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NARRATIVE OF DIGITIZATION-SUCCESSFUL DRIVE FROM PAPER TO PAPER LESS MAPPING

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Abstract

'Technological breakthroughs are leading the world'-is the most compelling achievement of the digitized world in the recent decade. Likewise, geospatial data modalities have taken unprecedent steps toward the cartographic revolution by letting go the orthodox practices. By all means, digital mapping lays the foundation of a comprehensive Geographic Information System (GIS). Digitized mapping is certain of the utmost transparency and precision of the geographic positions beside shrinking the timelines involved in manually designing the former. However, this transformation is yet to be seen in the developing countries lacking expertise and committed efforts to invest in geospatial infrastructure. Meanwhile, the digital world is skeptic about the accuracy of maps prepared by pursuing the traditional map making techniques. In a bid to move beyond, Pakistan Bureau of Statistics, being the National Statistical Organization (NSO) of the country, has recently geared up to digitize the boundaries of administrative units. Urban frames have already adapted digital format whilst, rural frames are in preliminary phase. Accordingly, digital maps of all urban localities of Pakistan have been prepared so far with the help of satellite images. Whereas, work on the rural part of the district is in process and actively pursued. This paper aims to vigilantly inquire into the digital map making process and how the digital interface preludes greater integration between GIS and census/surveys, expanded coverage and extensive accuracy. In addition to this, the digitized GIS would facilitate in census mapping, avoiding overlapping of area and population and expediting data dissemination methodologies. This technological regime shift could also serve as tipping point leading to the novelty of geospatial big data for which the nations are striving. Apart from all, digitized GIS has the capacity to embrace the area specific policy making by the government leading to informed decisions based on geographical data.

Keywords: Geographic Information System, Geospatial Data, Pakistan Bureau of Statistics, Big Data, GIS applications.

1. Introduction

1.1. Mapping down the Ages

Humans have recognized the importance of mapping since prehistoric times. Maps are in use long ago for making sense about the geography of the world at various dimensions. Babylon clay tablet, roughly belonging to 600 BC, gives us one of the oldest images of how our ancestors viewed the world (Smith, 1996). All the way back to the second century when the world was unfamiliar with the greatest bodies of water and today's super powers of the world were undiscovered, shortly after the invention of paper, primitive mankind sternly started the practice of cartography. In 150 AD, Ptolemy, an ancient Roman geographer set the foundation of science of geography by publishing the scientific treatise namely '**Geography**' containing the eight volumes as well as plethora of maps of different localities of the world along with the indication of latitude and longitude (Shcheglov, 2018).

In the medieval period, cartographers along with the merchants and travels sketched the maps of the places they had visited. Muslims clubbed together the cartography and calligraphy abandoning the over simplicity in mapmaking. Cartography was aptly perused in Arabic and Persian societies, for that matter they translated the work of Ptolemy into Arabic. Advancement of cartography in the Muslim epoch of exploration is notably credited to Al-Khwarizmi, Abu Zayd Al Balkhi and Al Biruni. Al Idrisi, by self-wandering and accompanied with travelers, came up with the Map of the World in 1154 that stood for next three centuries (Tolmacheva, 1995). Expansion of colonization and pursuit of military superiority in early modern period stepped up the need of accurate maps for controlling as much part of the earth as possible. Establishment of scientific research centers and thirst for public learning further aided the complexity and accuracy of mapping (Schulten, 2012).

As the time passes maps become more and more equipped with technological features. 20th century enriched the history of cartography as it embarked the transition from physical to digital mapping. From handmade deficient maps to satellite captured geospatial images, cartography defected the centuries old standards and grab the modern tools and techniques (Crampton, 2004). Advent of aerial photography altered the kind of the data required for mapmaking and no longer required the mapmakers to go far and wide and map the locations. Satellite imagery provided the high-resolution information and

guarantees the accuracy of interface between geospatial information and human users (Haines, 2017). Another headway in the digital mapping is a Geographic Information System (GIS), Global Positioning System (GPS) and Satellite Sensing devices which gained fame in the late 20th and early 21st century. GIS is a computer-based system that allow the users to store, analyze, manage and edit the geographical data. Basically, it transforms the geographical data into geospatial data overlapping the disciplines of cartography and geography (Van & Merwe, 2003). To document the interaction of GIS and cartography, it is necessary to describe the profound effect of digital technology on cartography. When using analog technology, the map served two functions:

1) as a storage medium for spatial data, and
2) as a medium of communication between humans about spatial relationships.

Digital technology has separated these functions into:

1) a digital database containing spatial data, and
2) the ability to create maps from that digital data through automated system. One such system is called GIS.

GIS is based on four component a) computer hardware b) computer software c) data and d) people and live ware. Now, maps are not only adorned with captivating panorama to its user but aid in area specific socio-economic decision making while etching out natural and climate phenomenon (Wieczorek & Delmerico, 2009).

1.2. Why Mapping is Imperative in Census and Survey?

Maps provide the distribution of population for enumeration as well as give the base plan for delimiting the census boundaries. The long-sought GIS have revolutionized the cartography and find its applications in every aspect of human business (Kogure & Takasaki, 2019). GIS has democratized the use of mapping and endorsed data intelligence leading to the big data (Ki, 2018). Mapping is considered as most concrete activity in the population and housing census. GIS applications are now being used in census/survey mapping extending the scope of geographical data analysis, evaluation, retrieving and sharing with greater accuracy and ease. Moreover, it provides the maximum coverage while minimizing the possibility of overlapping and omission of population and area during field survey (Huda, 2017).

1.3. Census Cartography

Map is the visual representation of earth's pattern as a whole or in parts on flat surface drawn with conventional signs corresponding to predefined scale with an aim to illustrate maximum information while occupying minimum space. **Map scale** is the ratio between distance on map to the respective distance on actual ground (Vasiliev *et al*, 1990). Maps can be prepared by physical surveys and photographs as well as hand drafting and sketching. Modern map making techniques include GIS and GPS. Maps can generally be categorized into two groups depending upon their usage: 1) **General Reference Map**, 2) **Thematic Map**. General Reference Map covers variety of locations and features such as cities, towns, rivers, lakes, roads etc. However, Thematic maps are single purpose or single topic maps used for extracting the specific information. Census mapping is the process of dividing the area into Enumeration and Supervisory Areas in order to avoid the overlapping and significant omission of any area.

1.4. Historical Background of Cartography from 1951-98 Censuses

In Pakistan, first census was carried out in the year 1951. In the said census, all sub-divisions in rural areas as well as big urban areas were labeled as census districts. These census districts were further divided into Supervisory Areas (charges and circles) and Enumeration Areas (blocks)[1]. Accordingly, maps were prepared for enumeration, illustrating the boundaries of every charge and circle. District maps and charge maps were drawn up on the scale of 0.789 cm to km and 1.579 cm to km respectively. In the province of Punjab, detailed mapping was undertaken and maps depicting the circle boundaries and corresponding blocks (Enumeration Area) in each circle as per the scale of 1.578 cm to km in all rural areas were sketched out. The census of 1961 was executed on the patterns of previous census. However, some valuable additions were made in the mapping, for instance, apart from the mapping of districts, circles and charges, blocks (Enumeration Area) were also mapped in urban areas.

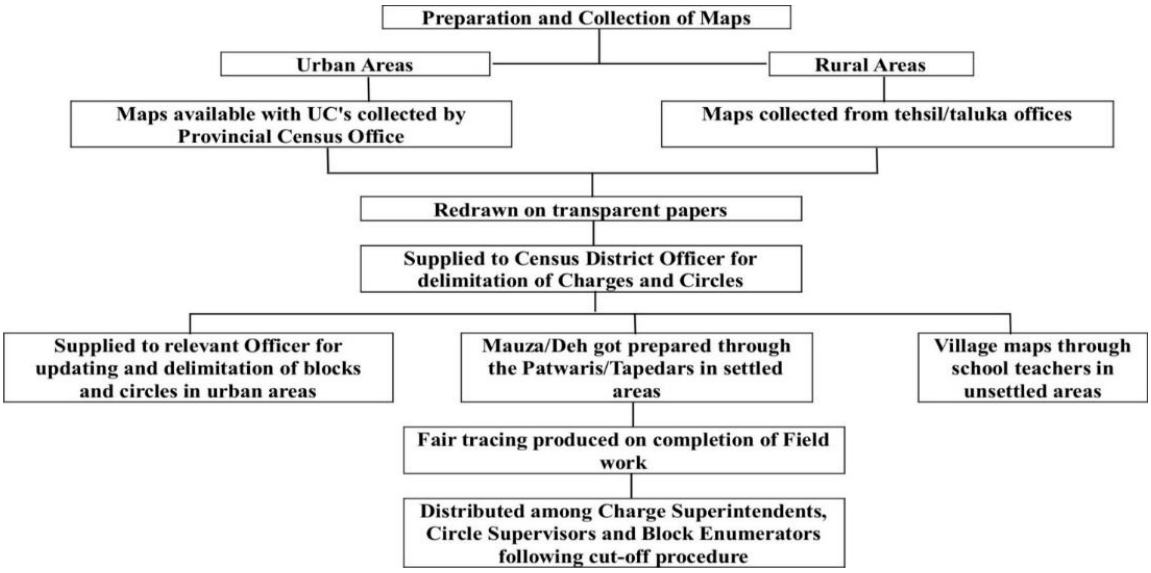
In the census of 1972, a comprehensive exercise for detailed mapping of the whole country was carried out. Maps of urban areas including cities, towns and cantonments were gathered from concerned agencies such as Municipal Councils, Town Committees and Cantonment Boards. As regard rural areas, Revenue Department provided maps of *Tehsil/Taluka* and also prepared maps for other areas in their jurisdiction. These maps contained boundaries of census circles and charges. In case of any explicit inaccuracy, the same was eliminated with the consultation of concerned agencies. In the census during the year 1981, further

[1] A Block (Enumeration Area) consists of 200-250 houses on average.

tiers were added by making the subsequent subdivision of census districts in Punjab, Sindh and KP. Moreover, map making practices were further upgraded in 1981 census, subsequently, distinction was made between big urban areas and small urban areas. Master map was prepared for the former to delimit census charges and circles. Furthermore, to demarcate the boundary of census block (Enumeration Area) , separate maps were designed for electoral wards. In the later, master map covering the entire city exhibiting the census circle was canvassed. 5th Population and Housing Census was conducted in 1998 and deep attention was given to the mapping of rural areas. Sketch maps of mouza/village of Pakistan including Gilgit Baltistan and AJK, were got prepared through revenue and local government staff school teachers in the settled and unsettled rural areas respectively reporting the number of houses in each settlement.

Due to the consistent increase in the population, census tiers were extended which necessitated more extensive map making leading to ultimate improvement in the head count over the time. Manual map making techniques were utilized in the first five censuses consuming human resources as well as great deal of time. In the first five censuses, process of mapping involved multiple steps as illustrated in the fig 1.

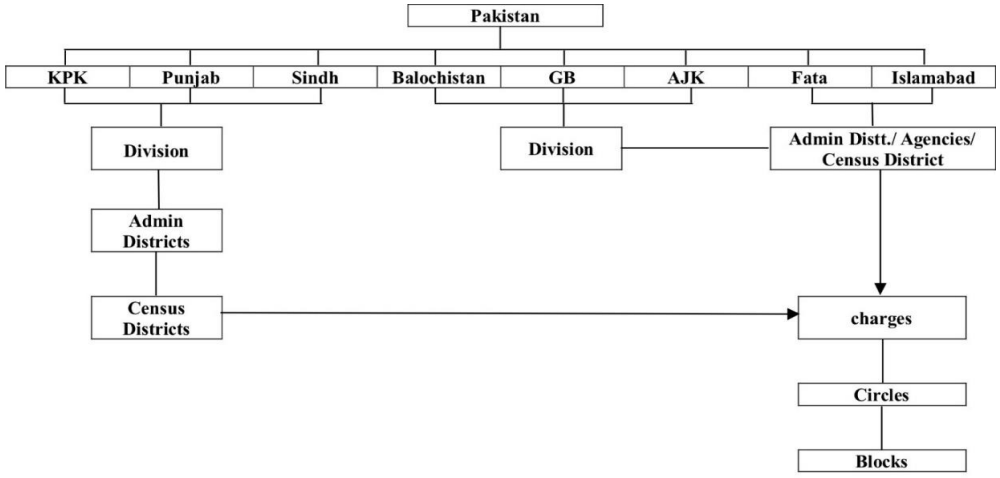
Fig 1: Manual Mapping Procedure



2. Methodology

Digital maps were used in all urban areas for field enumeration first time in the history of census taking process in Pakistan. At the onset of transition towards the automated methods, manual map making is ousted by GIS mapping in the Population and Housing Census of 2017. Census data have been collected through delineation of following census tiers, illustrated in Fig-2.

Fig 2: Administrative Division for Census Delineation



In Census-2017 PBS, being NSO, have prepared maps of both urban and rural areas describing the geography of whole country as detailed in Appendix 1. The rural area frame have settled and unsettled areas. In the settled rural areas, *mauza/deh* is the smallest revenue estate with predefined *patwar* circles and accordingly, their maps are maintained in the Revenue Department. The smallest revenue maps are known as *masavies*, sequentially, these *masavies* are *mosaic* to extract Mouza boundaries. However, in the unsettled rural areas, village is the smallest unit and their sketched maps are available with local government. As far as urban municipalities are concerned, they are divided into small and big urban areas. Urban areas having population of 50,000 and greater according to the 1998-Census was declared as big urban areas. As done in the previous censuses, 2017-Census had four census administrative tiers i.e. district, charge, circle and block (Enumeration Area). Enumeration mapping for the 2017-Census is as follows:

1. For the big urban areas two types of maps were prepared 1) Master map which covers the entire city/town for delimitation of census charges and circles, and 2) sub unit map which may be circle map to delimit the census blocks.
2. For small urban areas only single type of map was designed to delineate both census circles and census blocks.
3. In case of rural areas, *tehsil / taluka* maps were prepared to delimit census charges and circles while census blocks were demarcated on *mouza* and village maps in respect of settled and unsettled areas.

GIS mapping model employed in Census -2017 was based on micro level maps (layout/sketched maps), satellite images from google earth, Database Packages for layering and conversion (e.g. ArcGIS, Microsoft database), Plotters/Scanners, High end internet connection and supporting technological equipment for Data Processing and GIS. The procedure adopted for GIS mapping of the urban and rural area blocks is illustrated in figure 3 & 4

Fig 3: Procedure of Urban Blocks Digitization

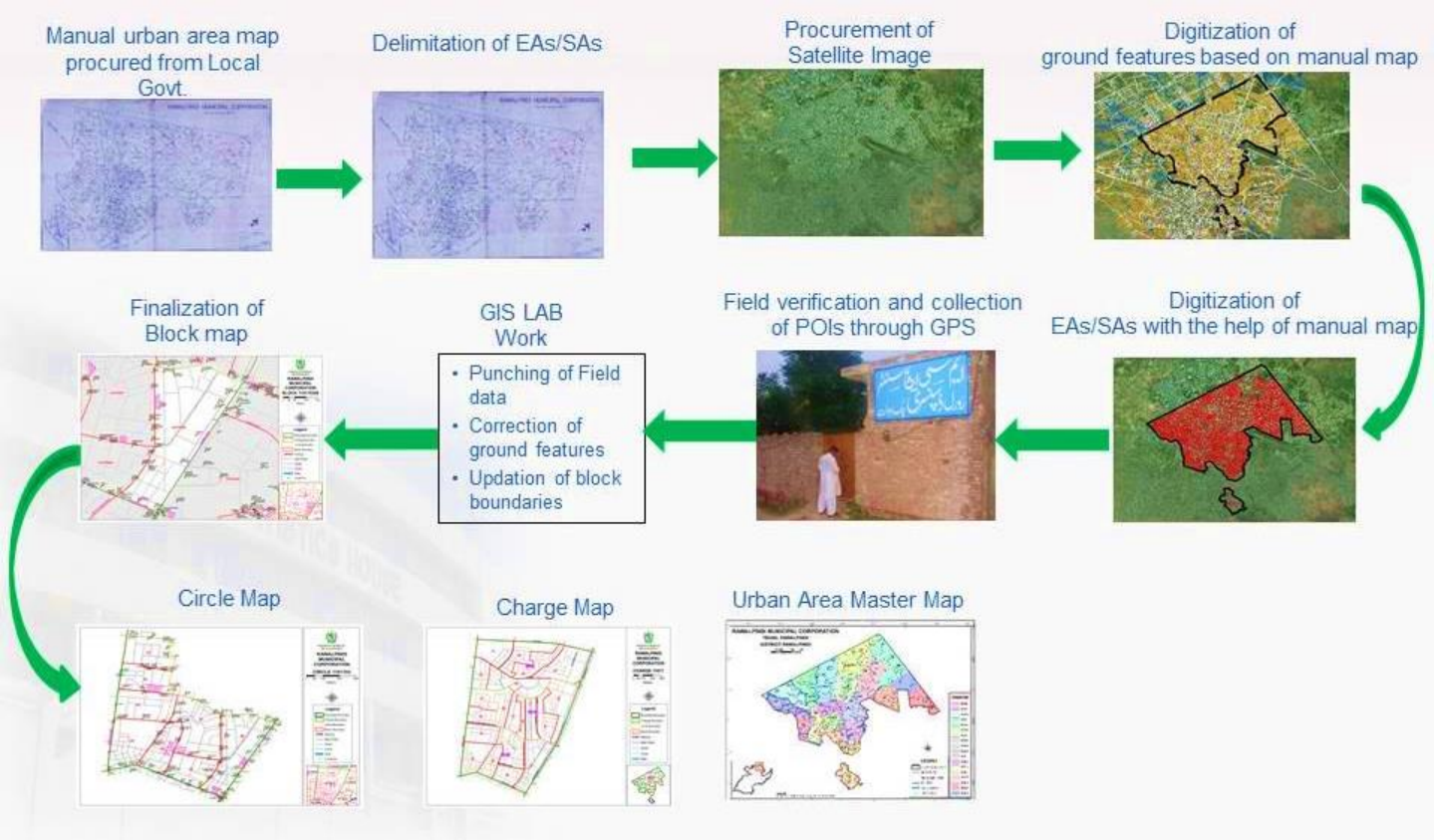
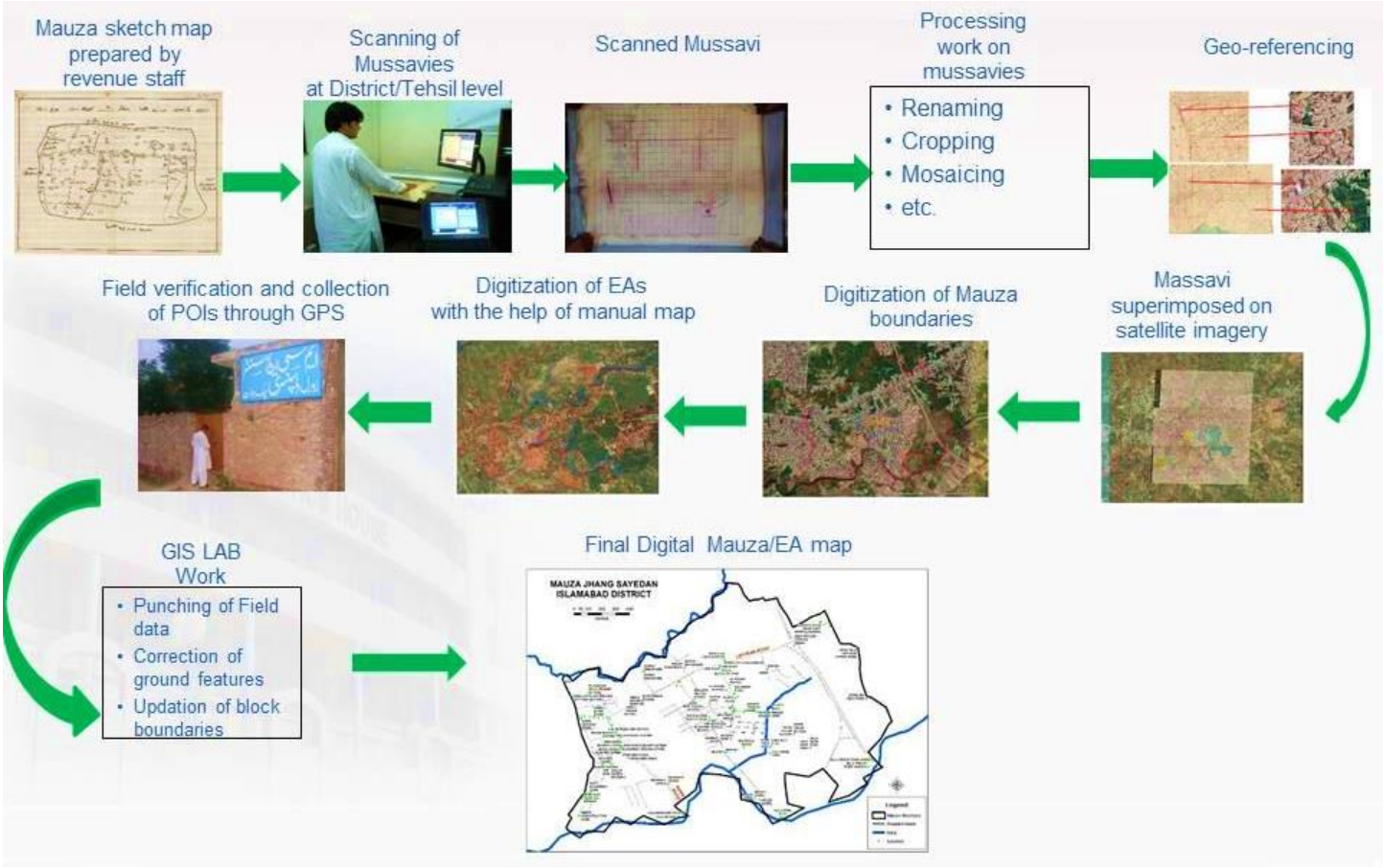


Fig 4: Procedure of Rural Blocks Digitization



3. Results

Census is the decennial activity which covers the huge range of socio-demographic information about the country's residents. Maps which demarcate the census boundaries are fulcrum in the whole census process. Applying the GIS mapping, the digitization work of all **55,560** Urban Blocks (Enumeration Area) of 616 Urban Areas of Pakistan have been completed. Similarly, the digitization work of **24,235** out of 113,384 Rural Blocks (Enumeration Area) also has been completed so far (transformation of manual maps into digital form in respect of urban and rural area is depicted in Appendix 2). Table 1 illustrates the progress of GIS mapping in respect of urban and rural areas.

Table 1: Progress of Urban & Rural Blocks Digitization

Province/ Area	**Urban Area**		**Rural Area**		
	Total Area	**Digitized Block maps**	**Total Blocks**	**Punched**	**Digitized Block maps**
Khyber Pakhtunkhwa	67	3267	22538	15386	2599
Punjab	255	27162	53885	45735	15831
Sindh	202	21892	17239	13584	1863
Balochistan	61	1839	8383	2441	372
Islamabad	1	726	6745	3417	3570
Azad Kashmir	25	526	3496	77	-
Gilgit Baltistan	5	148	1098	-	-
Grand Total	**616**	**55560**	**11384**	**80640**	**24235**

Digital mapping in Pakistan, inaugurated through GIS applications, has following preemptory limitations in its applications:

1. Country is deficient of adequate technical expertise in the implication of GIS mapping due to the lack of GIS professionals and expertise.
2. GIS software and related supports have fallen in prices over the year but still expensive as well as requires the professionally trained work force that is also expensive and costly to retain.
3. Satellite imagery captured through Google Earth is not only expensive but also old. These images are not available for the whole country especially for rural areas. Images available for urban areas are at least two to three years old and have not been updated to cover the new settlements established in those areas.

4. Conclusion

In past, about 880,000 km^2 area of Pakistan was mapped through traditional cartographic approaches. For conducting the census, the department needed to hire the mapping staff and impart them the necessary training. Apart from the laborious efforts involved and inadequacy of resources, continuous variability in the boundaries of census tiers made this task challenging. Moreover, timely communication of the updated boundaries among and by all stakeholders was the additional challenge. Diffusion of GIS technology in the mapping procedures has completely altered the way in which the country can be mapped. GIS has not only made certain the legitimacy of census mapping as well as yield the most organized and disciplined census in the census history through the credible demarcation of census areas. The benefits of GIS mapping are not restricted to the census and it also opened the way for more informed decision making at governmental level and invited the stakeholders for further research in this domain.

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Appendix 1

Table 2: Pakistan: Detail of Administrative Units as on 25-05-2017

S.#	Administrative Units	Divisions	Districts	Census District	Tehsil	QH/ STC	PC/TC /UC	Mouza/ Dehs/ Village	Metro. Coorp.	District. Metro. Coorp.	Municipal		Town Comt.	Cont.	Total Urban Areas
											Coo.	Cont.			
1	KPK	7	25	82	71 #	268 +	1853 +	7977	-	-	1	38	12	11	62
2	FATA	-	7 &	7	42	43$	281 $	1679 $	-	-	-	-	5	-	5
3	Punjab	9	36	166	145 **	813	7592	25321	1	-	11	187	36	20	255
4	Sindh	6	29	146	138 ##	275	1465	5717	1 *	6	3	37	148	8	202
5	Balochistan	6	32	35	133 @	213	542	6419	1	-	4	52	-	4	61
Total		**28**	**129**	**436**	**529**	**1612**	**11733**	**47131**	**3**	**6**	**19**	**314**	**201**	**43**	**585**
6	Islamabad	-	1	1	1	2	32	129	1	-	-	-	-	-	1
7	AJK	3	10	10	30	69	383	1647	-	-	5	13	7	-	25
8	GB	3	10	10	23	30	120	600	-	-	-	5	-	-	5
Grand Total		**34**	**150**	**457**	**583**	**1713**	**12268**	**49507**	**4**	**6**	**24**	**332**	**208**	**43**	**616**

& : Excludes Six Tribal Areas Adjoining to 6 Admn. Distts.

: Includes 15 Tehsils of un-settled part of Khyber Pakhtunkhwa (KP) (Chitral, Upper Dir, Lowe Dir, Malakand PA, Torgarh & Kohistan).

**: Including tow de-exclud3ed areas.

@ : Includes 47 sub-tehsils.

+: Tehsils and Union Councils have been treated at par *Qanungo Halqa* and **Patwar Circle**, respectively in Chitral, Dir, Malakand, Torgarh & Kohistan Districts.

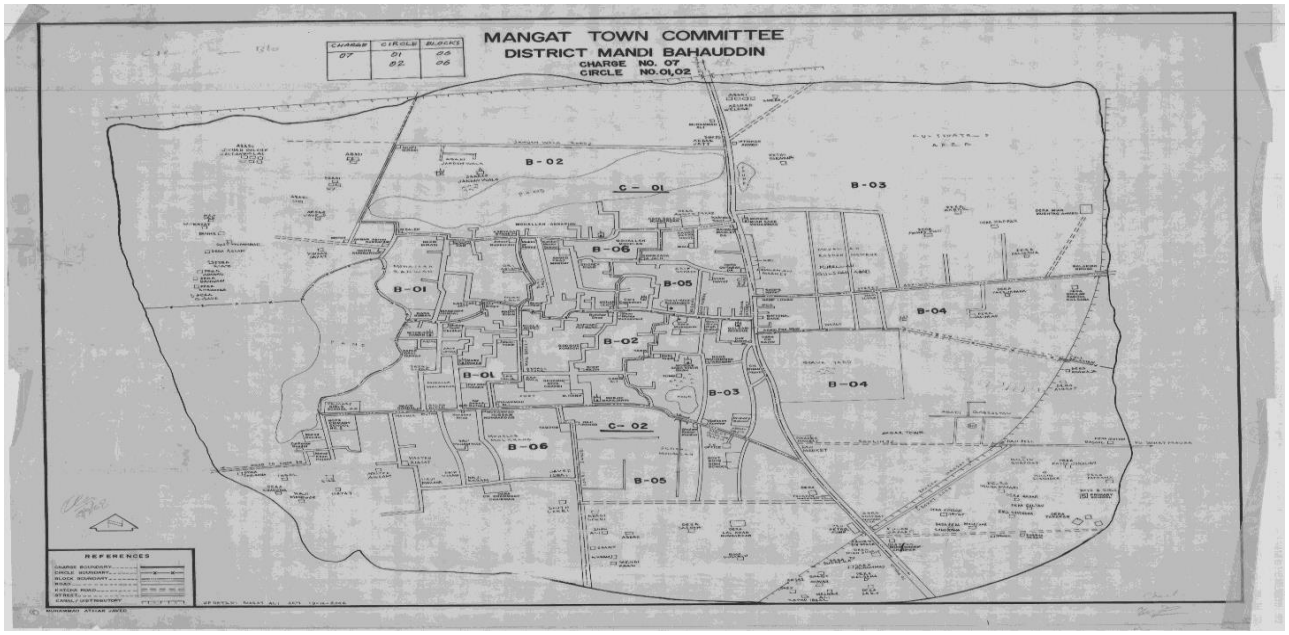
$: In FATA number of Tribes, Section and Villages have been shown in place of QHS, PCS and Mauza.

: Including 31 sub-divisions of Karachi Districts.

* : 6 districts municipal corporations of Karachi Division constitute Karachi Metropolitan Corporation.

Appendix 2

Fig 5: Transformation of Manual Map into Digital Form (Urban Area)



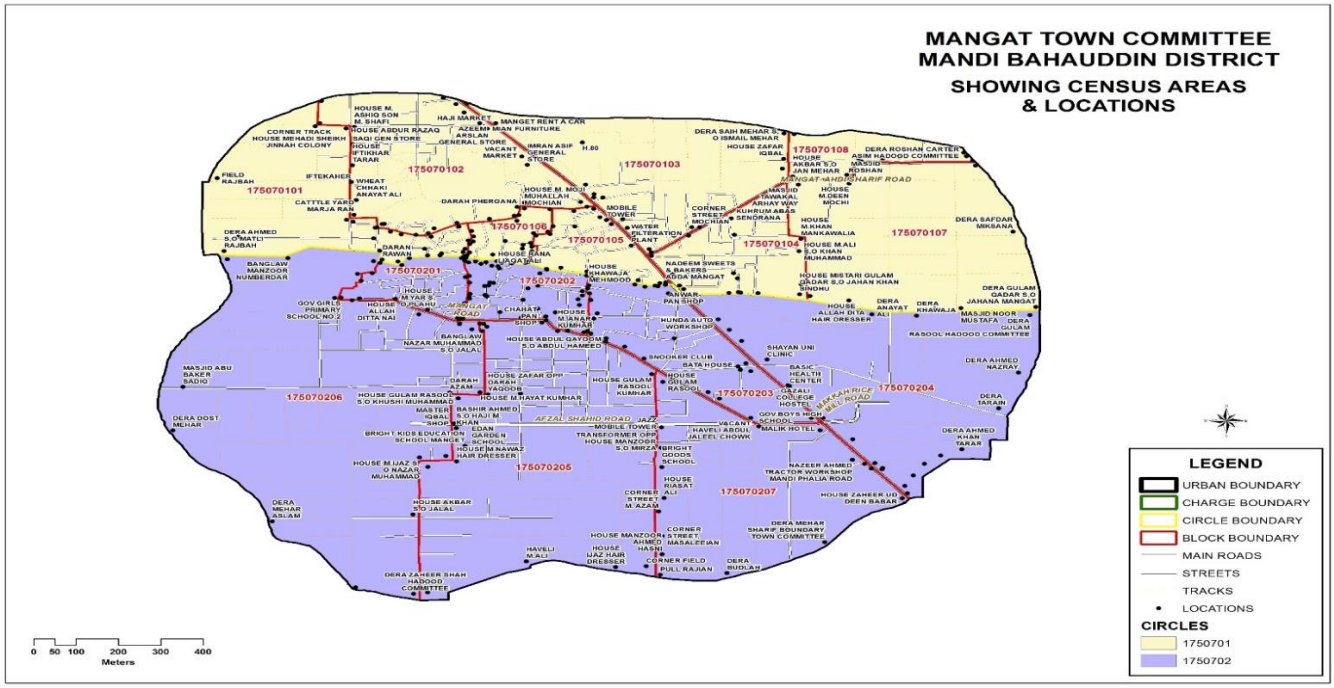


Fig 6: Transformation of Manual Map into Digital Form (Rural Area)