ascend to many land related questions, causing delay in pending cases and access to land records.

III. Land organization from number of sources: In Pakistan, many associations are related with the land organization exercises, which lead to the non-consistency in the land organization. As land arrangements are made at national level, there is no association to make the strategies at neighbourhood level.

IV. Reliability of cadastral data: Cadastral Maps are set up in indigenous language utilizing neighbourhood old reviewing methods and heading and estimations; along these lines, each guide sheet has its direction and exactness. Therefore, here and there the edges of the guide don't coordinate with that of neighbouring sheets. Cadastral guides are not coordinated with national datum so the land packages can't be incorporated in other formative exercises propelled by the legislature.

2.3 Geographical Information System (GIS)

A GIS is a mechanized information of executives' framework which can catch, store, oversee, recover, break down and show enormous databases of spatially referenced data. The Environmental System Research Institute (ESRI) is characterized a GIS as an arrangement of equipment, programming and methodology intended to help the catch, the board, control, investigation, demonstrating and the show of spatially referenced information for fathoming complex arranging and the executive's tasks.

GIS mainly works different from other programs with ability of connecting plain information to spatial area. The expository abilities of GIS and its ability to form data from mix and control records enhances its importance as compared to other frameworks. A GIS has also the ability of incorporating unique spatial data as well as gathering into structural form for ease of users. In this specific circumstance, a GIS has precisely characterized for emotionally supportive network, including reconciliation of spatially referenced information.

As the political, institutional, moral, social elements of Geographical Information Systems (GIS) have arisen questions regarding basic GIS and society. Discussions around the hypothetical suppositions and social ramifications of GIS as an innovation and Geographical Information Science (GI Science) as an applied system to control information. One substantial move regarding such studies has developed social mindful sort of GIS which gives more benefit and authenticity to all spatial information.

It is applied in a vast scope of settings which includes urban arranging and renewal with neighbourhood gatherings; overseeing strife over access to land and other characteristic assets; asset the executives and administration access in 'First Nations'

or indigenous people groups land-use and regular asset arranging and protection and natural administration. This appears to be far-fetched given the theoretical connection between elective types of GIS and basic talks around utilization of the innovation. To be sure the proceeded with conversation of this relationship appears to be fundamental if participatory types of GIS are to hold validity in the more extensive disciplinary settings of human geology and past.

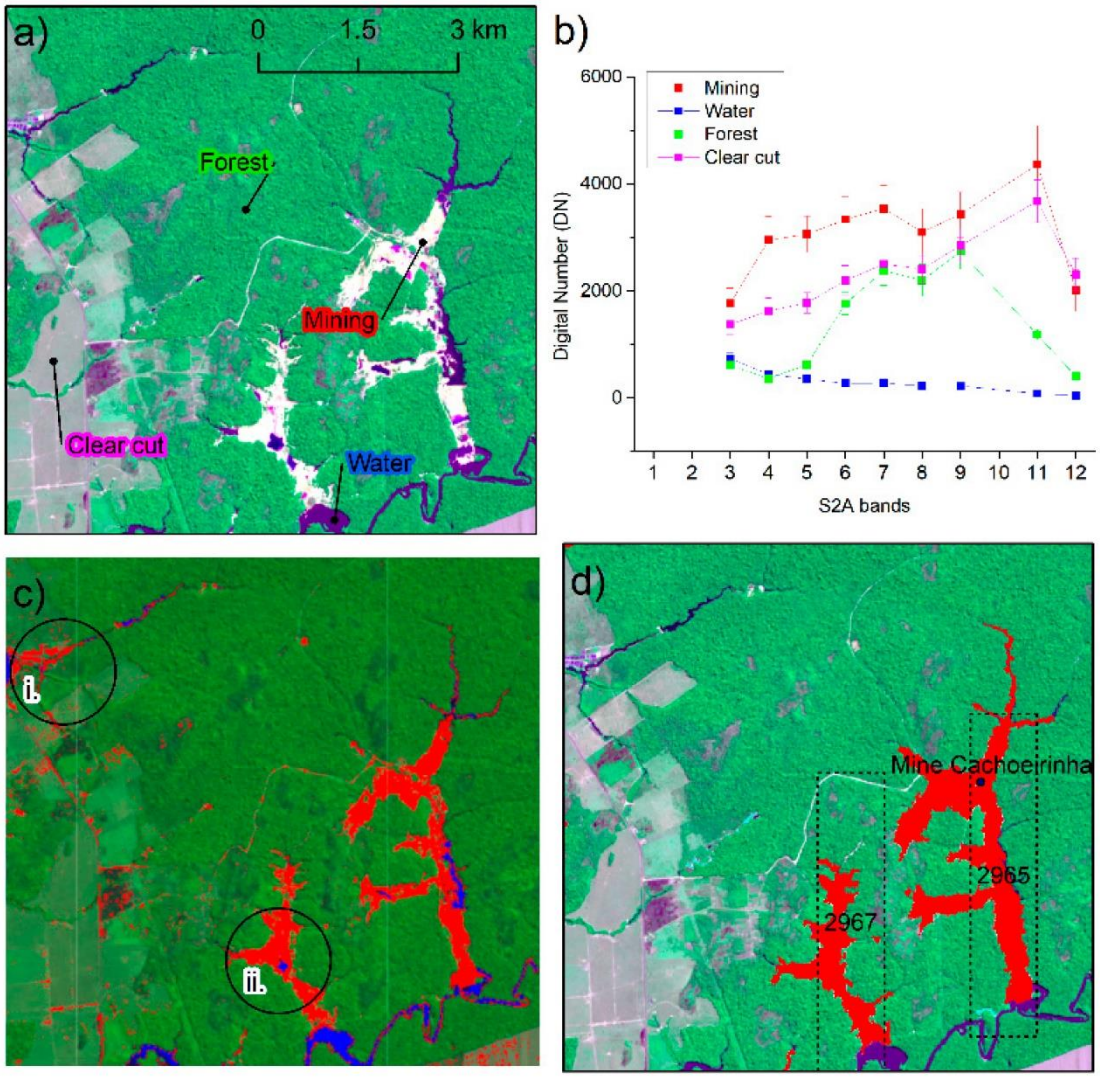


Figure 8 shows the recent events of mining impacts, the large extension of mining areas detected raises a concern regarding its socio-environmental impacts for the ecosystems and for local communities. (Felipe De Lucia Lobo, 2018)

2.3.1 GIS in Pakistan

In Pakistan like numerous other creating nations, the utilization of GIS is still in its outset. GIS execution is additionally hampered by restrictions in information accessibility and precision. They are regularly divided among and inside different associations and just mirror the individual undertakings that every association is liable for finishing.

Despite these issues, a few government and private associations in Pakistan are utilizing GIS to address area explicit applications including the Environmental Council of Pakistan. Some worldwide donor-supported asset the executives ventures utilizing GIS and related innovations are present in Pakistan. Concurring the Survey Department of the Ministry of Lands, the official planning organizations are having different partners, inside the National Environmental Information Network and Monitoring System to create computerized geographical database gauges and base guides are used for different ecological and regular asset the executive's applications.

2.4 Digitization

The changing way toward a simple guide into an advanced organization is known as "Digitization".

Digitization is the way towards changing data into an advanced, comprehensible position, in which the data is in bits form. The result portrays an article, picture, sound, report or sign by producing progressive numbers that give small arrangement of tests and focuses. The result is called advanced portray. In recent practices, the digitized information is twofold numbers, which encourage variety of activities.

Guide making has been one of the most significant accomplishments for mankind as it was a direct result of humanity. It had the option to spread all information through the globe. New terrains were found and possessed. In this way, for a long-time, maps have been utilized to depict the outside of the earth on to a paper. In any case, while seeing the guides, it will give a general overlook that each line or point delineated on the guide really speaks to an impressive region on the outside of earth. Along these lines, if lines present on the guides are not introduced precisely, it implies that an enormous territory of land gets questioned. Presently we have a period of computerized upheaval. Directly from advanced films and computerized music to

advanced data, the web has assumed a significant job in quickening this computerized setup. Guides have become a piece of this advanced insurgency and web planning is the 'in' thing now. The principle issue of conversation is the available resources of portrayal of guides in computerized structure and the plausible explanations behind the event of such mistakes all the while.

Information shapes the foundation of the GIS business. Spatial information is accessible for the most part in simple structure for example as guides, symbolisms, airborne photos and so forth. Maybe the greatest bottleneck in the GIS business is the correct proliferation of the simple information into computerized structure. Even though the most significant method of information and capacity in a GIS, digitization is additionally one of the most costly and tedious parts of information contribution to GIS. The computerized catch of information from the simple sources viz. maps, symbolisms, elevated photos and so forth is completed in two unique strategies, manual digitization and heads up digitization (for example by raster checking utilizing optical scanners)

Digitization is of urgent significance to stockpiling information, preparing and transmission, as it "permits different data types in arrangements to be shown with a similar proficiency and more blended". Although simple information is ordinarily increasingly steady, computerized information can all the more effectively be shared and gotten to and can, in principle, be engendered uncertainly, without age misfortune, if it is relocated to new, stable configurations varying. Due to this reason it is supported way for protection of data for organizations around the world. The digitization is used when various types of data, for example, an item, sound, text, voice or picture are changed over into a solitary parallel code.

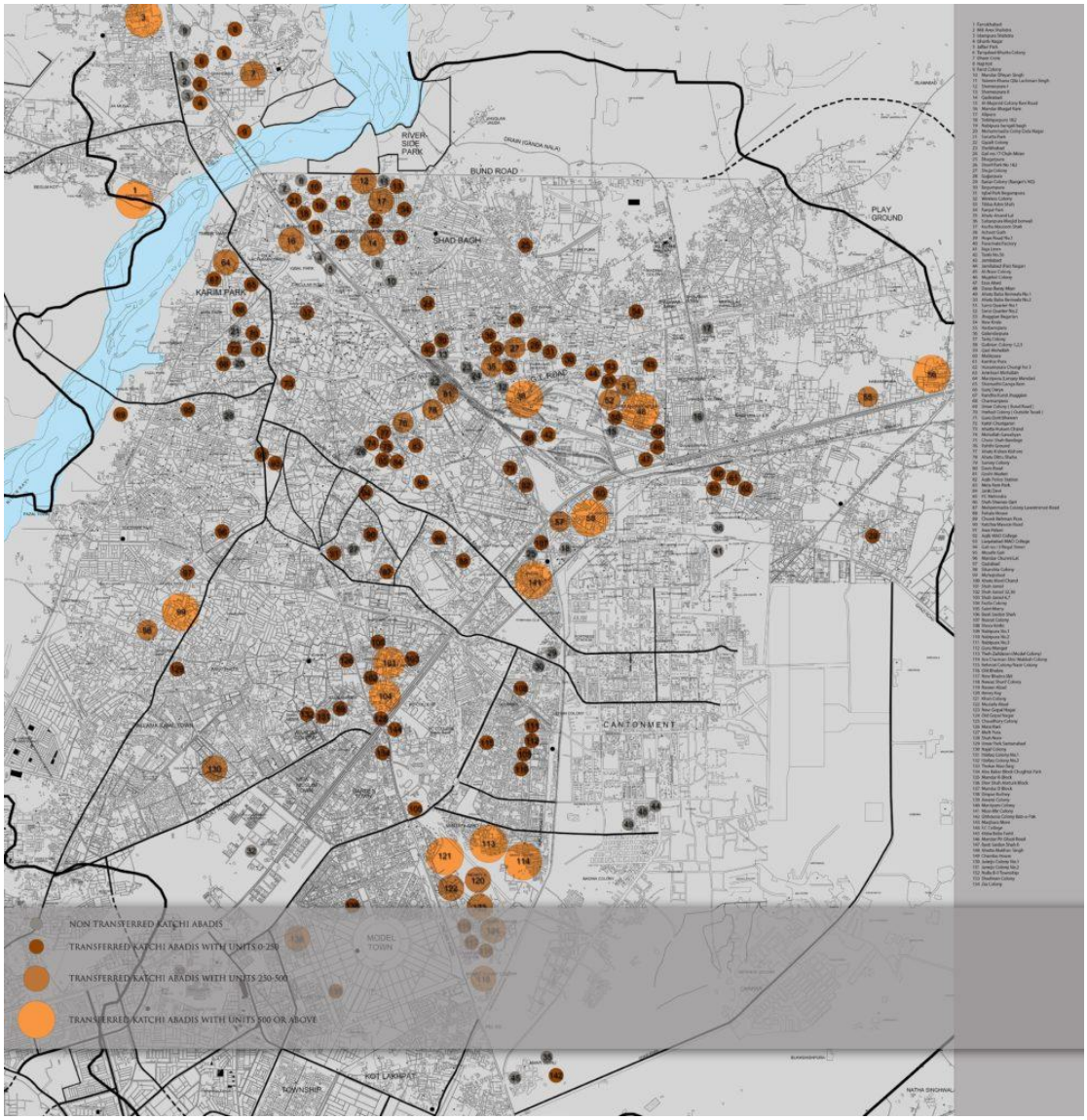


Figure 9 A digitized map of an area with the highlighted spots as per the key given at the left bottom. (citypulse, 2020)

2.4.1 Importance of Digitization

A significant part of digitization is the precision of the digitized items. Spatial precision of the highlights portrayed on the map is significant for a decent GIS database. Precision of the digitized map relies upon various sorts of mistakes. The most significant of which are cartographic, geodetic, machine, composition and arbitrary blunders. Geodetic mistake erases the ill-advised decision of a projection framework. This is on the grounds that maps present the three-dimensional face of the surface into a two-dimensional paper as per a projection framework. Digitization in an alternate projection framework brings about wrong situation of highlights with the

end goal that the map and the digitized picture don't cover one another. Machine mistake is an inborn blunder which can't be evacuated yet must be limited. It relies upon the exactness of the digitization table and possibly acquainted while change from simple with map of digital type. Cartographic mistakes are blunders that are available in the original map itself and which get moved into the advanced type of the map. Composition blunders are presented dependent on nature of the source maps. Paper maps are quite known to contract with the time. Any distorting, extending, collapsing or wrinkling of first guide will influence the digitization procedure as legitimate coordinates of such guides can't be put. Aside from this, the nature of digitization additionally, relies on the administrator who is digitizing the guides. An accomplished digitizer can digitize the guides with more precision and speed when contrasted with a recently delegated digitizer. Additionally, on-screen digitization is increasingly exact when contrasted with manual digitization as the pictures for on-screen digitization are examined at higher goals to such an extent that the administrator can zoom the picture to the size of the first raster information and digitize with a more significant level of exactness. At the end of the day the nature of digitization despite everything stays with the administrator.

2.5 Digitization of Cadastral Mapping

Segment separating and characterizing have been critical to humankind since hundreds of years. They give a visual or realistic thought of how any region would appear and who will include rights inside the restricted domain. At the point when a piece of land is isolated and possessed independently it is smarter to put a demographic record of the equivalent for reasons of distinguishing proof. Cadastral maps give data identified with the locale and who has the qualification rights over the equivalent.

Digitization of cadastral guides is only speaking to the physical type of the territory as a picture on a screen.

The advanced cadastral guide is essential part of any cadastral framework. The map isn't put away in any other ordinary sense; nor it is a perspective or picture on geographic zone. Instead, the information is put away, from which it is able to get attracted an ideal view to suit a specific cause

In computerized maps spatial connections are delineated utilizing topology. Topology is a scientific method for unequivocally characterizing spatial connections. Topology communicates various sorts of spatial connections as arrangements of highlights (e.g., as zone is characterized by the lines involving its fringe). Spatial information is connected with non-geographic (unmistakable) data about a specific element on a guide. The data is put away as characteristics of the topographically spoken to highlight. Those characteristics may have the type of names (labels) connected to the realistic components and are put away in vector documents or as plain information, on which certain investigations can be directed. The primary arrangement is utilized basically to give straightforward data on specific items like the article's name, date of placement, and so on. The last case requires an outside database, the records of which relate with comparing graphical guide object.

The estimations of those properties are:

- Quantitative: estimated and communicated with units of length, zone, time and so forth.
- Qualitative: when each property may expect just one incentive out of a lot of qualities, decided previously, for example, names, addresses, hues and so forth.

The intensity of the framework lies in its capacity to connect the two kinds of information (spatial and clear) and keep up the spatial connections between the map highlights. There are three important qualities of this association:

There is coordinated connection between highlights on the guide and the records in the element property table: -

- The connect between the element and its record is kept up through an exceptional numerical identifier allotted to each component;
- The special identifier is physically put away in two spots: in the documents that contain the directions and with the comparing record in the component attribute table.

The idea portrayed above applies to something beyond monitoring highlights and their properties. It is conceivable to associate any two tables if they share a typical trait. A typical thing is utilized to set up associations between relating records in two

tables. Each record in one table is associated with a record in another table that has a similar incentive for a typical thing.

There are different advantages of digitization of cadastral maps and yet it ought to be finished by specialists with the assistance of redesigned and exceptional innovation. Directly from catching and estimating territory to completed digitized test a great deal of steps is included which request significant levels of value and precision.

2.5.1 Benefits of Digitized Cadastral Maps

I. **Economical** - Digitization of cadastral guides is an affordable and pocket-accommodating choice since there is no compelling reason to store them up anyplace truly and they wind up requiring no room space. Likewise, it is significantly more proficient and helpful to keep up a computerized library where your digitized cadastral map can be put away.

II. **Accessible** - One of the most significant advantages of digitizing a cadastral guide is the comfort of discovering them. It is effectively retrievable and can be gotten to from anyplace by any individual who is approved to utilize them. Also, it tends to be gotten to by numerous individuals at different spots. Regardless of whether it should be available on the web for open use or on the intranet for the utilization of select individuals the decision stays accessible to the customer.

III. **Reduced errors** - Digitized cadastral maps are transparently accessible on the system of the customer which permits any number of clients or watchers. Since the equivalent advanced guide is being seen at different spots there is a lot lesser degree for any mistakes or blunders. The nearness of precise before every watcher dodges difference or error during improvement ventures.

IV. **Recording** - Digitization assembles chaotic unpredictable material in a composed manner. This change makes it simpler to record, measure, decide and perceive property. Computerized recording is known to be exceptionally valuable since it stays in the information framework interminably till new alters or refinements are entered.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology is the crux of any problem-solving activity. It describes various methods and procedures that have been adopted to carry out the tasks.

In this chapter the main procedure of the project will be thoroughly explained with the aid of diagrams. All of it was performed on software. The two primary software used are: -

I. ArcMap
II. MS Access

3.2 Procedure

The background of all components of the project was detailed in the chapter two of Literature review. The main aim as quoted in chapter one is that we will use the acquired coordinates of all the mining titles in KP and plot them in ArcMap after converting their units from yards to meters. After plotting the polygons or shapes will be made to distinguish each site from the other. This will be done one by one for all mines, district by district until the Digital Cadastre Map is complete. After completion it can be used for analysis as well as commercial purposes. This chapter will put all that together and help to understand how it was performed. Following are the broad steps of our work: -

I. Coordinate converter
II. Conversion of units
III. Locating the coordinates on ArcMap
IV. Polygons
V. Compilation of shape files

Methodology flowchart

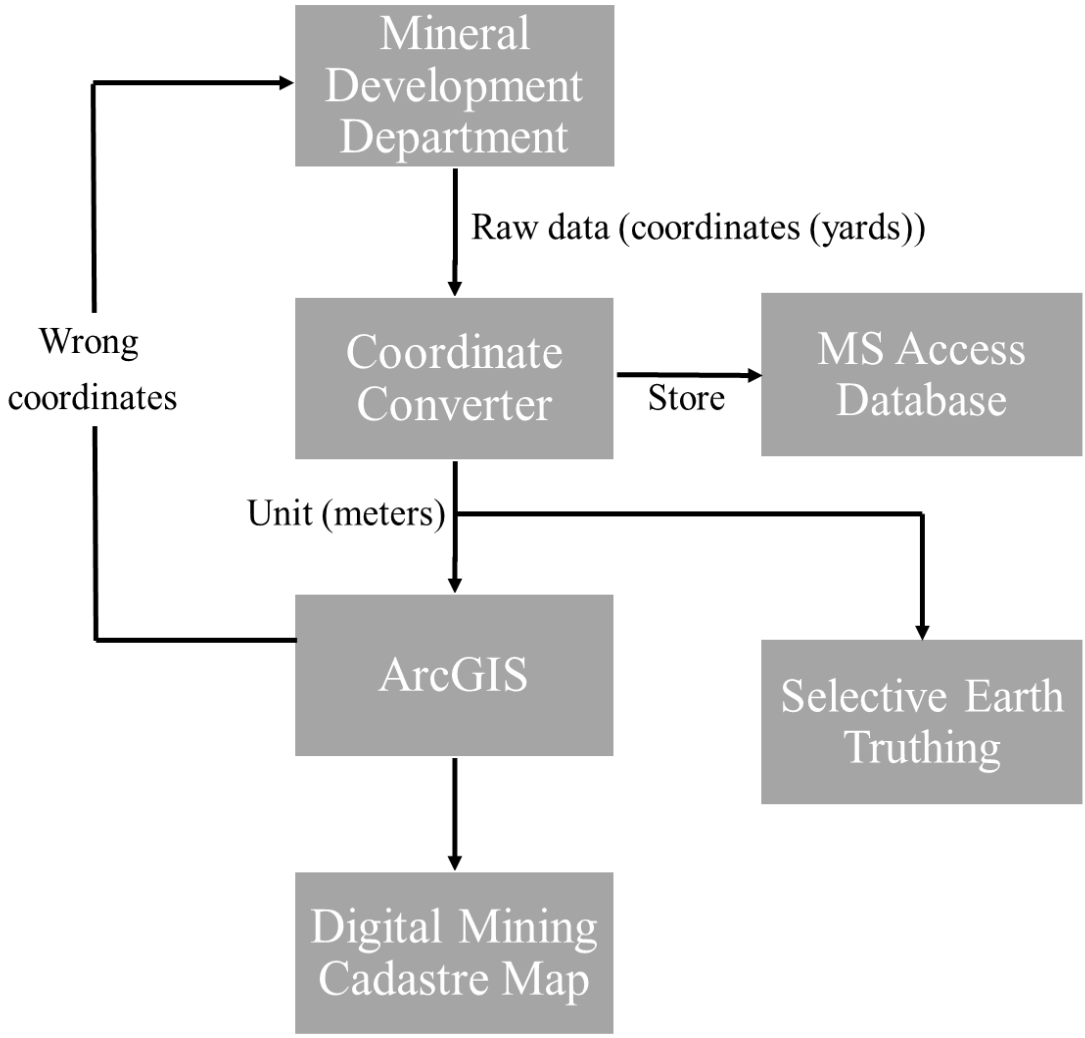


Figure 10 Methodology Flowchart

3.3 Coordinate converter

This tool is one of the most vital one. The units used in ArcMap are projected coordinate system whereas the coordinates provided to us by the departments are mostly in yards, hence the requirement of unit conversion.

The converter is made on MS Access database platform. This tool alone can only convert the units but in order to use it in accordance with ArcGIS, we need to link its database with that of ArcMap. Even the files can directly be opened from there.

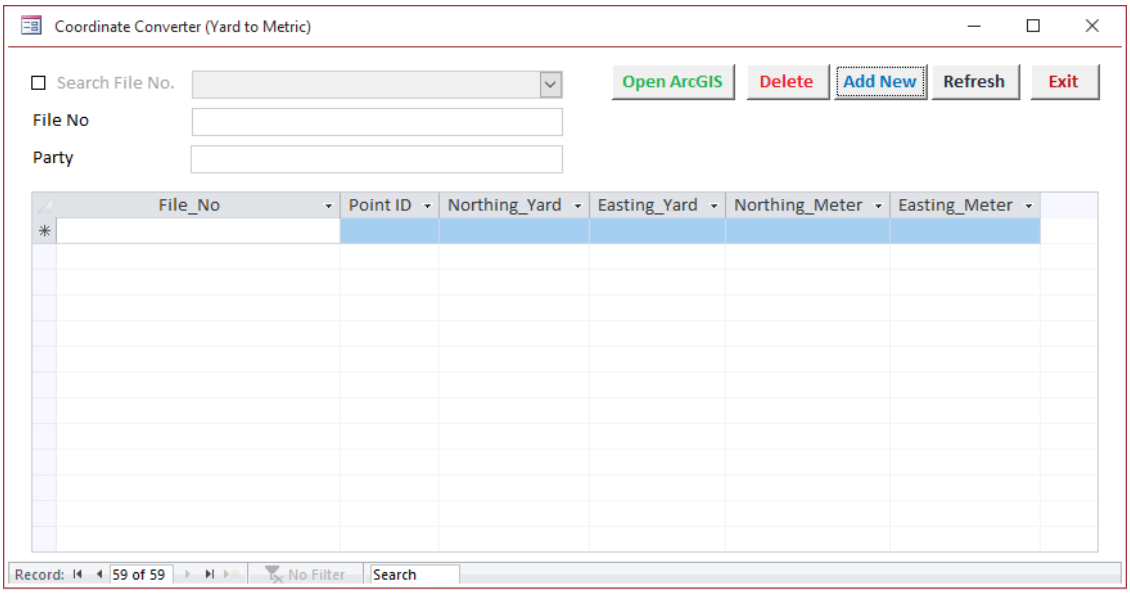
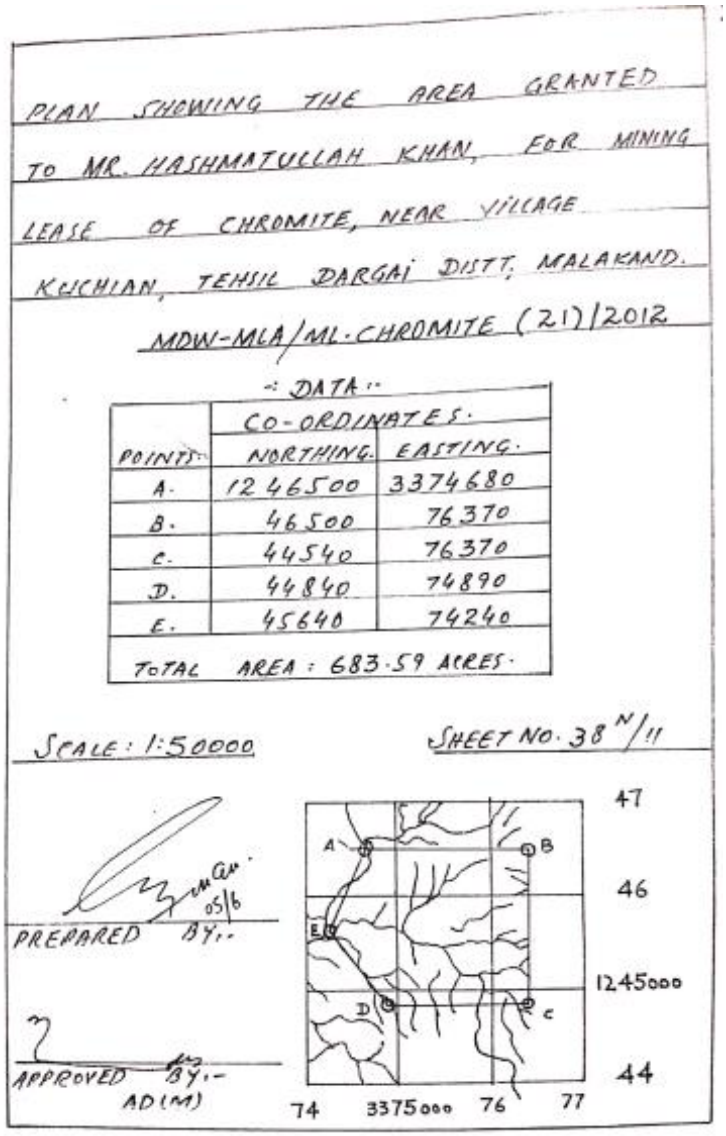


Figure 11 This is a blank coordinate converter in which all the fields are filled along with the coordinates (Northing and Easting) in yards and then they are converted automatically.

3.4 Conversion of units

One of the two most vital aspects of our project. This step corresponds directly with the stated objects of this thesis in heading 1.4.

The coordinates were provided to us in the form of files. Each file is corresponding to one mining title. Larger sites can have multiple blocks, but all the blocks will be under the same name. There is a proper nomenclature for the titles which is explained in detail in the next portion.


PLAN SHOWING THE AREA GRANTED
TO MR. HASHMATULLAH KHAN, FOR MINING
LEASE OF CHROMITE, NEAR VILLAGE
KUCHIAN, TEHSIL DARGAI DISTT, MALAKAND.
MDW-MLA/ML-CHROMITE (21)/2012
:: DATA ::

POINTS	CO-ORDINATES. NORTHING.	EASTING.
A.	1246500	3374680
B.	46500	76370
C.	44540	76370
D.	44840	74890
E.	45640	74240

TOTAL AREA : 683.59 ACRES.

SCALE : 1:50000
SHEET NO. 38 N/11
PREPARED BY.. 05/6
APPROVED BY.- AD(M)
47
46
1245000
44
74
3375000
76
77

Figure 12 The ID or the name of the mine is given in the fifth line of the above shown image.

Following are the components of these names: -

I. <u>District</u>

Every district has its own abbreviation. This is the first thing which distinguishes mining sites from each other. In order to sort them district wise we use this.

E.g. **MLA** for Malakand district

AD for Abbottabad district

II. Type of contract

There are generally 3 types of contracts used in mining. Namely as: -

- Prospect Lease or **PL**
- Mining Lease or **ML**
- Reserved For Auction or **RFA**

This format is also used for the sorting out of files. RFA files are those whose ownership has not yet been granted or it has not been leased therefore these files are kept and marked separately.

III. Mining material

Next comes the name of the rock/material which is being mined. Generally sorting is not done with respect to name of material as there are plenty of materials co existing in more than one districts.

E.g. MDW/AD/ML-**LATERITE**(15)/2016
MDW/AD/ML-**LIMESTONE**(103)/2007

MDW is a file extension for a work group file format used by Microsoft Access. These files contain information such as usernames and passwords of users authorized to access a secured database. They have to be linked to an Access database in order to be effective.

IV. Mine number

The significance of mine number is that when the same rock is being excavated in the same district and tehsil but at two different mines then those two mines are distinguished by their mine number. Sorting is not done using mine number anywhere.

E.g. MDW/AD/PL-BARYTES**(122)**/2007
MDW/AD/PL-BARYTES**(39)**/90

V. Year

This is the final element in the title of a mine. It is generally used for mentioning the commencement of that contract or title.

E.g. MDW/AD/PL-COAL(154)/**2005**

MDW/AD/PL-GRAPHITE(51)/**2011**

Process

The process of unit conversion has a couple of small yet tedious steps. The difficulty is following the steps in the order instructed as well as inputting all coordinates one by one. This is a time-consuming task.

I. Recalling the coordinate converter interface, there are a set of buttons/options on it. When it is opened, usually a set of coordinates is already input in the fields. This is because whichever set in once input in the converter and then opened in ArcMap, its values remain saved in the converter. Hence every time we open the converter, we must first press "Add New" option in blue. This will present a new page or a blank interface.

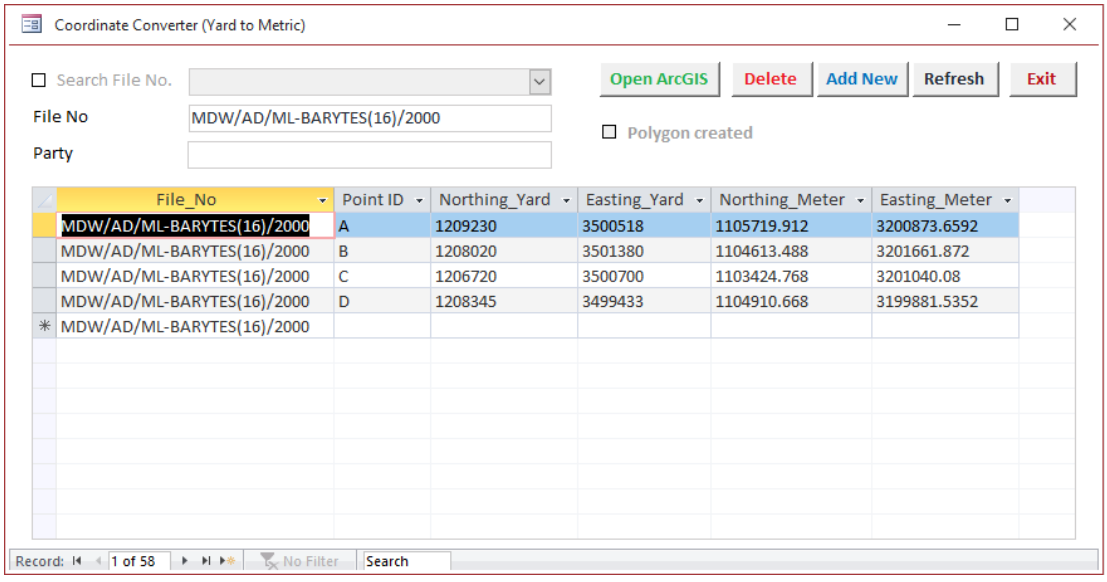


Figure 13 Coordinate Converter showing entrance of fields. This figure shows how it looks when all the points of one file have been converted.

II. After this we will enter the File title name in the "File No" field. One thing needs to be ensured that the format of the title, which was explained earlier

must be followed. Otherwise an error can occur, and that file will not be plotted on ArcMap.

III. Once the name is there, the "Party" field will be left empty.

IV. The "File_No" column automatically gets filled. The number of points we input is decided by the number of points on the document we have. The points are denoted in alphabetical order. Order is followed so that once plotting is complete, no point is lost. This also makes it easier to locate the points on ArcMap.

V. The coordinates are entered in the "Northing_Yard" and "Easting_Yard" fields. When the cursor is moved into the next field, previous coordinate value is automatically converted and viewed in the corresponding "Northing_Meter" and "Easting_Meter" fields respectively. One by one all coordinates are entered and converted.

VI. Once all the coordinates of the file are complete then the "Refresh" button/option in black is pressed. This will refresh the database of both converter and ArcMap. This is a necessary step because without it the database will not be updated and the points in turn will not be plotted.

VII. The last step of inputting coordinates is that the "Open ArcGIS" button/option in green is pressed. One thing of note here is that in case there is a delay, or the ArcMap is not opening, then the solution to that is that ArcMap should be opened separately while inputting coordinates or before that. Then when the "Open ArcGIS" option is pressed, we can directly go to the map and continue our work.

Note

The "Polygon Created" check box under the "Open ArcGIS" option in the previous image is unchecked. This shows that the polygon for this file has yet not been created.

This option serves as a check for duplicate files as well, which will be explained in the upcoming topics.

3.5 Locating the coordinates on ArcMap

This part of the procedure of mapping is the most time consuming and prone to error. Till now we have successfully plotted the coordinates of a certain file number in ArcMap.

Navigation in ArcMap is not very complicated. The key is to focus on the scale of the map. The relatively smaller scale maps require much zooming in because the points will be all clustered up when zoomed out. Once zoomed in, we can see the points separately and they may be in some shape. The figure below shows the coordinate points of a mineral title in the district of Abbottabad. To draw its polygon, we first zoom in to an appropriate scale.

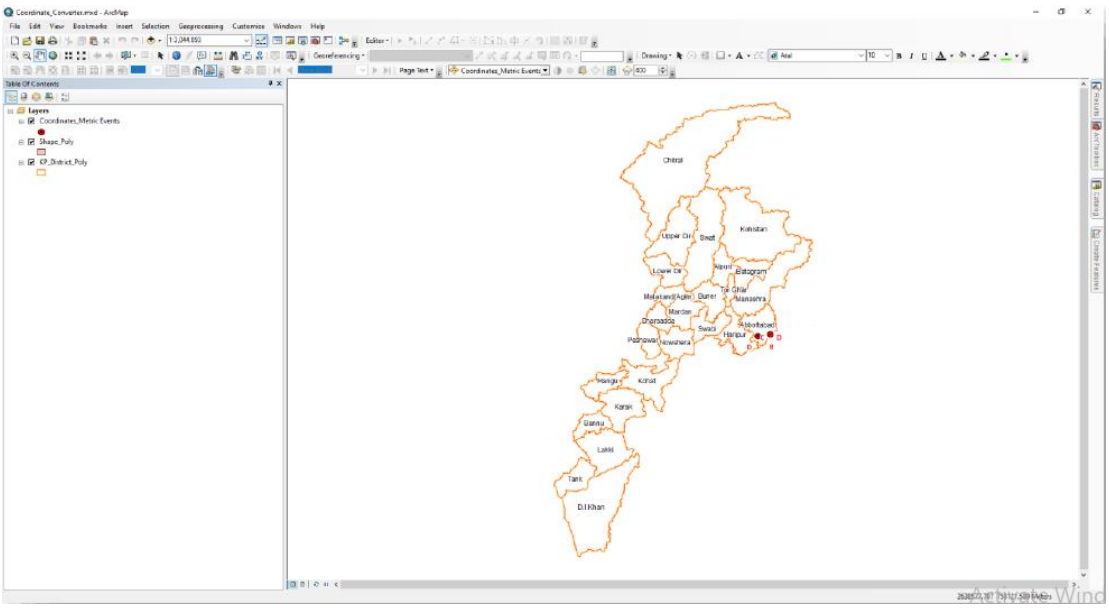


Figure 14 Coordinate points of a mineral title in the district of Abbottabad. The map is zoomed out for reference with the rest of districts.

Usually the original shape of the mine title is shown in a figure in the original file. But even if it is not, we can interpret it. As mentioned earlier, the points when being input in the converter must be in alphabetical order. This will ensure the proper shape/polygon of the mine.

3.6 Polygon

The figure below shows a mining title with four coordinates which have been joined into a polygon using the “Editor” tool of ArcGIS.

The “Editor” tool is a very important part of mapping. Without it we cannot differentiate the mines from each other. It is the one on the top right side of the Polygon.

To start editing we select the drop-down menu of Editor and choose “Start Editing”. The cursor changes shape. Formation of polygons is simple, starting from point A till the last point which in this case is point D. Once the polygon is complete, we go back to the drop-down menu, save the progress and select “Stop Editing”.

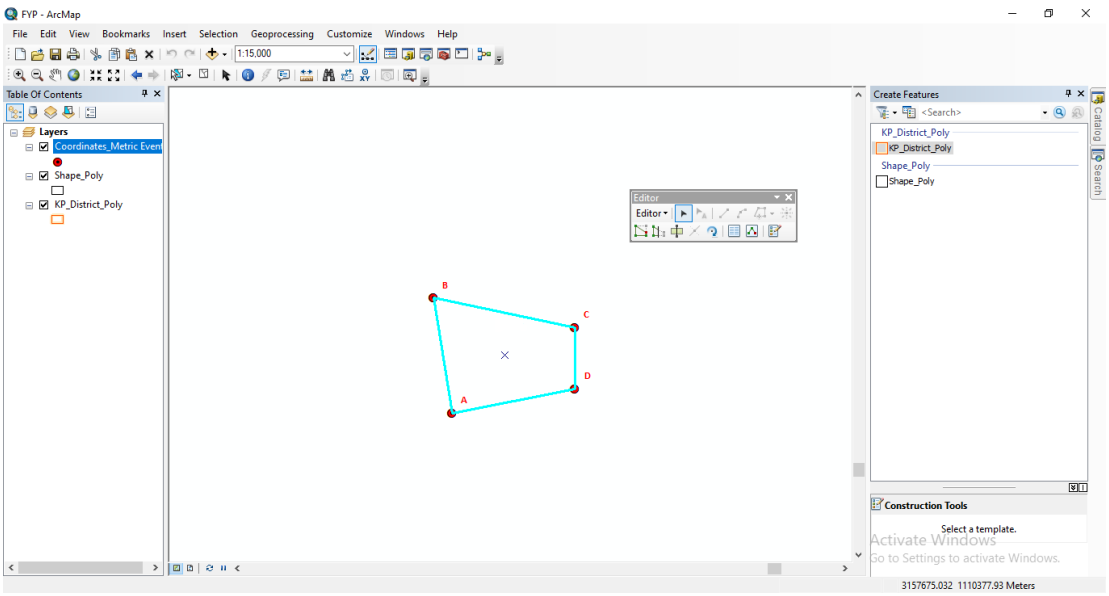


Figure 15 Connecting coordinate points to make a Polygon. The editor tool is also shown in the workspace towards the northeast of polygon.

3.7 Compiling of Shape files

Since there are many files then there must be a method of compiling all these files. One method is: -

I. District file

To complete all files of one district first and save that Shape file with the district's name separately. The following figure is such an example. It contains all the Mining Lease and Prospect Lease files of district Buner.

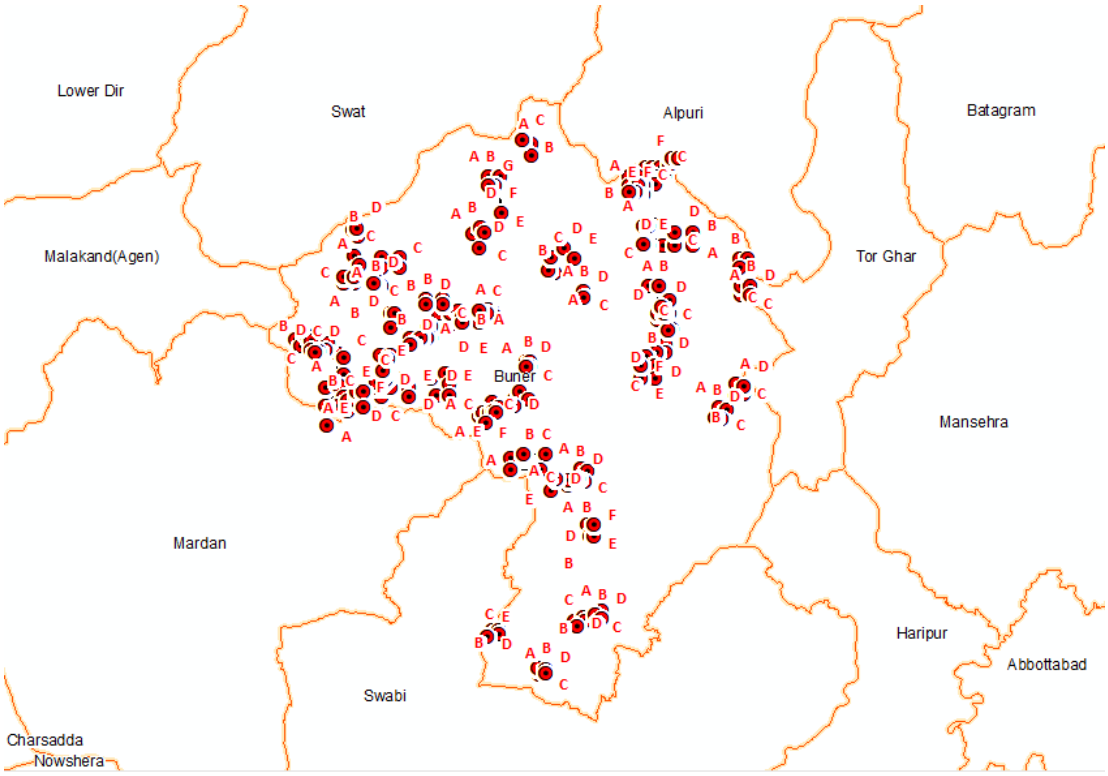


Figure 16 Mining Lease and Prospect Lease files of district Buner. This is a zoomed in view, but the polygons are still not visible because of the difference in scale of the mines and of district.

Advantage

On the other hand, the benefit is that in case of faulty Shape file or the data getting corrupt, the loss will not be as great as in the case of one big file being corrupted.

Disadvantage

The drawback in this method is that once all districts have been completed individually, there is a need to compile those numerous Shape files into one so that they can represent one map of KP. This will require effort and time.

II. RFA file

If we separate the RFA files from the ML and PL files, then we can create one map of the Mining titles which are yet to be Auctioned and the other of the Mines which already have existing ownership or contract.

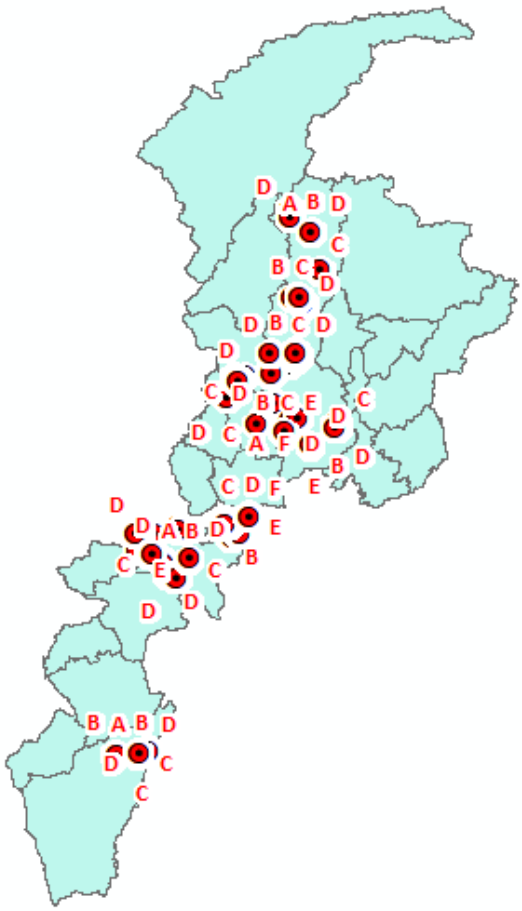


Figure 17 Representation of all the RFA files from a few districts. Note the change in colour of KP map. Such changes can easily be made in any shape file.

3.8 Selective Earth Truthing

Ground or Earth truthing is the procedure of collecting information by direct observation (i.e. empirical evidence) rather than information which is obtained by inference.

3.8.1 Importance

The presentation of the map and its accuracy depends on the input that was given while initially collected data. The methods for initial observations can be: -

- Satellite imagery
- Survey instruments

In case of Satellite imagery, the accuracy is sometimes not as much since resources in KP would not be too large. If the collected data is not precise enough then the mapping process will be affected by it. One meter may not seem too much in one kilometre but when such small differences add up in any map, then they cause big errors. Hence the importance of Ground Truthing is justified due these lackings.

The reason why it is selective and not complete is that the number of locations and sites is very large. It is not possible to go on site and take the readings all over again of all of them. Therefore, we must choose a selective few options and then work on them.

3.8.2 Usage

As the importance suggests, Ground Truthing is used in many fields. Some of which are: -

- Cadastre maps
- Political maps
- Aerial or satellite imagery
- Land Information System (LIS)
- Geographic Information System (GIS)

3.8.3 Instruments

Although in general the most important instrument for the coordinate readings is a GPS, there are still other instruments used in Ground Truthing of other maps and purposes.

3.8.4 Selection of sites

The basis of criteria on which we decided on which sites to go to was: -

- Distance from Risalpur
- Security concerns
- Accessibility (because some mines are located in places where a vehicle cannot go, and hiking is required)
- Administrative concerns
- Size of site (preferably small)
- Mine Title contract phase

3.8.5 Procedure

The procedure is rather simple but a little tricky. We would work in the same syndicate of 5 but only 4 members would go to the corners and boundaries of the sites. Each member is supposed to have a tested and configured GPS, along with a mobile phone or in case of bad reception, a notepad and pen to ensure the new coordinates are noted down so that they can be compared with the original records.

The syndicate leader would stay in the center or the rendezvous point from where he will be in contact with all members. If the reception is compatible, then the members will communicate their observations to the syndicate leader via the cellphones. Those readings will be tallied with the original ones and by the time the team is back, one site should be checked.

Figure 18 Ground Truthing in Panama. A group of surveyors can be seen with their instruments taking measurements. (Institute, 2016)

CHAPTER 4

ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

The methodology of this project is explained in detail in chapter three. In this chapter, the working that was carried out on the lines of methodology will be explained. Specific results from the project will be discussed and analysed. As well as the issues that were encountered in different steps of the procedure will also be explained. In the end, the results which were obtained from the workings will be briefly mentioned. The steps of working are: -

I. Linking of ArcMap and coordinate converter
II. Coordinate Input
III. Joining points into Polygons
IV. Data compiling
V. Finding Points

4.2 Linking of ArcMap and Coordinate Converter

This linking is done from ArcMap settings. The path settings of the shape file are configured and linked to address of the converter. In the left side of the ArcMap screen, it shows the different layers upon which we work. When a layer is not linked with the database there is a marker on it. We left click on that and then the pop up shows the options with which it can be linked. From there the coordinate converter is selected and linked to it.

Fig 19 shows the layer when it is not linked with a database. The error is shown in the form of red exclamation mark.

Fig 20 is when we click on the prompt sign and then this dialogue box shows up. The destination folder in which the data of converter is, is selected here.

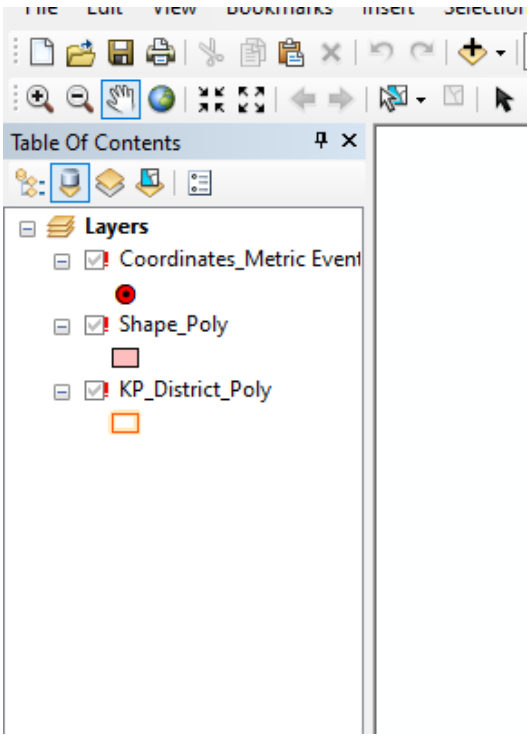


Figure 19 Delinked Database

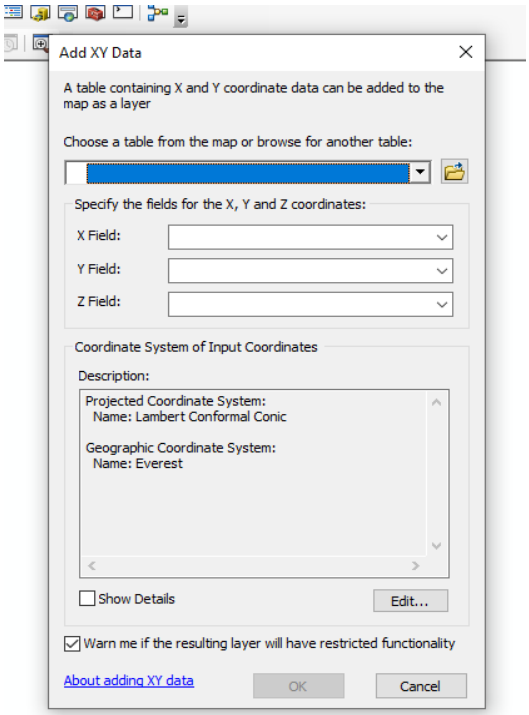


Figure 20 Linking Dialogue Box

After this, ArcMap can directly be opened and worked upon from the coordinate converter.

4.3 Coordinate Input

This step was explained in detail in the previous chapter. As such there are no big issues in the procedure of this step but there can be difficulties in reading the files in which the coordinates are provided to us. These difficulties will briefly be explained in the coming headings.

4.4 Joining points into Polygons

After plotting of the coordinates, they will appear as dots on ArcMap. The properties of the points can also be modified in ArcGIS. Towards the right side of the figure, two Poly files can be seen. To change the points' properties, Shape_Poly is selected and then settings are modified as per desire or requirement.

One thing needs to be kept in mind while doing this step. This was mentioned in the methodology as well.

The files should be input one by one so that a cluster of nearby lying points is not formed on the map which can hinder and affect the formation of polygons.

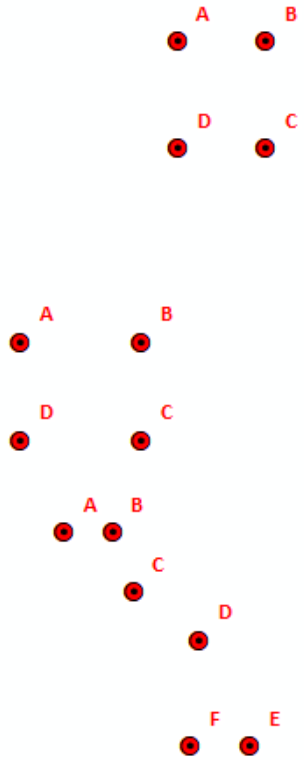


Figure 21 Points without Polygons

The image above shows what happens when more than one files are input into the converter without first making their polygons. Now it is difficult to determine which point belongs to which file and that is troublesome.

4.5 Data Compiling

Any cadastral system can have hundreds of data entries or input. Similar is the case with our mining cadastre system. There are more than 200 mining files registered in the system. To just convert their coordinates and then plot them into ArcGIS would be an uninformed decision. There has to be a system of sorting and compiling this data. Hence, we firstly do that in the converter.

Since converter is a tool, it can be used again and again for different districts of KP. The issue with this is that all coordinate values are similar, so we need to be careful while sorting them.

This was an issue faced where some files were sent later so they were then carefully added to their respective district databases.

4.6 Finding Points

If there is a need for finding a certain point or a polygon, it will be very time consuming and difficult to go through all the points of that district. Even then there is a chance that we might not find the right one. To tackle this problem, we have two solutions.

4.6.1 Go To XY tool

This tool is provided in ArcGIS. It is located in the second tool bar. The purpose of this this is to find a point on the map.

Its procedure is such that we input the X and Y coordinates known to us in the field provided by it. Then it pinpoints the cursor to the point under observation.

4.6.2 From Attribute Table

This method is formulated on a need-based usage by us. Every layer in ArcGIS has its own Attributes Table. When we open that table, we are provided by a list of all the points in that layer. It also shows all digital details of that point.

First, we search the table for our desired point by using the search option. This will take us to that point's row in the table. Next we select that and use the locate option to go to that point on map. This directly zooms in on that point with the cursor.

4.7 Issues tackled

Over the course of mapping there were a few issues which arose for different reasons. Some were simple in nature but some complex. Following are the ones: -

I. Auto arranging of file numbers in converter
II. Mistyping in files
III. Coordinates in meters

IV. Outlying coordinates
V. Overlapping blocks
VI. Shape file error

4.7.1 Auto arranging of file numbers in converter

While inputting the coordinated of any one type of files i.e. RFA or that of any district, there is this issue when for example a file has been entered at no. thirty seven in that coordinate converter, it changes the file's numbering automatically by the time we have made its polygon. So now if for any reason we have to change a coordinate in that file number or recheck it for its shape made on ArcMap, the same very file will no longer be at no. thirty seven.

This happens because while we may be entering files randomly irrespective of the mineral type, the converter has its settings configured in a way that within a set of files from the same district even, it will sort the files of same minerals together for later ease in usage.

Solution: The simple way we can avoid this inconvenience is by sorting out the files of same minerals together before they are input into the converter.

4.7.2 Mistyping in files

As mentioned in the previous chapter, the files are the effort of concerning departments. The raw data that is the coordinates, along with area calculations and shape determination is done by them. Once that data is completed then it is compiled into a file in hardcopy. These files are in some cases written by hand and in others typed. Thus, there is always a factor of human error in them.

To identify this issue, we have to carefully scan each file before inputting its information into the converter and look for any mistakes in the name or other fields.

Solution: The mistakes in names can easily be fixed and updated. But the careful point here is that the correction in file information has to be done before the points are plotted into ArcGIS.

4.7.3 Coordinates in meters

In continuation with the previous point, sometimes the field data is already taken in meters and does not require to be converted. But the issue arises when they do not mention the unit in such files.

These coordinates when converted lie beyond the general series of Easting and Northing of KP. Hence, they can easily be recognized before plotting.

Solution: There is no need to convert them. And even if the conversion has already taken place then they can be converted back into meters.

4.7.4 Outlying coordinates

Some coordinates are wrong. There can be any reason for them e.g. incorrect reading in the field, typing mistake etc.

These coordinates do not fall into the district that they have been entered in. Sometimes the fault can be such that the coordinates lie outside the political boundary of KP.

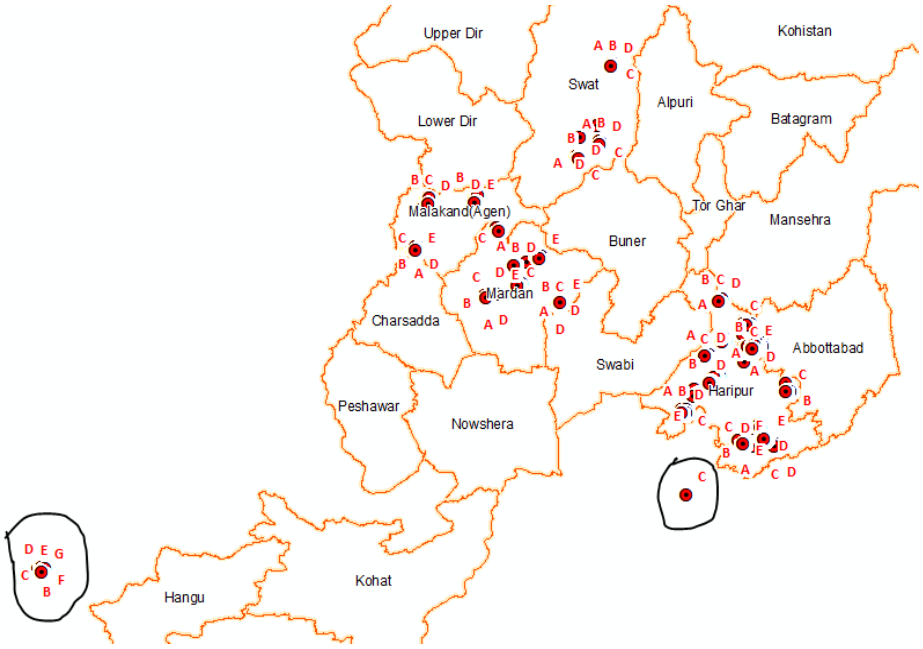


Figure 22 Faulty coordinates. The encircled sets of coordinates are lying outside the political boundary of KP.

Solution: Such coordinates are sent back to the Mineral Development Department. Then when the corrections are made, they can be plotted on ArcMap at any time in the future.

4.7.5 Overlapping blocks

Bigger mining titles have more than one set of coordinates. These are called blocks. One set makes up one block. Mostly these blocks are very close together or they have common coordinates and boundaries. But occasionally is the case where a few blocks have overlapping boundaries.

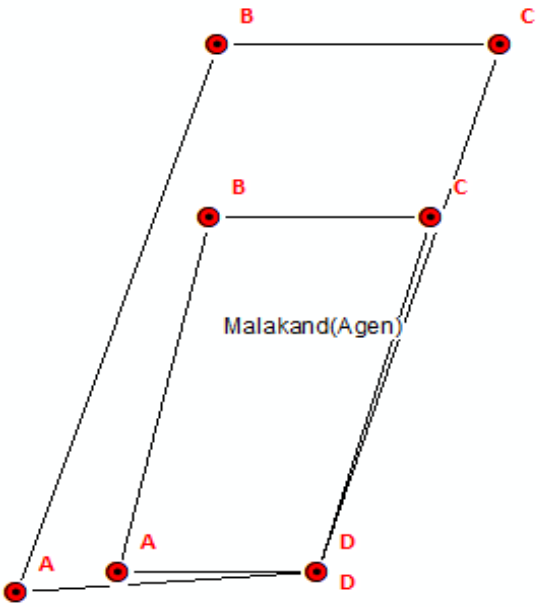


Figure 23 Two blocks of the same mine in Malakand having overlapping areas completely. Overlapped area can vary from mine to mine.

There can be two cases here: -

- Blocks of same mine
- Blocks of different mines

This generally happens either because there is something wrong with the coordinates or the coordinates of the blocks are correct, but they have mistakenly been put together with the file of another mine.

Solution: Consult the department, the corrections will be amended by them and updated in turn.

4.7.6 Shape file error

This is the worst error of all. That is because it causes the most wastage of time and effort. It is noted when the file fails to open or load when ArcMap is loading. Also, when the software itself crashes in the middle of work. There are a number of reasons the Shape file can crash: -

- Power issues
- Virus in system
- If file becomes too heavy
- Unknown reasons

Solution: As such there is no fixed solution for this sort of error, but a few remedial measures are as follows: -

- Keep saving the work after every few minutes.
- Do not overload the file, split the work into more than one files.
- And most importantly, always keep a backup. This backup should be renewed daily if not more than once a day.

4.8 Results

Following are the images of results of some districts of KP.

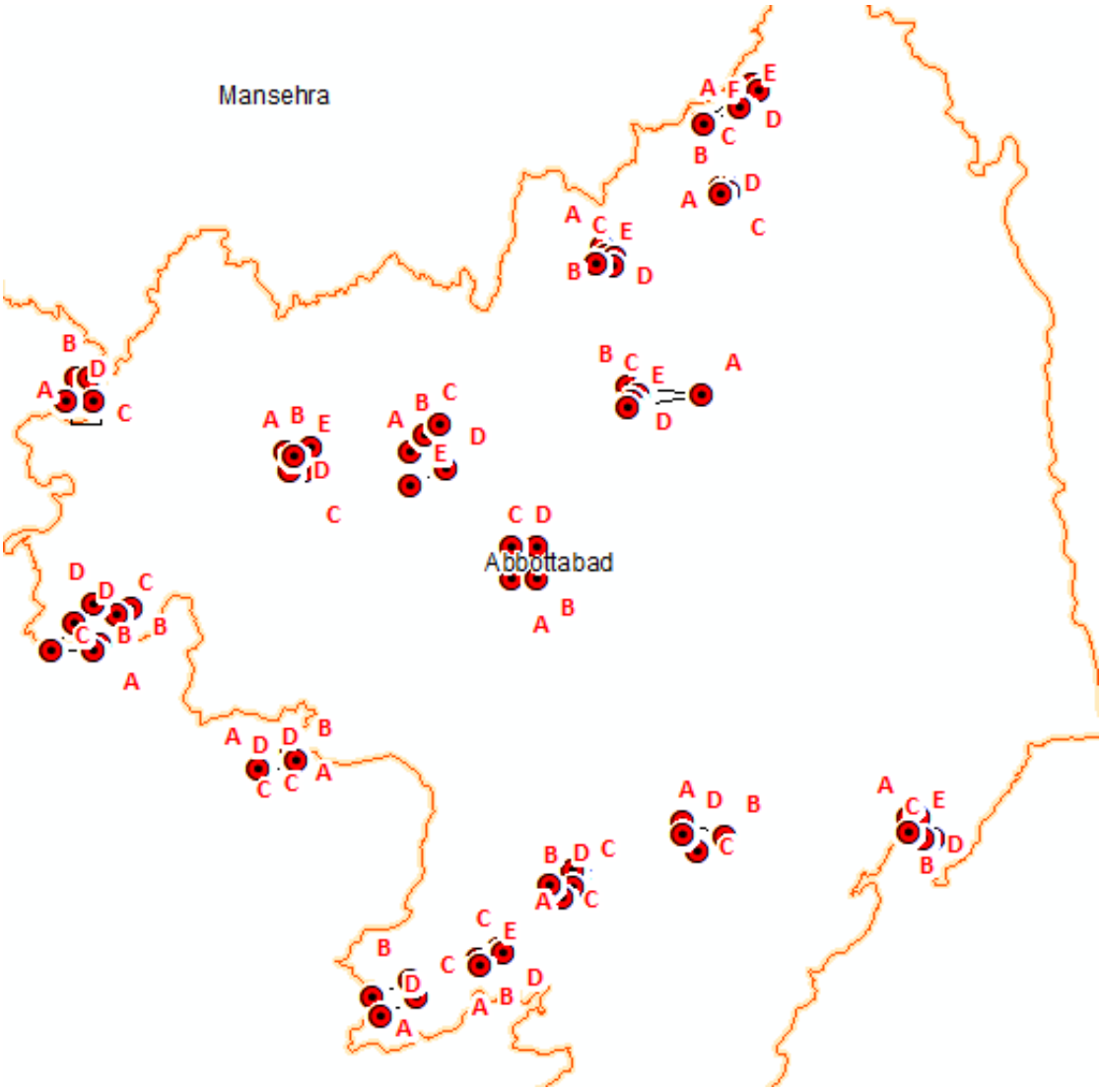


Figure 24 End result of district Abbottabad

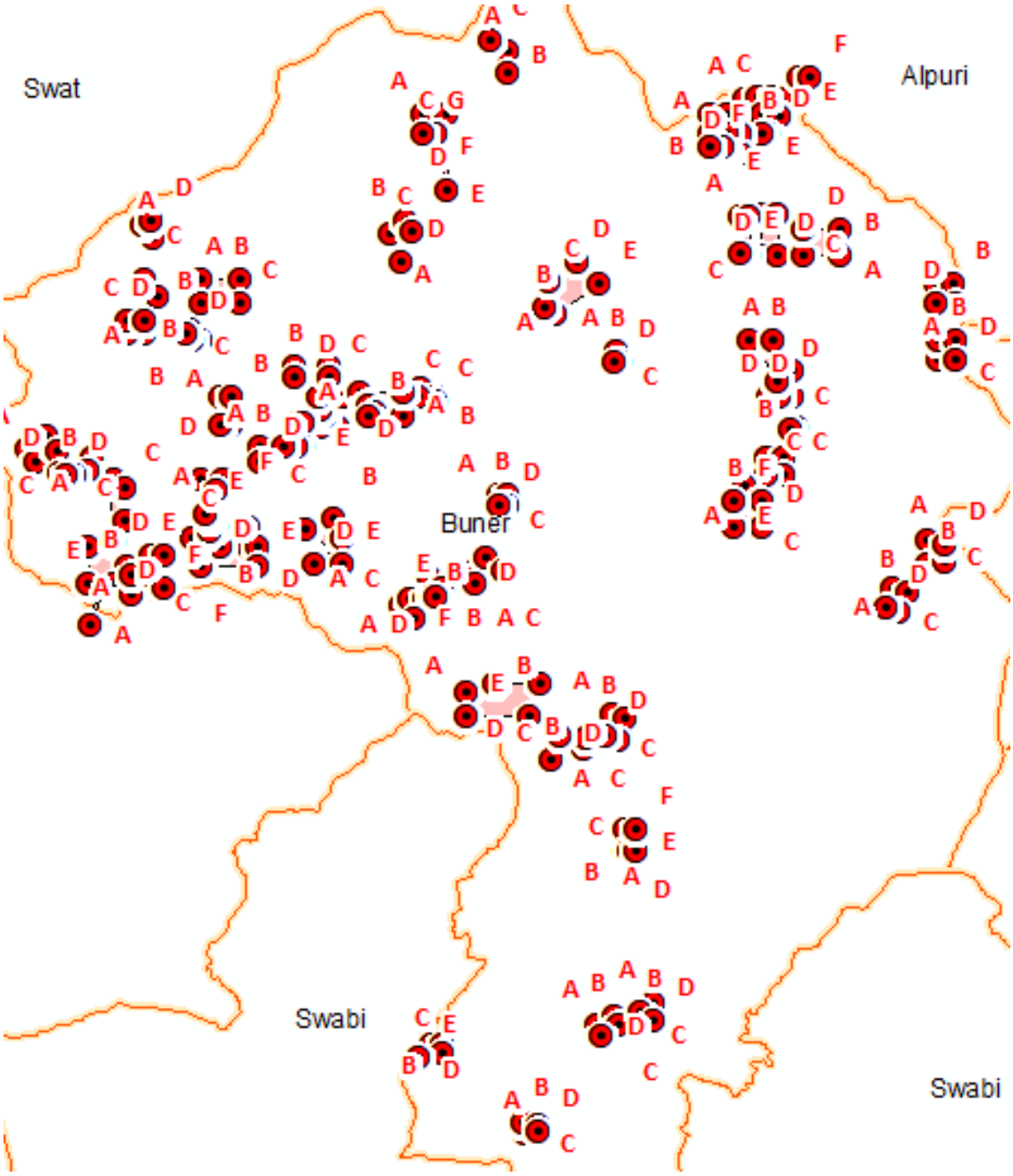


Figure 25 End result of district Buner

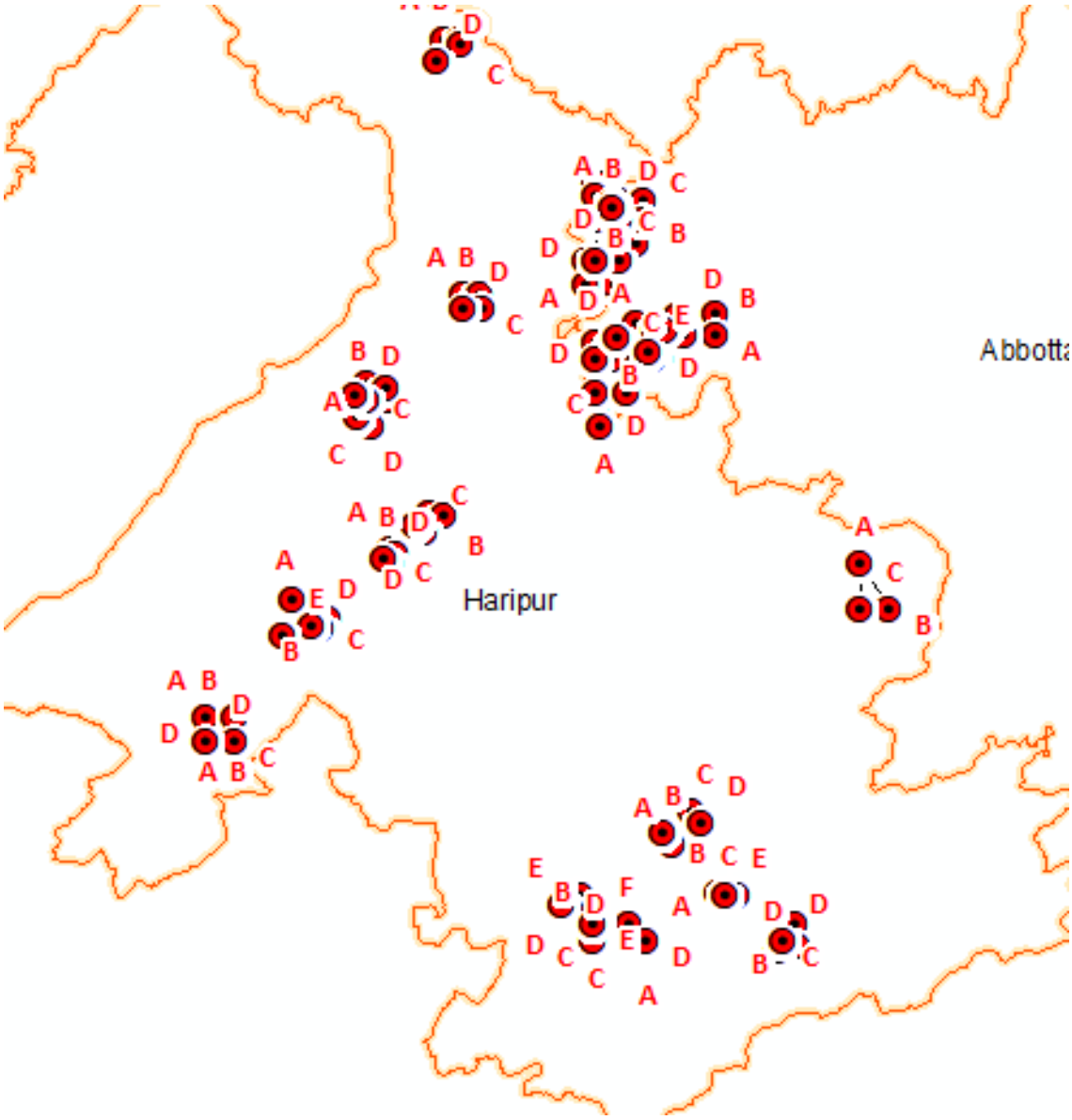


Figure 26 End result of district Haripur

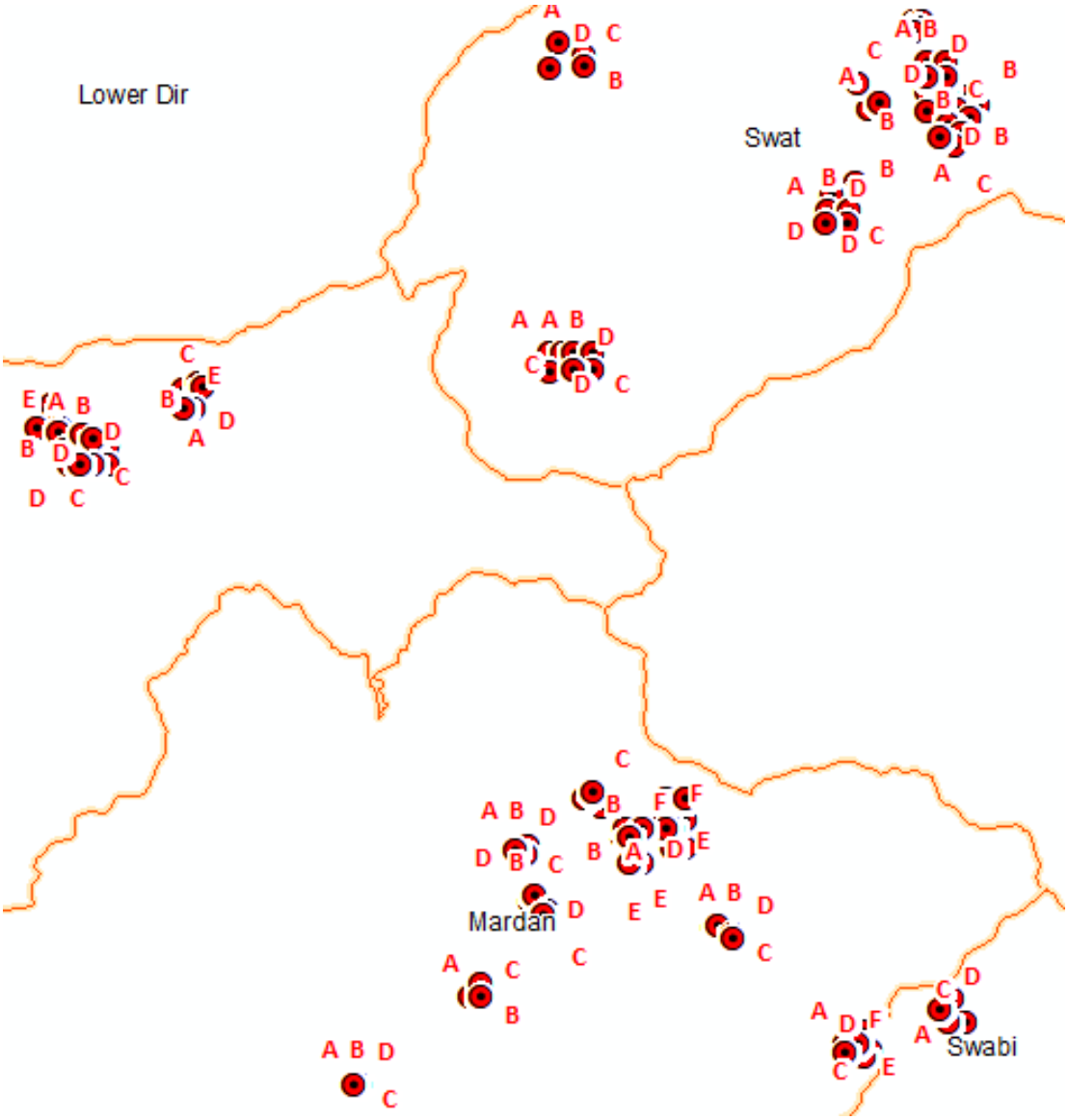


Figure 27 End results of districts Swat, Mardan and Swabi

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion and Outcomes

Outcomes: The auditing and stock taking of all mineral titles data of KP will be possible and ensured. Digital mining cadastre system of KP using ArcGIS is complete. Refer to section 1.4 for these objectives.

Successes: Corrections were made to numerous Mining Titles' records in the process. Goal of efficiency and transparency of mining cadastre system of KP can be achieved through this.

Conclusions: Analogue data is difficult to preserve and keep in its original form. With the help of digitization and digital data we have overcome this problem. With this system, finding record of certain property can be easily done and all the information can be accessed readily within seconds. Issuing of licenses in leasing of mines will be made drastically more efficient. With improved licensing system, transparent ownership and accurate demarcation of the mines, the taxation system will be improved.

This project will serve as a steppingstone for future cadastre-based systems in Pakistan for varying applications.

5.2 Recommendations

I. The mining cadastre system of KP can be used to replicate the same system in other provinces of Pakistan by collecting the relevant data.

II. This idea can be implemented on forest cadastre system, land information system, and other fields where cadastre mapping applies in Pakistan.

III. Out of all the benefits, this will reduce the lack of information about the modern digitized cadastre system and information, so like the digitized mining cadastre system it should be implemented in other sectors as well.

IV. For undertaking the implementation of task of GIS, absence of framework is a hurdle in this process in our country. This should be considered.

V. Like the Coordinate converter tool used in our project, similar data and unit converters can be introduced and made functional to provide the analogue and traditional data into the GIS supported format.

VI. For future use, ground truthing can be made more efficient by using drones and modern survey techniques.

VII. A tool can be designed which will automatically locate the faulty coordinates before plotting them into ArcMap, hence saving valuable time spent in manually doing this procedure.

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