Final Progress Report of the GIS Project of Sindh Education Reform Programme (SERP)

Basemap Development and Risk Appraisal

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1. INTRODUCION

Pakistan is having one of the lowest rate of literacy in the region of South Asia (about 55%), whereas, the female literacy rate is only 40%. Even with this rate of literacy the real spending of the Pakistani Government on education sector is even less than 1.6%. The situation is even worse in Sindh Province having a literacy rate of 45% only; especially in rural areas the condition is further deteriorated with one of the lowest literacy rates. There are about 50,000 schools in Sindh and millions of students. The situation of these schools physically and in terms of imparting knowledge is catastrophic. This has been timely noticed by the World Bank and they have taken several initiatives in Pakistan, such as the Sindh Education Reform Project (SERP). The management and maintenance of these schools is a serious challenge for the decision-makers. It is an established fact that with the advent of new technologies such as Geo-informatics the management of schools is highly effective and cost effective. Therefore, for the effective management of schools and education system World Bank has implemented and recommended the Geographical Information System (GIS) on many projects around the Globe (Bigman and Fofack, 2000). In continuation of the GIS project conceived by the World Bank for supporting environmental management decisions in public education for the Governments of Sindh and Punjab. In this regard, the Department of Geography, University of Karachi (DoG-KU), Karachi, Pakistan has been awarded with the ***"GIS Development, Deployment of Software and Training Project***," to formulate a strategy to evolve a project on the prescribed objectives as set-forth by the World Bank to implement Environmental Safety in the Schools of the Sindh Province. The basic objective of this project is to assist Government of Sindh (GOS) in the management of a wide range of schools across all areas of Sindh Province. This data would certainly leads to improve in the basic infrastructure, greater efficiency and better decision-making. The use of GIS technology considerably expands opportunities to analyze the risks of the disaster on various kinds of infrastructure with the help of various thematic layers, such as hydrology, geology, transportation, administrative boundaries etc.

The SERP GIS Database shall be oriented towards the requirements for the management of a wide range of schools across all areas of Sindh Province and its subsequent monitoring and evaluation. It provides a platform from which more detailed, extended and sophisticated systems could be built. Drawing on existing cartographic data, the database will be characterized by an integrated data and mapping system which can support policy setting, planning and public information for Sindh's education sector. At the initial stage, all possible resources were explored to tap digital and hard copies spatial data. These included visits to many Federal and Provincial Government agencies and private organizations. After the collection of geo-spatial data, the major task is the development of the relevant attributes using the parameters of the initial framework. The relevant spatial data, as presented in the first progress report, followed by mapping of geographical features as the second stage. For this purpose, following objectives has been set-forth to formulate a GIS database of the international standards to serve as an integrated tool for the school management in Sindh.

2. MAJOR OBJECTIVE

To develop Comprehensive GIS system as an integrated platform to incorporate fundamental thematic GIS layers (cultural and physical features) along with the significant hazard intensity layers as provided by the other components of this project (geology and hydrology). This tool would instantly estimate the risk exposure of the schools located in various districts of Sindh province from various natural calamities.

2.1 Objectives

a) To design a strategy for the Development of GIS for SERP;
b) To identify the list of the layers and their hierarchy (ER Flowchart);
c) To develop thematic layers of physical, cultural and environmental features;
d) To transform all the collected and developed GIS data on an identical projection system (preferably WGS-84);
e) To populate the attributes of each digitized layer;
f) To rectify the topological errors from each layer; and
g) Verification of Digitized Layers on Google-Earth Portal (High Resolution data)
h) Formation of Customization Layers; and
i) Development of Risk Model and Appraisal of the School at Risk

Furthermore, following actions have been taken to address the various issues and recommended solutions to resolve these problems:

3. IDENTIFICATION OF ISSUES AND ACTIONS TAKEN

a) Resolution of the data (Data uncertainty and quality);
b) Implementation of Snapping and topology rules;
c) Data standardization (normalization of the attributes);
d) Application of Topology modules to remove the errors;
e) Positional Accuracy Issue of Sindh Schools and Recommended Solutions; and
f) Precision of the Spatial Data

4. COMPONENTS OF SERP GIS MAPPING SYSTEM

SERP GIS database is recommended to be multi-purpose as it will be used by the forthcoming projects and various agencies like the World Bank, Education Sector of the Province, Town Planning Departments, Local Bodies, Public Works Departments, Services and Utilities Agencies, etc. Hence, the Design for SERP GIS comprises of the following major components:

4.1 **SERP GIS Mapping System**: The digital-base automated system that has ability to visualize, store, retrieve, manipulates and analyze related to school and associated spatial features. The GIS Mapping system mainly divided in three major components:

a) Base Mapping (Thematic GIS Layers as the foundation layers);
b) Geological layers (basic layers needed for the assessment of seismic risk);
c) Hydrological Layers (added to evaluate the risk of floods, cyclones and tsunami); and
d) School Risk Attributes

4.2 SERP School Management Information System: The system is capable of storing non-spatial attributes (such as the details of associated accessories, number and gender of students etc.), relationships and strategies, which ultimately needed to be integrated into spatial system to facilitate the school management in Sindh.

This SERP-GIS System would be a specialize solution to School related management services, maintenance services and access to the large information database that have to be organize in such a manner that the concerned department(s) will retrieve the required information with specific geographic location by using the GIS software user interface with a click of a button. The GIS project will provide a foundation for the other components of the project, mainly, geology and hydrology. The layers identified by the geologist and hydrologist will be integrated in the final GIS system to evaluate the risk exposure of the schools to various hazards, especially floods, earthquakes and cyclones. This would facilitate the management, development, renovation and maintenance schools promptly and would explore the opportunity to built schools on safer places having low vulnerability to natural hazards.

The GIS platform will integrate and superimposed all the layers and would calculate the risk exposure of each school both on vector layer and attribute data formats. Each hazard layer has been developed as vector layer containing geometry and attribute of each thematic layer. With the help of Weighted Overlay Analysis technique of GIS the risk zone (low to high intensity) of each hazard will be summed-up together to enumerate the accumulated risk of the hazards. Furthermore, the risk of each school has been determined in a tabular format through the attribute data showing the risk intensity of each occurring hazard. In addition to that the intensity of the risk will be filtered out by various geographical features such as (accessibility, settlements, canals, streams, etc. Each and every frequent hazard such floods, cyclone and earthquake treated as the **contributing factors** in the risk exposure appraisal of the schools. In addition to that the intensity of the risk will be filtered out by various geographical features such as (accessibility, settlements, canals, streams, etc.) termed here as **controlling factors**. The information for both contributing and controlling factors has been developed both in spatial (geometry) and attribute (tabular) formats.

5. GIS MAPPING METHODOLOGY

The design methodology is based on the water fall model approach to accomplish the World Bank Initiatives and SERP. The waterfall model is a highly structured approach to a project life cycle that cascades linearly through the developmental phases of requirements analysis, design, implementation, testing, integration, and maintenance (ESRI, 2012). Methodology we have adopted comprises of following stages:

- Identification of target layers for GIS, mainly categorized as Physical and Cultural features;
- Displaying environmental, land-use, and socio-economic data on maps using GIS thematic layers;
- Identifying conflicting data attributes and presentation of these datasets uses via GIS layers to avoid redundancy and sustainable utilization of resources; and
- Development of prioritizing uses, based on analysis of natural and economic resources and land-use features
- Development of spatial geo-databases by using primary information and evaluation of land uses, and display via GIS layers

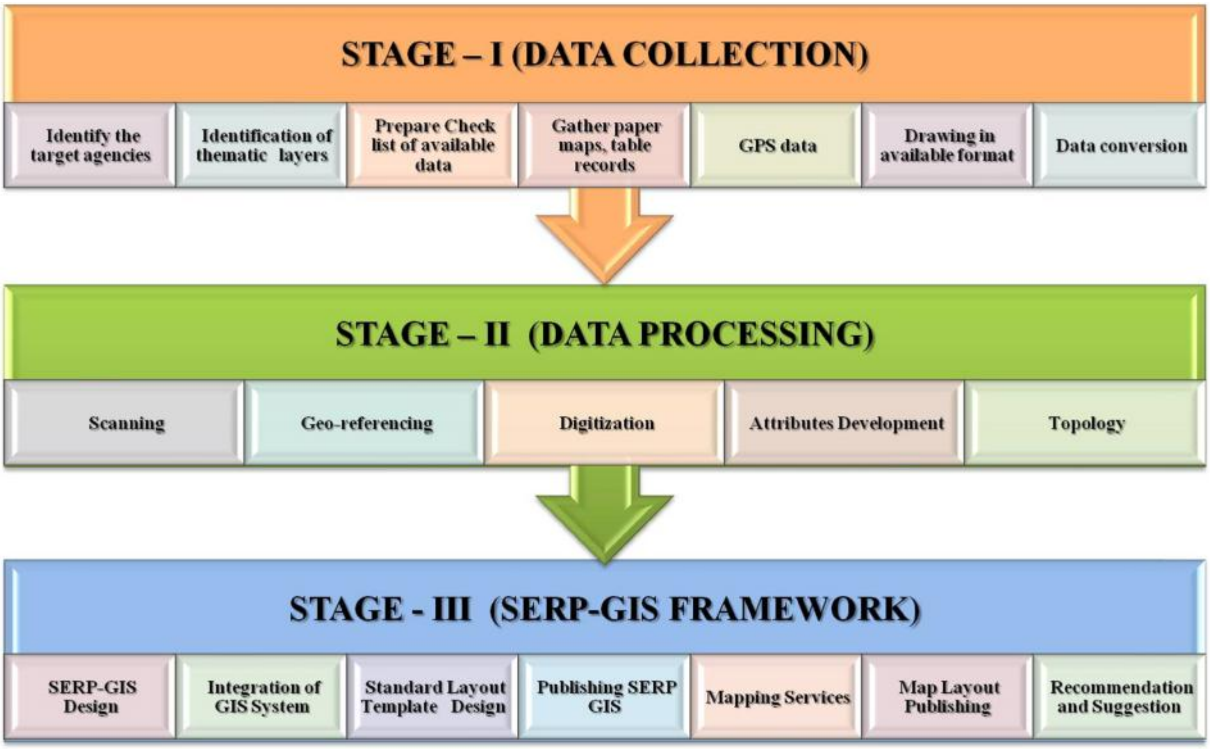


Figure 1: GIS Design for SERP

6. DATA COLLECTION STRATEGIES

Collection of relevant spatial data is essential requirement for the development of a GIS that would support the effective school management in Sindh. On the bases of the consideration of School related data collection the design strategy based on following main issues:

1. Data need assessment;
2. Data Quality;
3. Data redundancy issue ;

These three objectives are correlated to each other and linked with the following strategic initiatives:

1. Utilization of the existing information data sources (both digital and hard copies) for Vector data development as per the needs of the Sponsoring and User agencies, as outlined in the TOR;
2. Preservation of the quality of vector data by preserving the identical digitization scales; and
3. Rectification of data redundancy from the collected through geo-processing techniques.

Collection of data from various departments is the most critical and time consuming activity of this study. Nevertheless, some of the vital information has been obtained from highly credible sources. Most of these datasets are in hard copy format and un-projected digital (in pdf & jpeg) maps collected mainly from following national and international sources:

i) National Sources

1) Population Census Organization, Government of Pakistan
2) Survey of Pakistan, Government of Pakistan
3) Geological Survey of Pakistan, Government of Pakistan
4) Soil Survey of Pakistan, Government of Pakistan
5) Pakistan Meteorological Department
6) Water and Power Development Authority (WAPDA)
7) SUPARCO
8) Pakistan Agricultural Research Council (PARC)
9) Board of Revenue, Government of Sindh
10) Sindh Education Reform Programme (SERP)

11) Ministry of Transportation, Government of Sindh
12) Sindh Wildlife Department, Government of Sindh

ii) International Sources

1) World Bank
2) Office for the Coordination of Humanitarian Affairs (OCHA), United Nations
3) MapAction, United Kingdom
4) Centre National d'Etudes Spatiales (CNES), France
5) German Aerospace Center (DLR)
6) NASA, USA
7) USGS, USA

7. IDENTIFICATION OF THE LIST OF THE THEMATIC LAYERS

The data obtained from these sources have been converted into projected digital formats, mainly identified as the following layers (Figuer-2):

1. Physical features
2. Cultural features

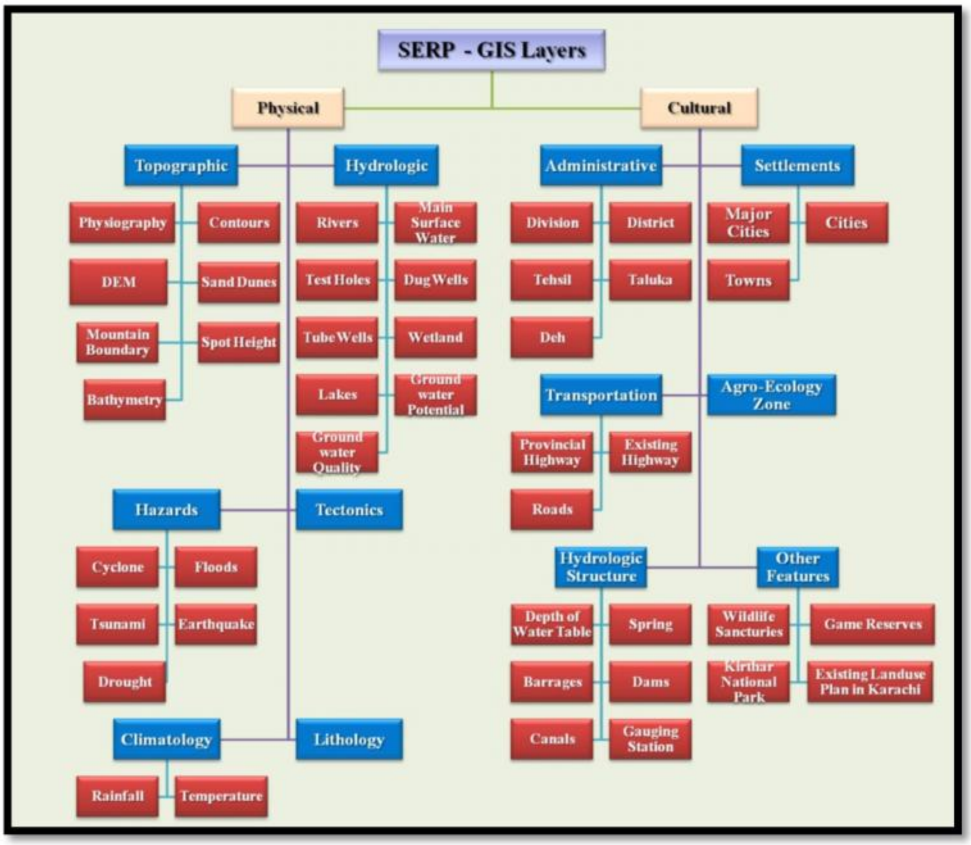


Figure 2: Thematic Layers of the GIS

8. DEVELOPMENT OF THEMATIC LAYERS

8.1 Physical Features

The physical are mainly divided mainly divided in topography, hydrology, geology, climatology and natural hazards. Following is the brief description of these characteristics:

8.1.1 Topography

The topographical features mainly extracted from the various tiles of SRTM (Shuttle Radar Topographic Model) data of NASA on 30 meters. However, at few places it has been modified with the spot-heights acquired from the hydrological sheets of WAPDA, mainly driven from

Survey of Pakistan topographical sheets. At the first stage, the Digital Elevation Model (DEM) extracted from SRTM data, which is then converted into relief contours (Figure – 3).

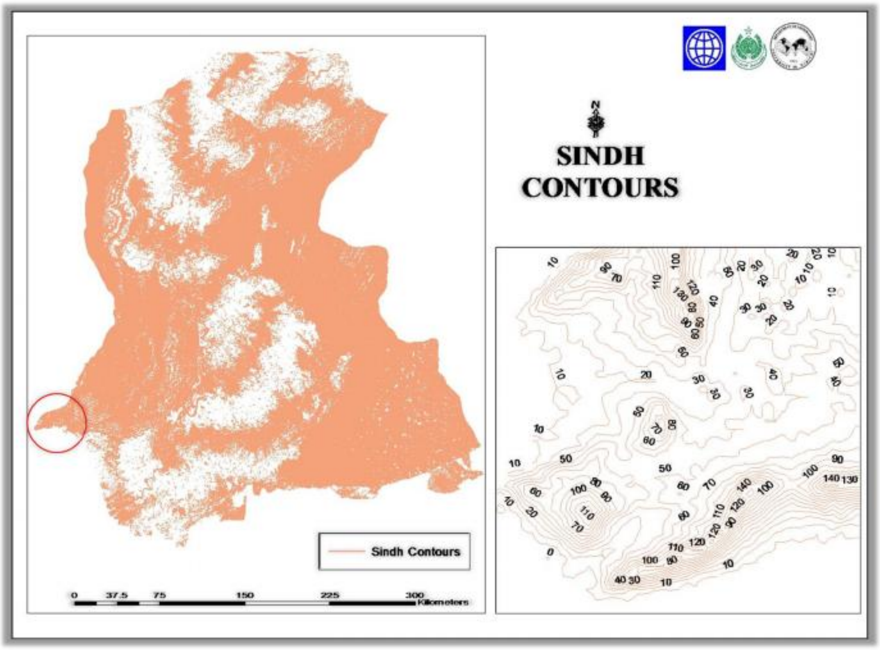


Figure 3: Contours Formation with SRTM Data

These contours then successfully converted into various uniform relief regions that has been shown as relief surface maps (Figure – 4). On the basis of these relief maps some prominent physiographic regions have been discovered.

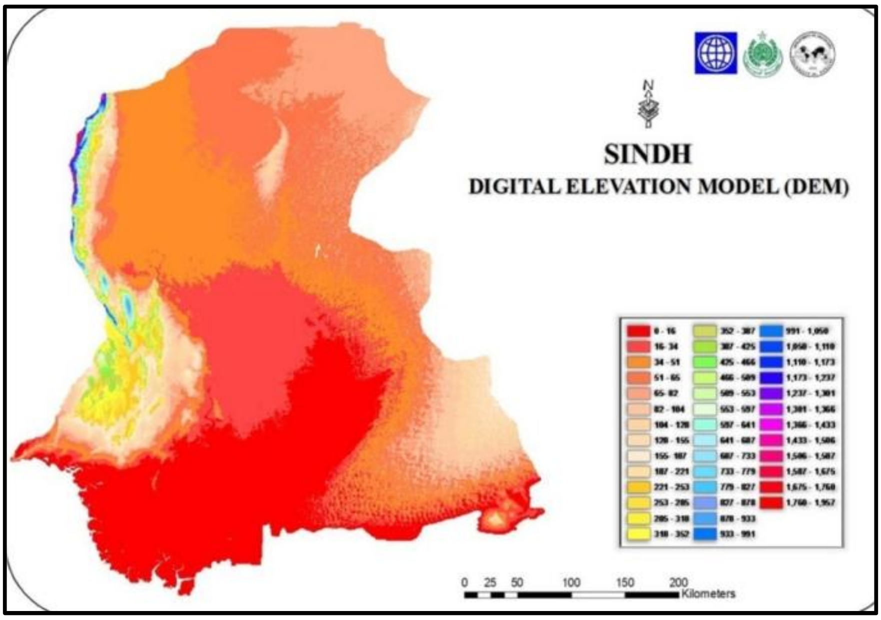


Figure 4: Distribution of Relief in Sindh

Physiographically, Province of Sindh comprises of three prominent relief features; namely, fringe of hills in the west (the extension of Suleman and Kirthar ranges), a sandy desert in the East (which is the extension of Rajistahn Desert and large alluvial plains in between the hilly and deserted areas (Figure - 5). The plain area is being irrigated by the mighty Indus River, which is forming a delta in the South of Thatta District. Generally, relief is showing a very regular pattern of gradual decrease in the slope as we move from West to East (Rahman, 1974). Northern portion of western hills is known as Kirthar and the Southern half as Sindh Kohistan. North-eastern part is locally known as Nara desert while Central and south eastern areas are called Thar, collectively this area is famous as Tharparkar desert which is the continuation of Rajputana's desert extending from India. Central Plains extends from the Lower Indus valley to the border of Punjab. According to location and physiographic differences the valley has been divided into a narrow western and wider eastern valley section. The southern low lying plains south of Thatta are identified as the Indus Delta. Other prominent relief features as obvious in the Figures – 6 and 7, are the Rohri Hills in District Sukkur, Ganjo Takker in Hyderabad and Makli Hills in Thatta. Massive distribution of Tidal plains is also common in Thatta district. Most of the concentrations of Schools are found in the plain areas of Sindh.

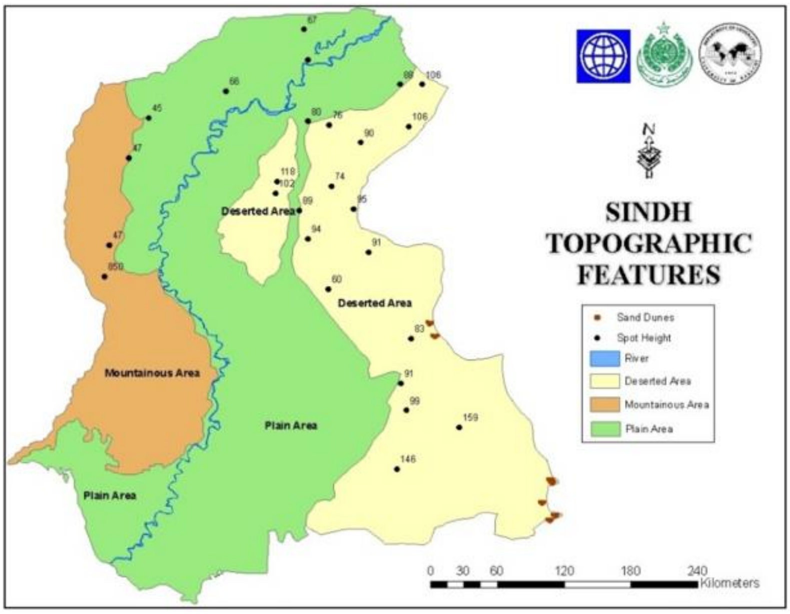


Figure 5: Sindh Topographic Features

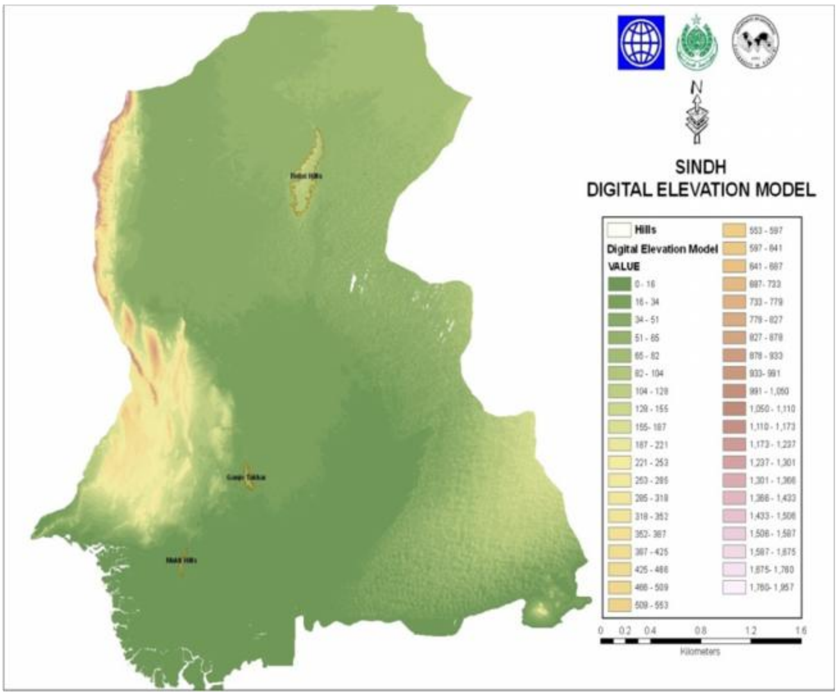


Figure 6: Other Prominent Relief Features in Sindh

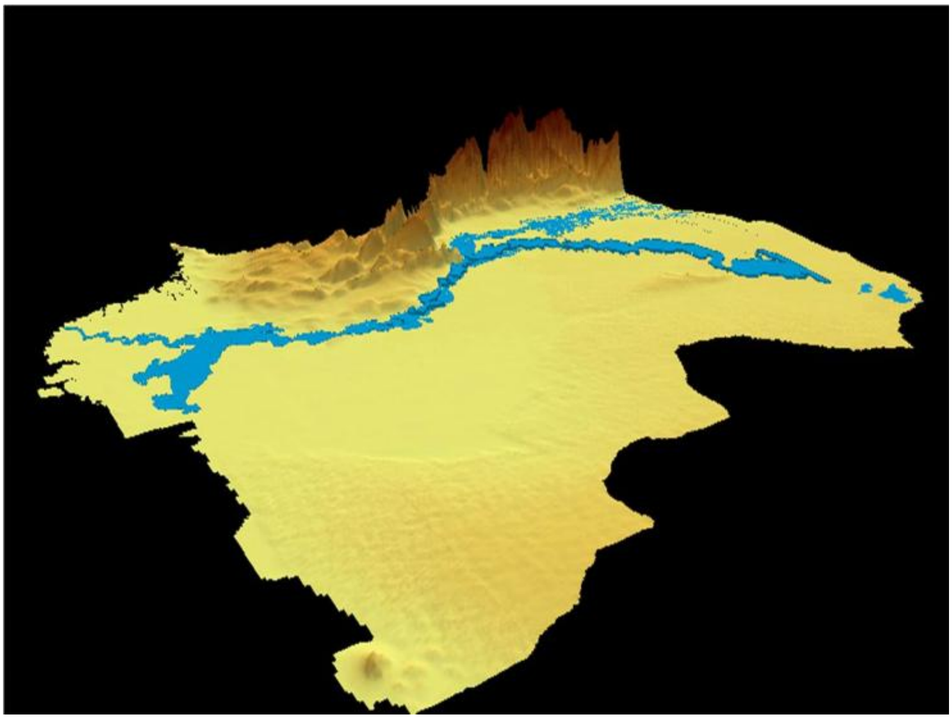


Figure 7: Relief Features in Three Dimensions (3D) in Sindh

Most of the schools fall (88%) in the plain areas of the Sindh and within the proximity of the Indus River. The distribution of the schools according to the relief regions has been summarized in the Table – 1.

S. No.	Physiography	Area (%)	% Schools
1	Plain Area[1]	52.16	87.60
2	Deserted Area	32.00	10.01
3	Mountainous Area	15.84	2.39
	Total Area	**100**	**100**

[1]Including Rivers, Canals and wetlands

Table 1: Distribution of Schools in Physiographic Regions

Whereas, about 10% of schools found in desert areas and 2.4 % in highlands of Sindh. With this distribution schools, most devastative type of natural hazards in Sindh are floods.

8.1.1.1 Bathymetry

The South of Sindh is coastal belt bordering the Arabian Sea, Figuer-8, is showing the bathymetry of Arabian Sea, with the jurisdiction of the territorial limits of Pakistan.

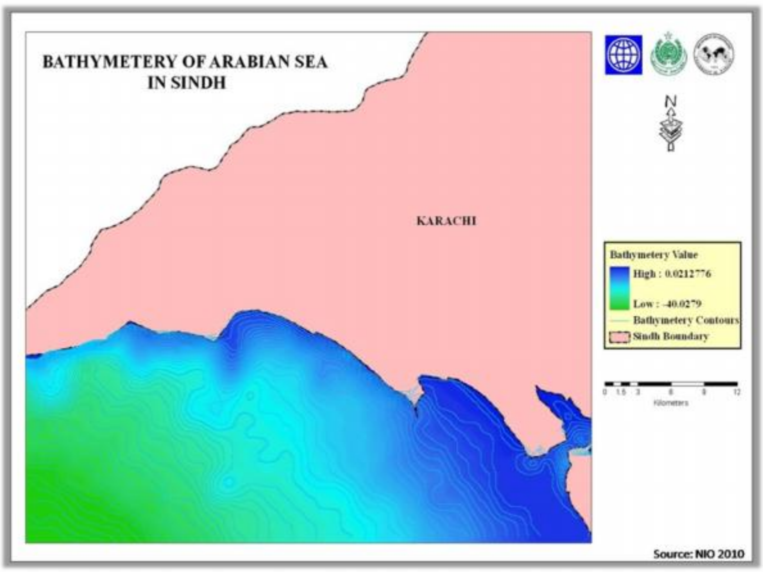


Figure 8: Bathymetry of Arabian Sea

8.1.2 Climate of Sindh

Climate of Sindh is easily defined by the Aridity except the Southern maritime climate; the complete area is receiving the low amount of rainfall while having the high temperature and humidity. Throughout the year numbers of hot summer days are very high as compare to winter days and also the numbers of rainy days are low and may vary year to year (Figure-9).

8.1.2.1 Temperature

The province of Sindh generally categorized as Arid zone which experience high temperature and low and variable amount of rain. The province is divided into microclimatic regions based on average weather con. Based on Thornthwaite' Classification Sindh is divided into semi-arid Tropical type of climate which covers lower Sindh and arid Tropical climate of upper Sindh. Isohytes in the above climatology map is validating this classification as Lower Sindh (Khan, 2007) from coast to Hyderabad receives a greater amount of rainfall than other parts of Sindh.

8.1.2.2 Rainfall

The amount of rainfall in Sindh is mainly driven from monsoon with some sporadic patches in winter because of Western Disturbances. Sindh received the remarkable low amount of rainfall only five inches in summer monsoon while only two inches from the western depression in winter. The major reason of low amount of rainfall is defined by Orography and upper air circulation in the area. Monsoon rains a highly contributing factor in floods of Sindh, especially the recent floods of 2011 (Figuer-9).

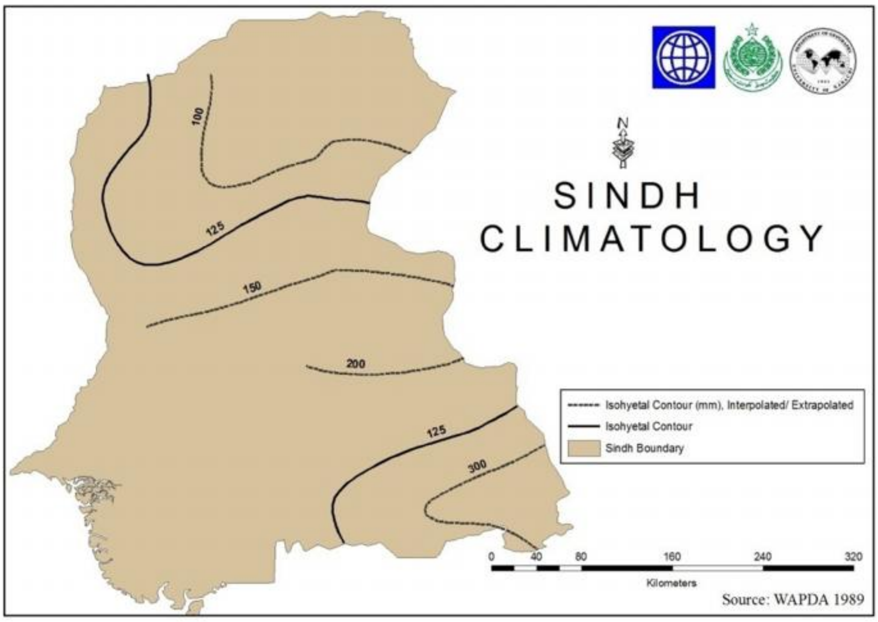


Figure 9: Sindh Rainfall Distribution

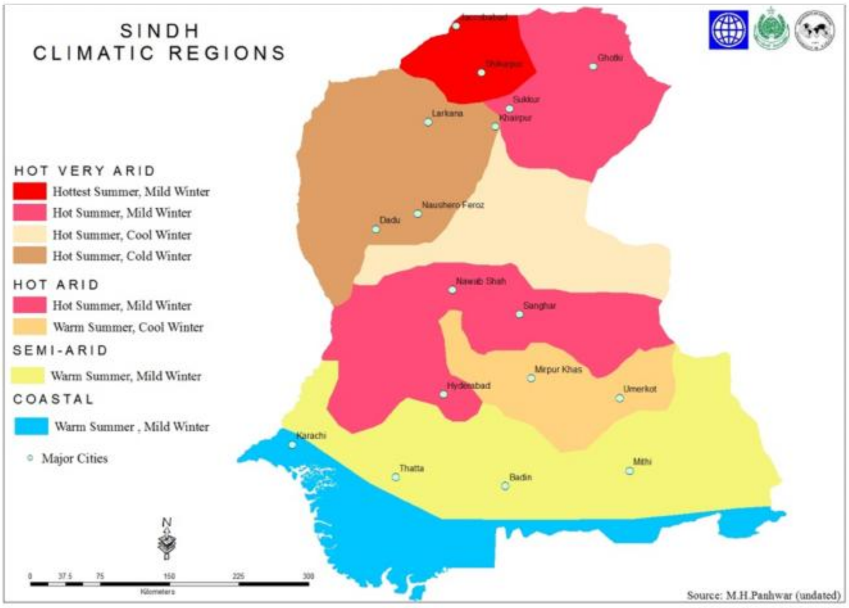


Figure 10: Climatic regions of Sindh

8.1.3 Sindh Protected Areas

The presence of Indus River in Sindh gives birth to many national parks, protected areas and game reserves. There is a great potential of eco-tourism in Sindh due to variety of flora and fauna near the wet lands. Figure – 11, is showing the distribution of national parks, protected areas, game reserves and wild life sanctuaries in the Province. Overall it is well distributed from north to south mainly along the river Indus with highest concentration in the southern valley (deltaic region). Few protected areas are also found in the western margin foot hills of Kirthar. Being located at the accessible locations these protected areas can be source of earning for the government as well.

Figure 11: Sindh Protected Areas

8.1.4 Sindh Hydrologic Features

Figure -13 is showing the depth of water-table in Sindh, mainly in Canal areas the depth ranging from 1.5 - 4.5 meters, whereas at the periphery of deserts it is about nine (9) meters in height.

Figure 12: Sindh Hydrological Features

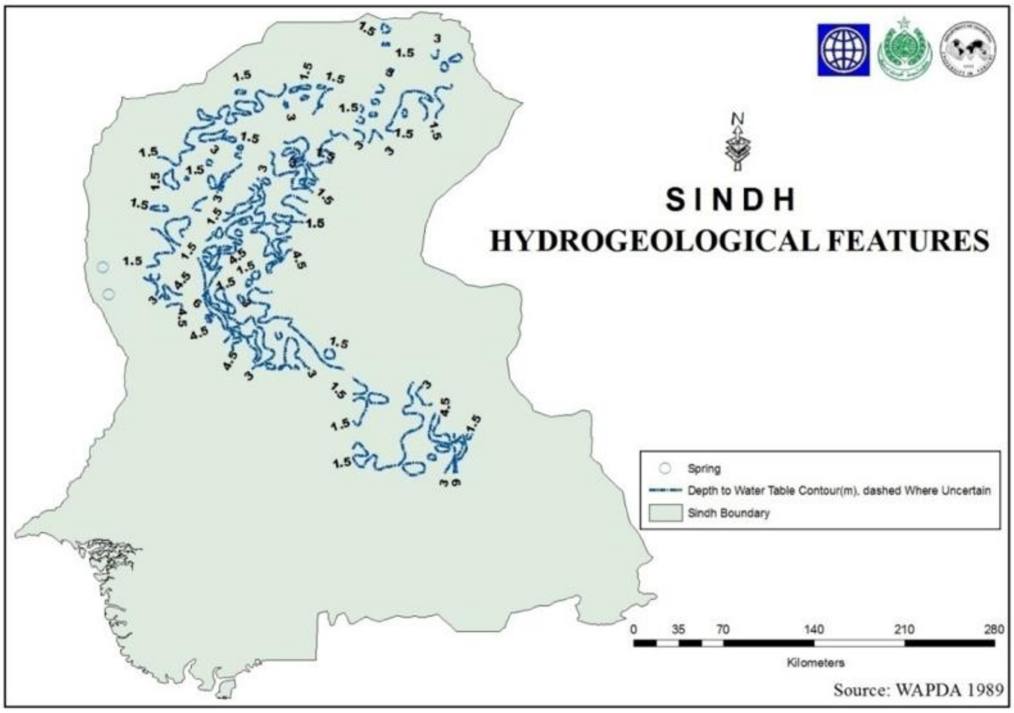


Figure 13: Prominent Hydrological Features in Sindh

8.1.5 Ground Water Conditions

Because of the low amount of seasonal rainfall with high temperature the amount of evapo-transpiration is very high in most of the province. Therefore, the sizeable population is depends on the ground water availability for recharge their wells. As obvious from Figure – 14 in upper Sindh a large area covered by the saline water which was previously assumed as the fresh water areas because of the contamination of the ground aquifer.

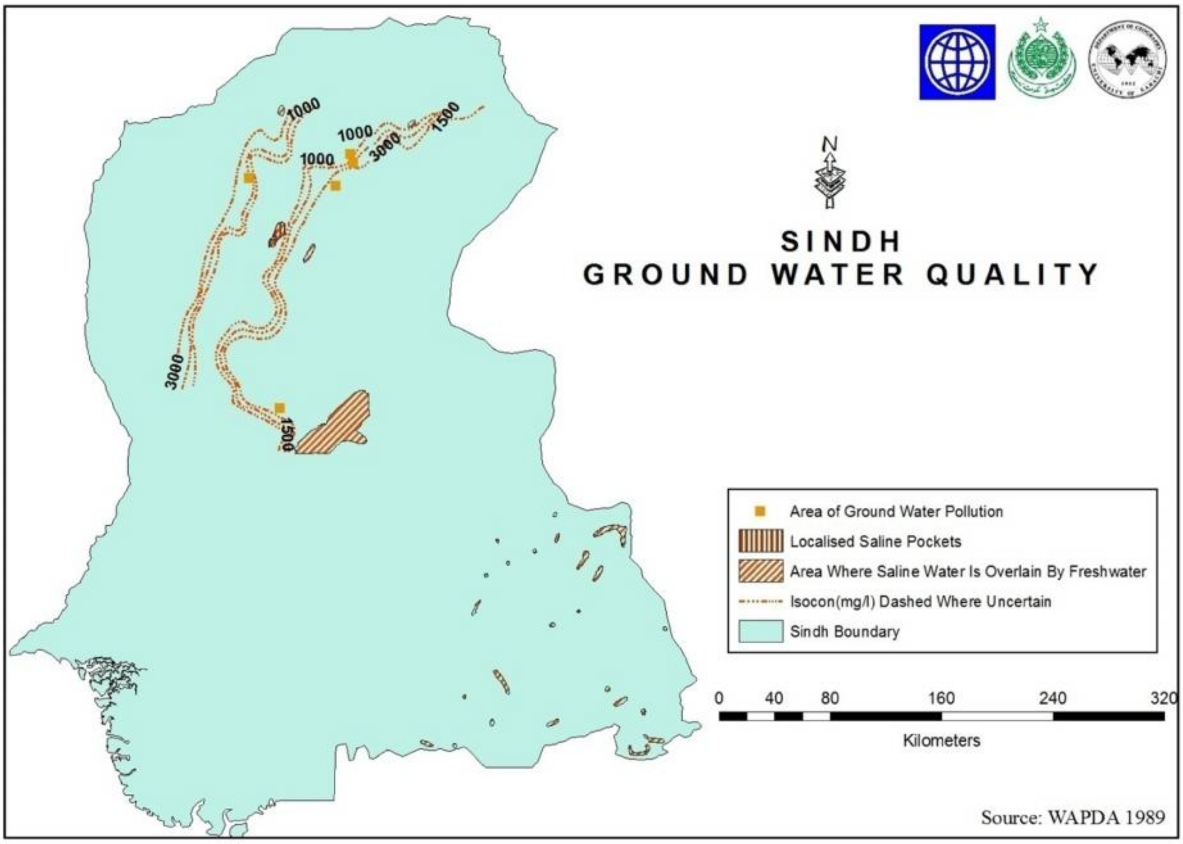


Figure 14: Sindh Ground Water Quality

High Rate of evapo-transpiration due to high temperature and variability of monsoon rain induce the use of ground water in the province of Sindh. Wells and tube wells are commonly found on the active flood plains along the banks of river Indus to meet the growing demand of water. Water quality as reported from the various locations is not suitable for drinking purposes. This is concerning as these narrow belts are populated by schools and farms where contaminated water is used, which might cause severe health hazards.

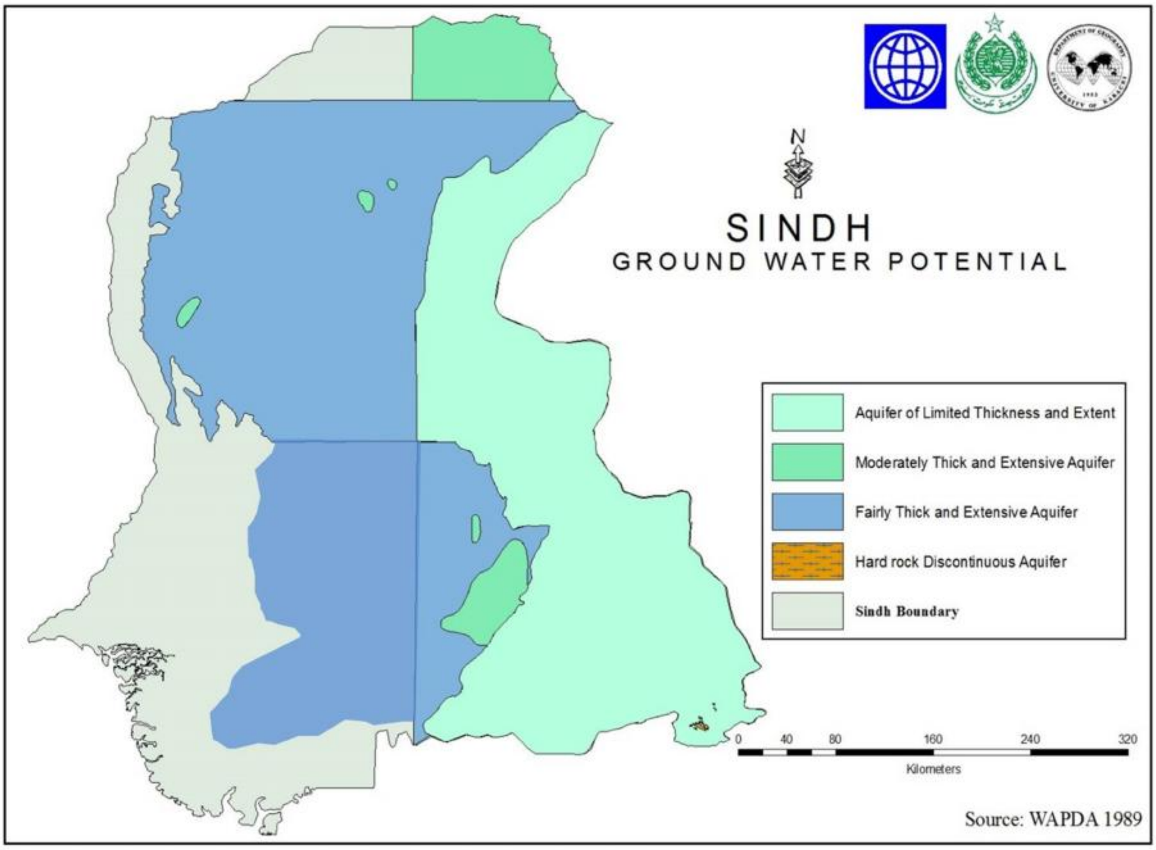


Figure 15: Ground Water Potential

Central and upper Sindh having denser irrigation network of perennial canals which allows constant percolation of water in the sub-soils. Hence, resulted in high water table with fairly thick and extensive aquifer in the Guddu , Sukkur and Nara command areas. Some small, moderately thick and extensive aquifer pockets are found within and adjacent to the fairly thick aquifer regions. Aquifer of limited thickness is comprises of whole eastern Tharparkar desert where groundwater table is available at greater depths.

8.2 Cultural Features

Cultural or anthropogenic features are very important geographical elements that determine the distribution of schools in Sindh province, following categories of cultural features have been mapped:

a. Administrative
b. Irrigation Network
c. Settlements
d. Transportation
e. Hydraulic structures
f. Schools
g. Agro – ecological Zones

8.2.1 Administrative Layers

Following administrative layers have been developed as the key foundation theme of the base map. Based on these layers other spatial layers have been adjusted accordingly:

S. No.	**Administrative Layers**	**Total Counts**
1	*Dehs*	6142
2	*Taluka*	102
3	Districts	27

Table 2: Number of Basic Administrative Units in Sindh

Deh is the smallest spatial unit in Sindh, followed by Taluka and District. In old commissionery system another unit called division, which was the greater unit than district, carrying many districts within.

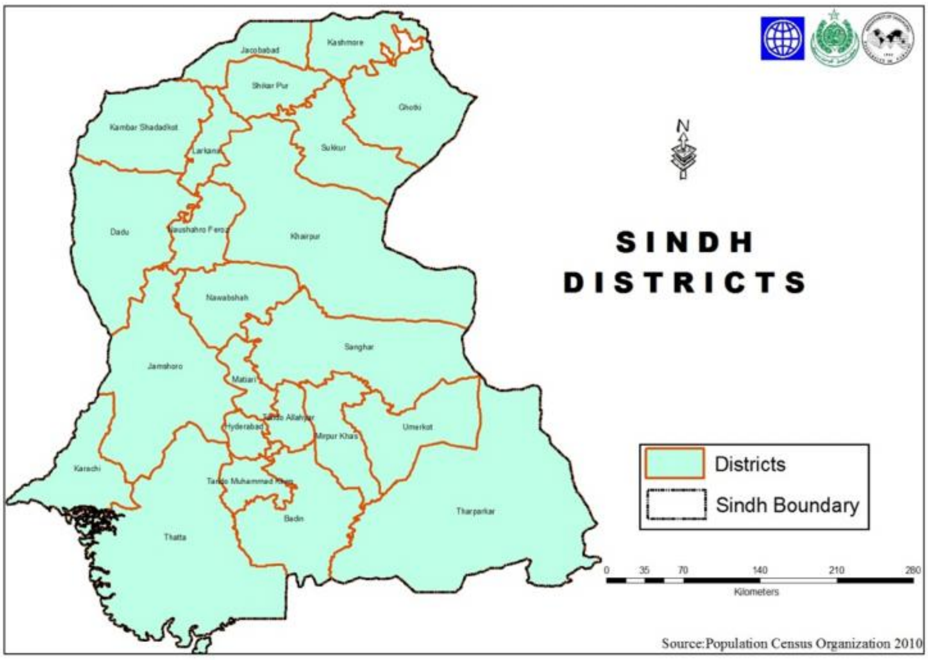


Figure 16: District Boundaries

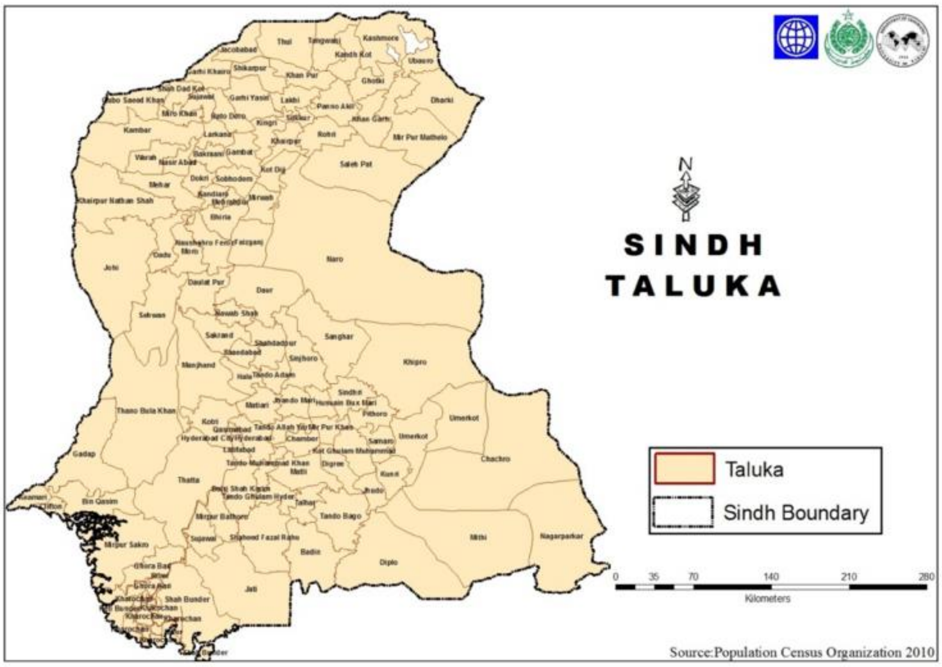


Figure 17: *Taluka* Boundaries

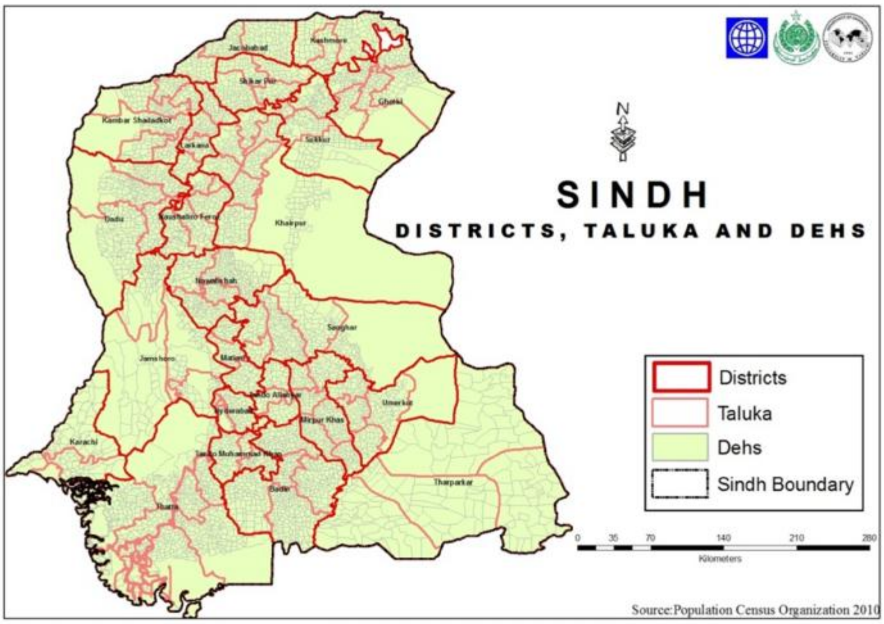


Figure 18: ***Deh*** **Boundaries**

8.2.2 Irrigation Network

The entire irrigation network of canals based on the Indus River Systems, main network of canals exist in the upper Riparian of Indus. Details of the network would be available in the forthcoming progress report.

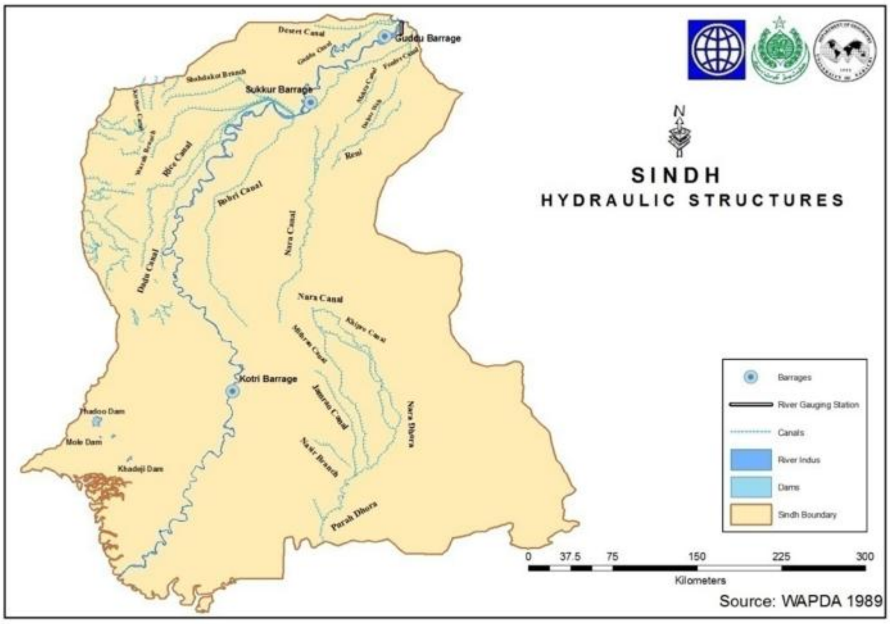


Figure 19: Hydraulic Structure in Sindh

8.2.3 Settlements

The settlements in Sindh mainly distributed along Indus River, Canals and major road networks. For this GIS all major cities, minor cities, towns and point of interest places have been marked (Figuer-17).

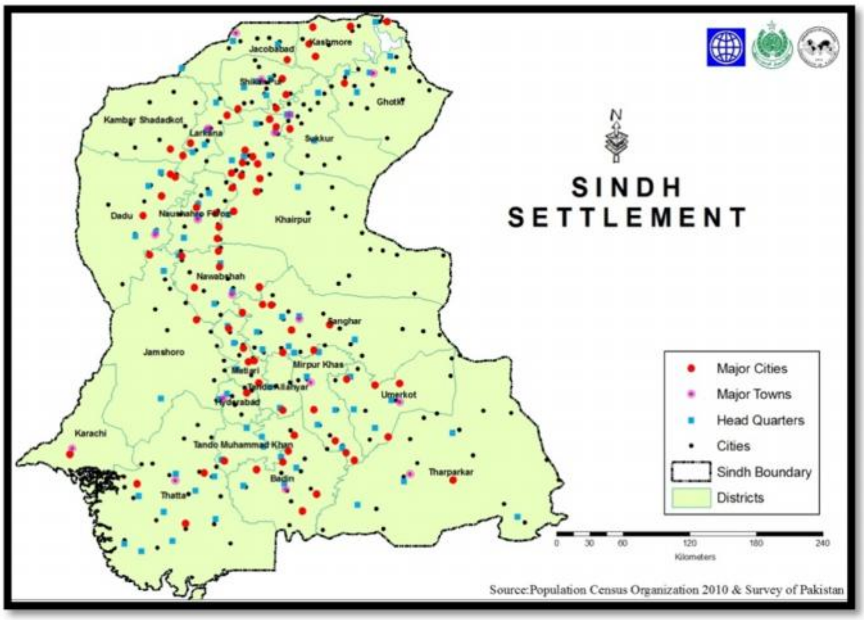


Figure 20: Settlements in Sindh

8.2.4 Agro – ecological Zones

The various agro-ecological zones formed because of the unique physiographic features developed Province of Sindh is consists of 7 agro-ecological regions. Agriculture is mainly confined to central part of Sindh along the river Indus, as these regions are fertile, undulating and well drained plains with dense population. So other main area is drained by network of perennial canal driven from Kotri Barrage, area above it being drained by taking canals from Sukkur and Guddu Barrages respectively. Agriculture is less /rarely likely to occur in the rugged terrain of Kirthar and Kohistan region on the West and dry sandy desert of Tharparkar on the East.

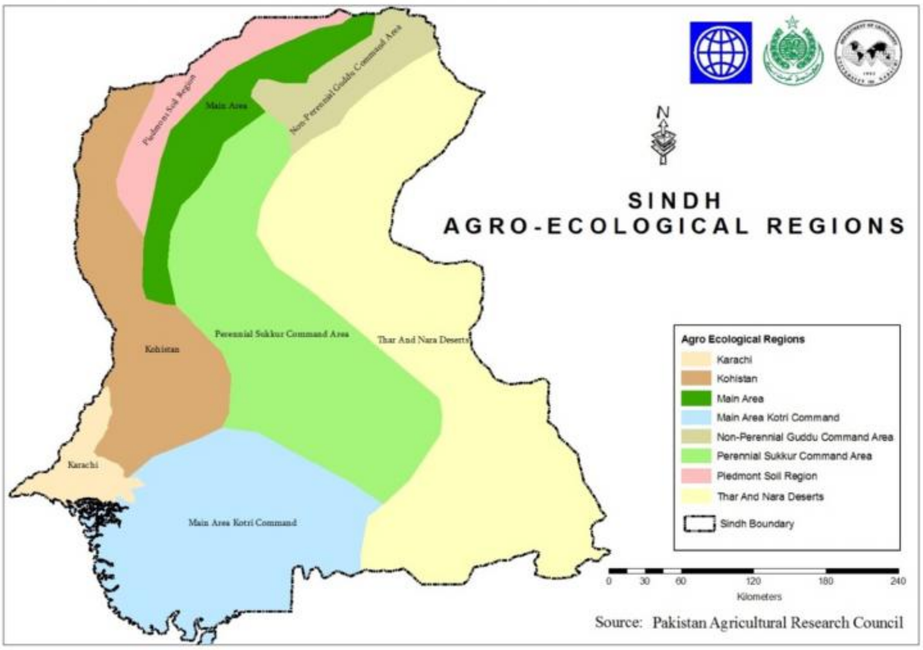


Figure 21: Agro - Ecological Regions Source: PARC (2000)

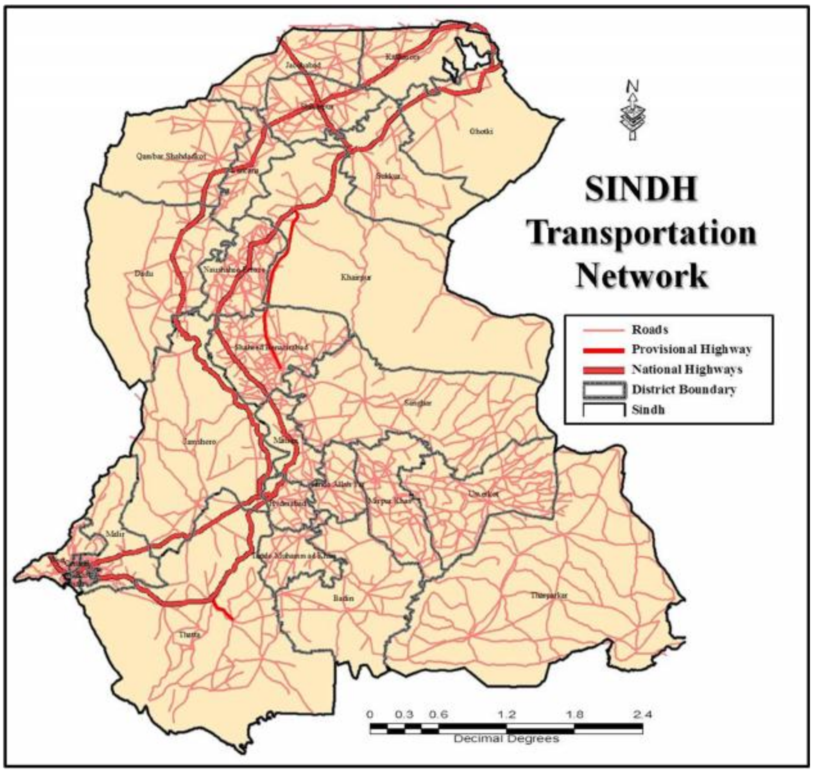


Figure 22: Transportation Network of Sindh

8.2 Hazard Mapping

One of the most important GIS layers in this project is the mapping of the distribution of natural hazards. In this context, the hazards which are frequent and have created significant impacts on human activities were mapped. These are floods, earthquakes and cyclones as the priority hazards, the extent of each of these were marked with the help of the satellite imageries and other relevant spatial data. The main objective of this mapping is to evaluate of the risk exposure of each school in Sindh.

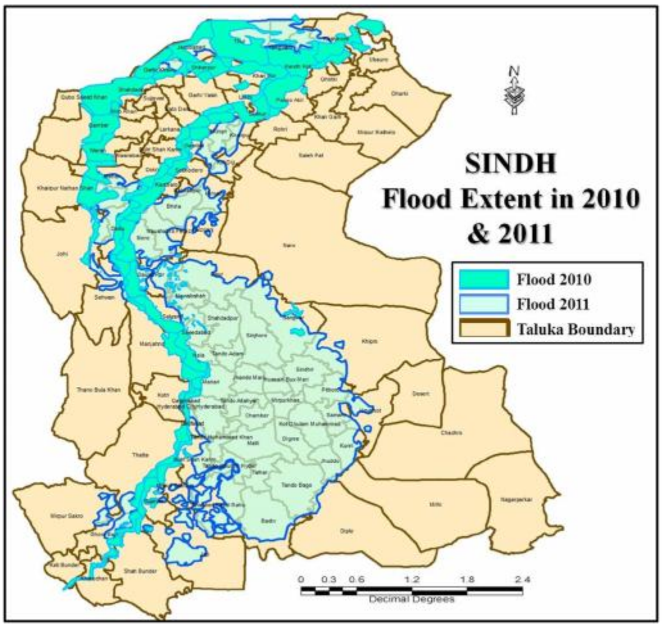


Figure 24: Composite Floods Extent in Sindh

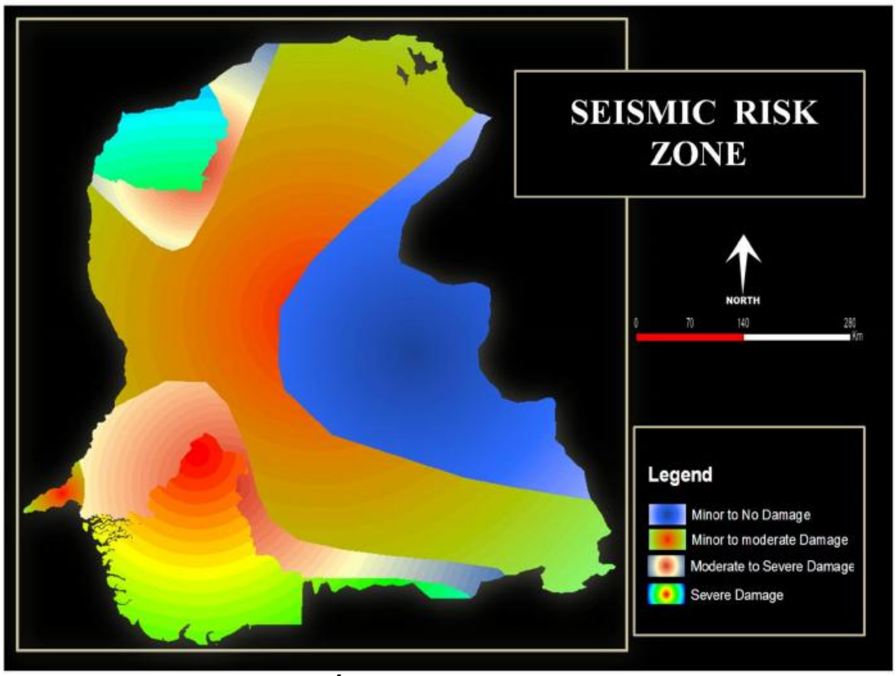


Figure 23: Seismic Risk in Sindh

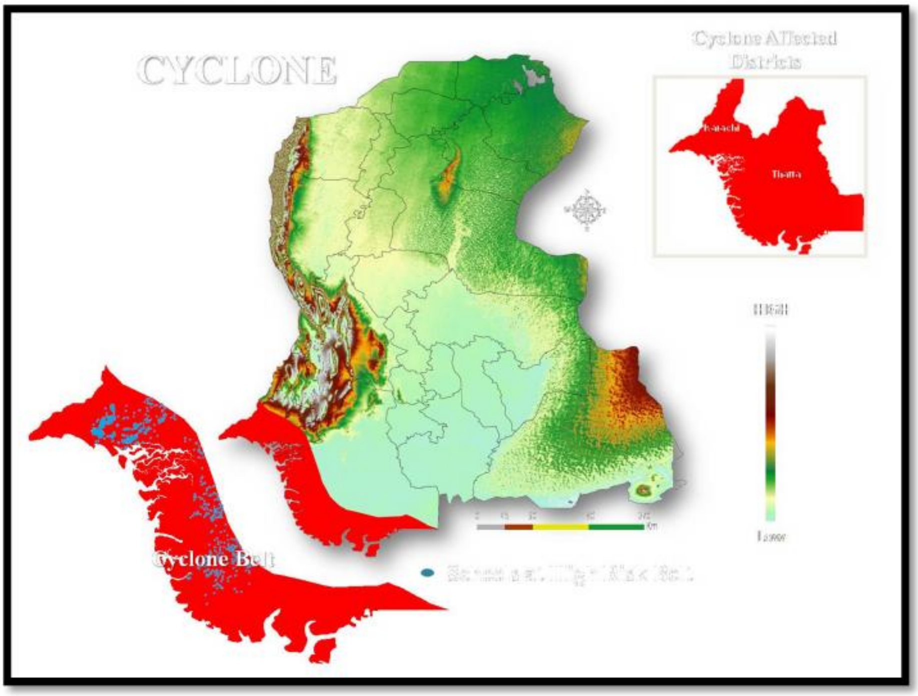


Figure 25: Cyclone Risk Distribution in Sindh

Beside these important hazards some other events such as drought were also identified. In addition to this water contamination distribution in the Lower Sindh for 10 parameters were also mapped (Figurers-26 & 27).

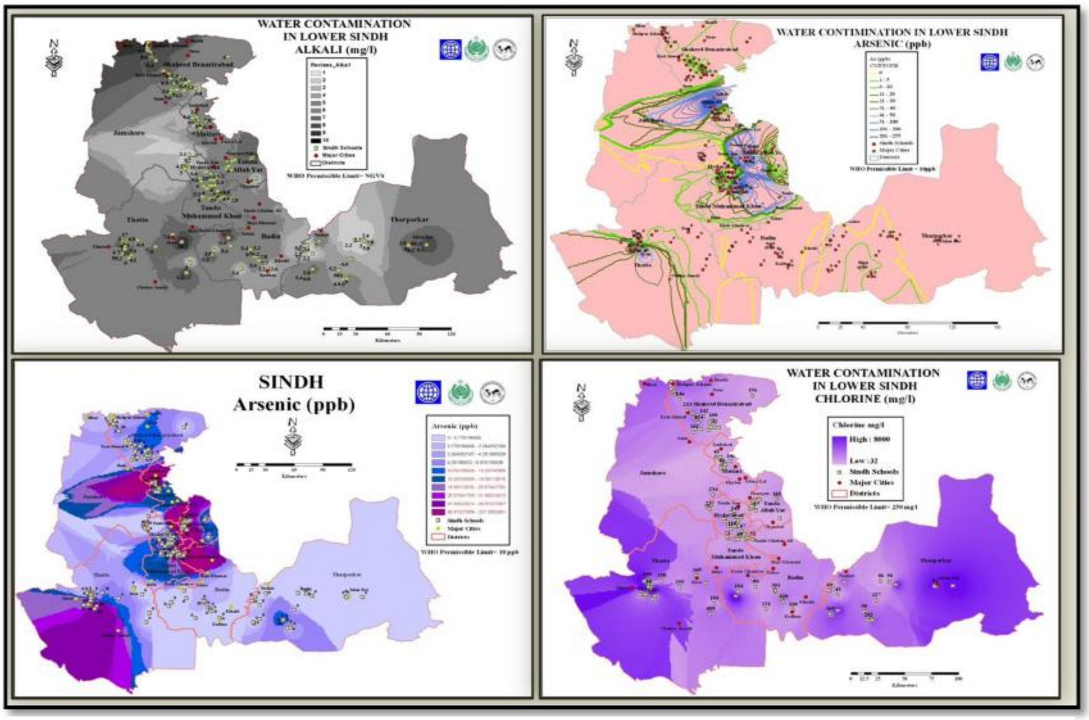


Figure 26: Alkali, Arsenic and Chlorine distribution in Lower Sindh

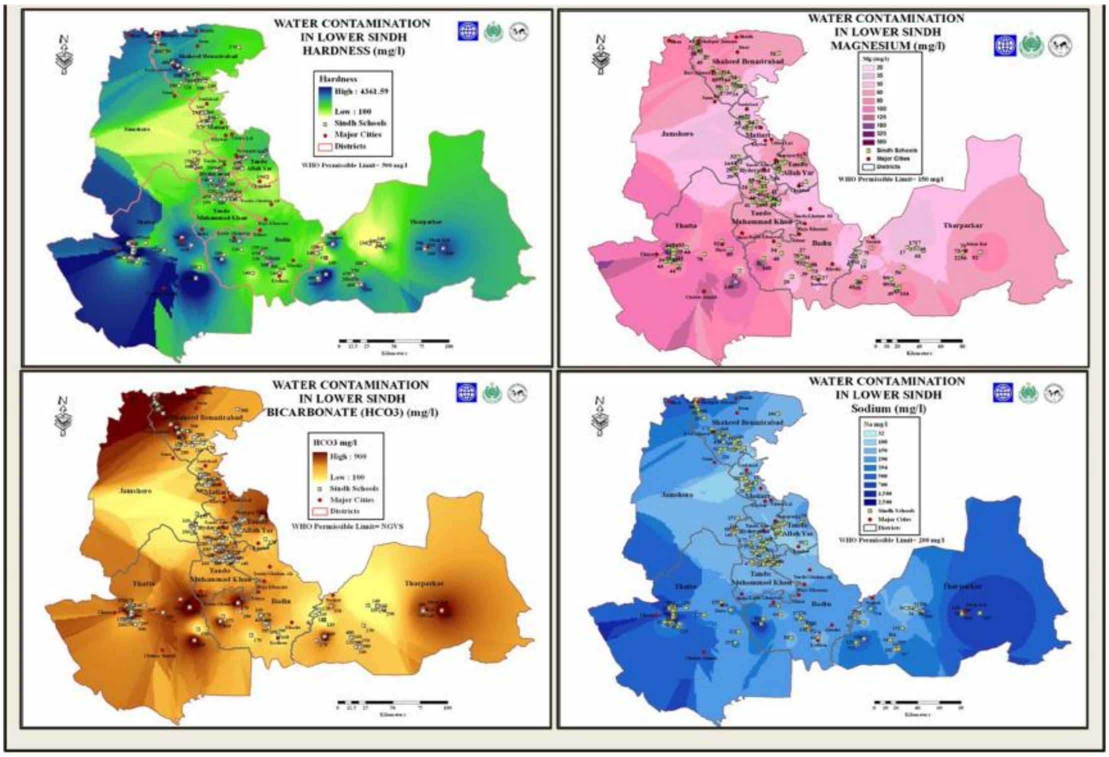


Figure 27: Hardness, Magnesium, Bicarbonate and Sodium Distribution in Lower Sindh

8.3 The Computation of the Composite Risk of Hazards

The objective of this risk appraisal is to estimate the risk of the priority hazards in vector layer formats. Risk model is developed to classify the extents within a development plan that are vulnerable to flooding and other natural hazards and collect those factors that are relevant to current and future natural hazard risk which helps in delineating and implementing the policies to such areas to minimize and manage that risk.

Following steps were followed to reach to the composite risk:

- Development of vector based model for Cyclone, Earthquake, and Floods in (Point, Line and Polygon) formats.
- Superimposition of District, Taluka, Deh and other relevant layers.
- Generation of Risk Buffers at different distances by considering the survey results and spatial extent of former events.
- Generation of terrain surface using (DEM) for identification of topographical barriers and Fault lines.

- Calculation of events and entity density per district and on other administrative divisions performing Risk entity polygon in Administrative polygon and Risk point in the Administrative polygon analysis.
- By getting risk rank from 5th step Risk mapping is performed for individual events.
- For getting the Pixel based result or per unit calculation as well as assigning the users desired ranks the layers are converted into raster which also helps in simulation development.
- Finally the composite risk is calculated by using the additive method.

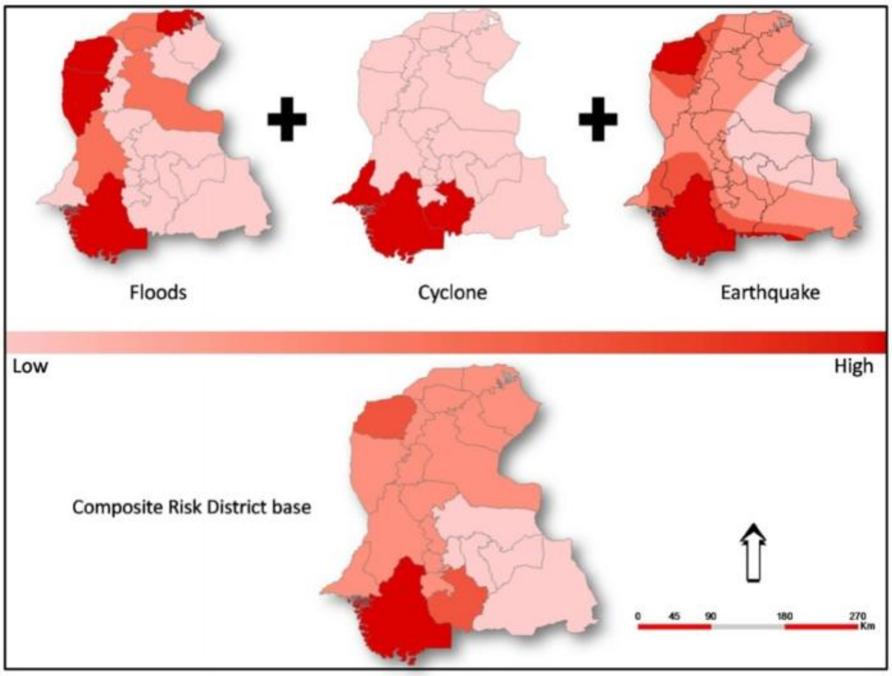


Figure 28: Composite Risk Distribution

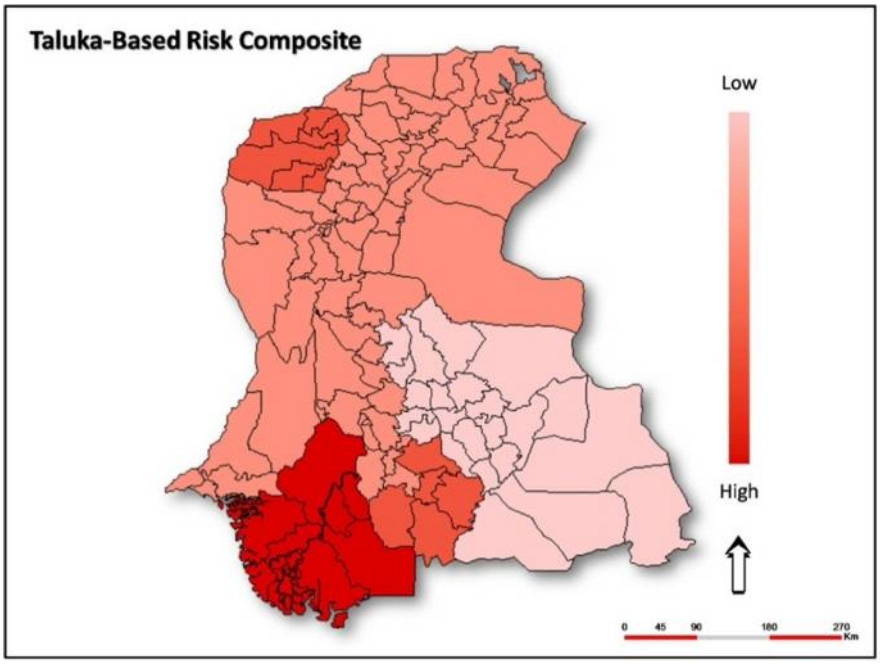


Figure 29: Taluka Based Risk Composite

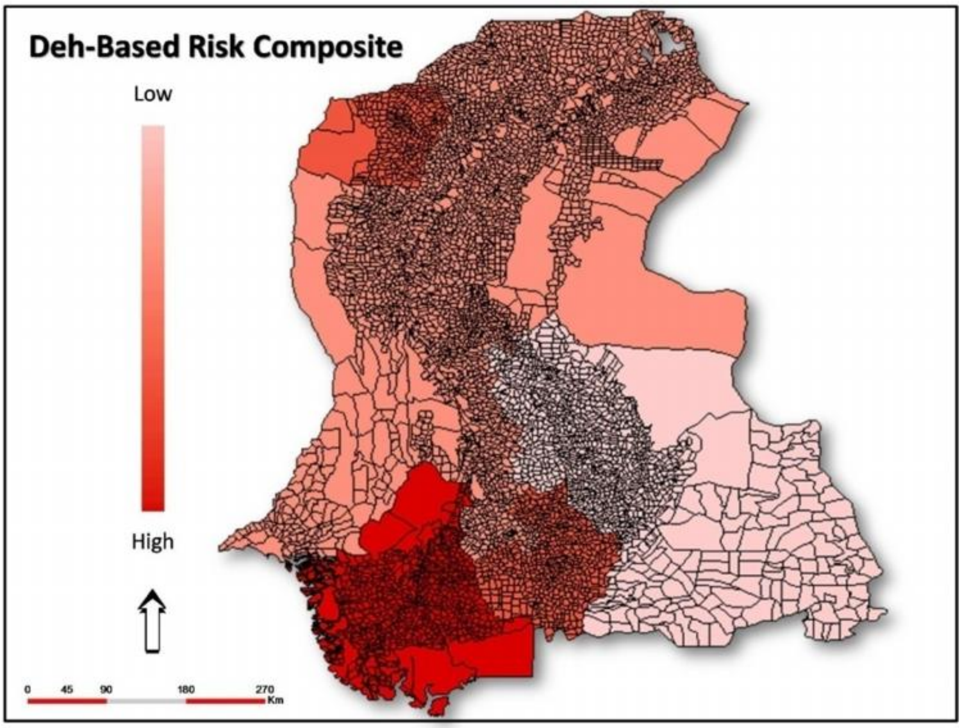


Figure 30: Deh Based Risk Composite

District	Source	Cyclone_De	Flood-Dens	Earthquake	Cyclone	Flood	Composite
Badin	Dept. of Geography	0	0.000948	0	1	1	2
Dadu	Dept. of Geography	0	0.211189	0	0	1	1
Ghotki	Dept. of Geography	0	0.008304	0	0	1	1
Hyderabad	Dept. of Geography	0	0.022717	0	0	1	1
JAMSHORO	Dept. of Geography	0	0.11368	0	0	1	1
Jacobabad	Dept. of Geography	0	0.120715	0	0	1	1
Kambar Shadadkot	Dept. of Geography	0	0.18763	1	0	1	2
Karachi	Dept. of Geography	0.173181	0	0	1	0	1
Kashmore	Dept. of Geography	0	0.23161	0	0	1	1
Khairpur	Dept. of Geography	0	0.071154	0	0	1	1
Larkana	Dept. of Geography	0	0.050319	0	0	1	1
Matiari	Dept. of Geography	0	0.044456	0	0	1	1
Mirpur Khas	Dept. of Geography	0	0	0	0	0	0
Naushahro Feroz	Dept. of Geography	0	0.048875	0	0	1	1
Nawabshah	Dept. of Geography	0	0.037926	0	0	1	1
Sanghar	Dept. of Geography	0	0	0	0	0	0
Shikar Pur	Dept. of Geography	0	0.148976	0	0	1	1
Sukkur	Dept. of Geography	0	0.061169	0	0	1	1
Tando Allahyar	Dept. of Geography	0	0	0	0	0	0
Tando Muhammad Kh	Dept. of Geography	0	0.007056	0	0	1	1
Tharparkar	Dept. of Geography	0	0	0	0	0	0
Thatta	Dept. of Geography	0.52259	0.259625	4	1	1	6
Umerkot	Dept. of Geography	0	0	0	0	0	0

Table 3: Attributes of Composite Risk

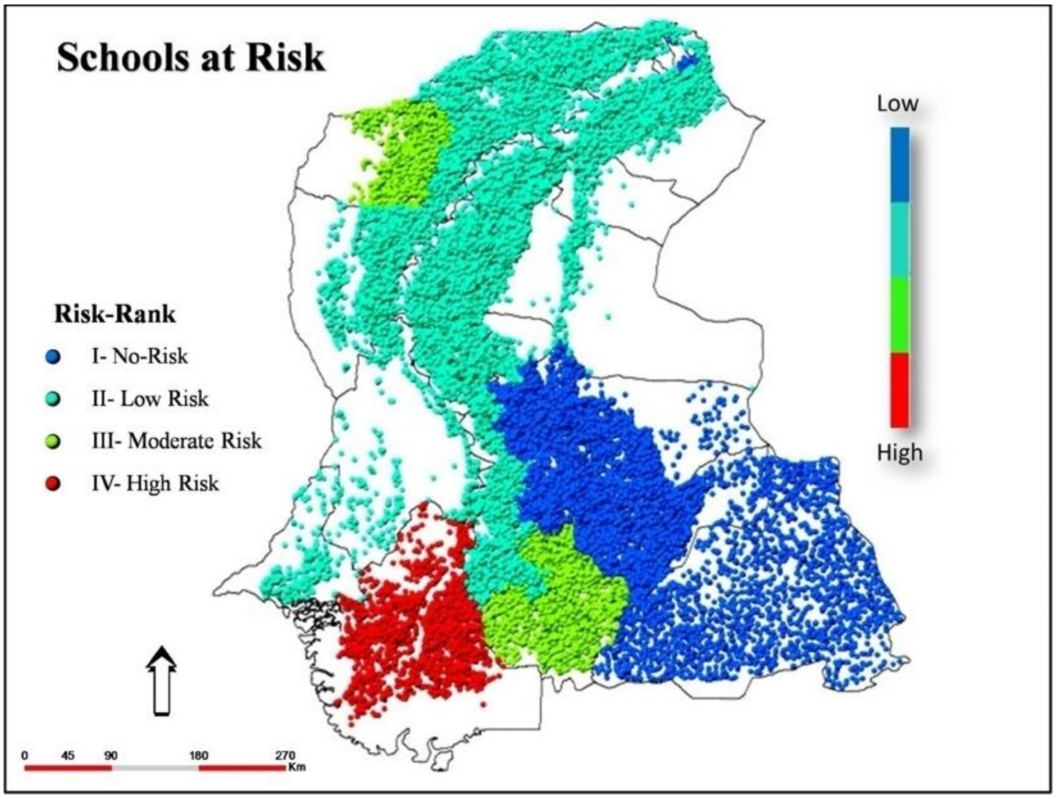


Figure 31: School at Risk (Composite Hazards)

8.4 Development of High Scale Embelished Layouts

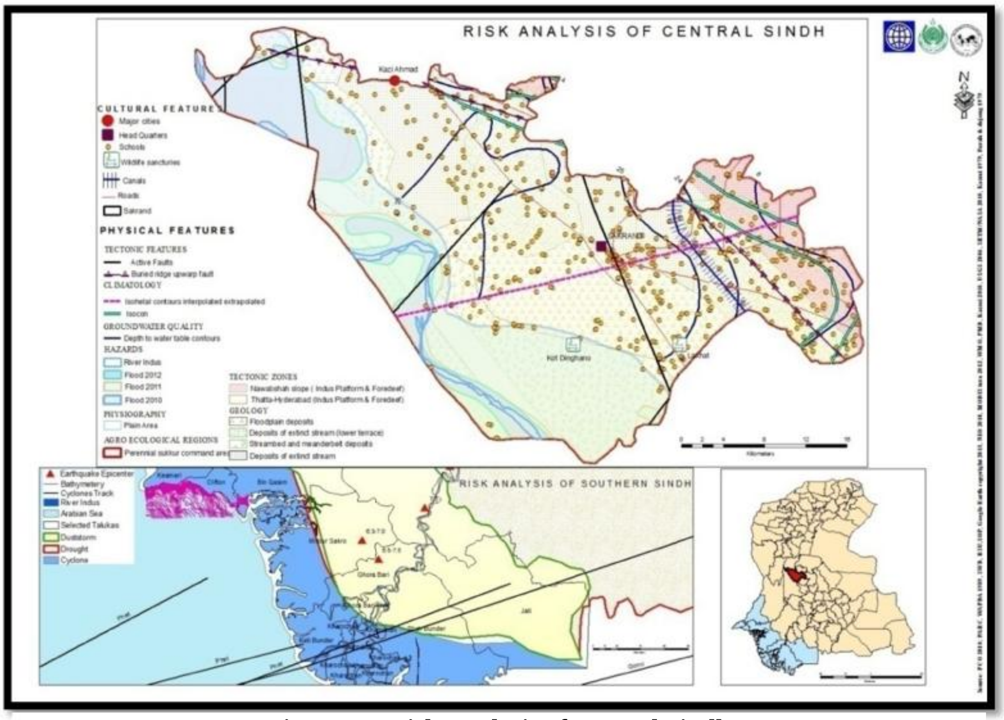


Figure 32: Risk Analysis of Central Sindh

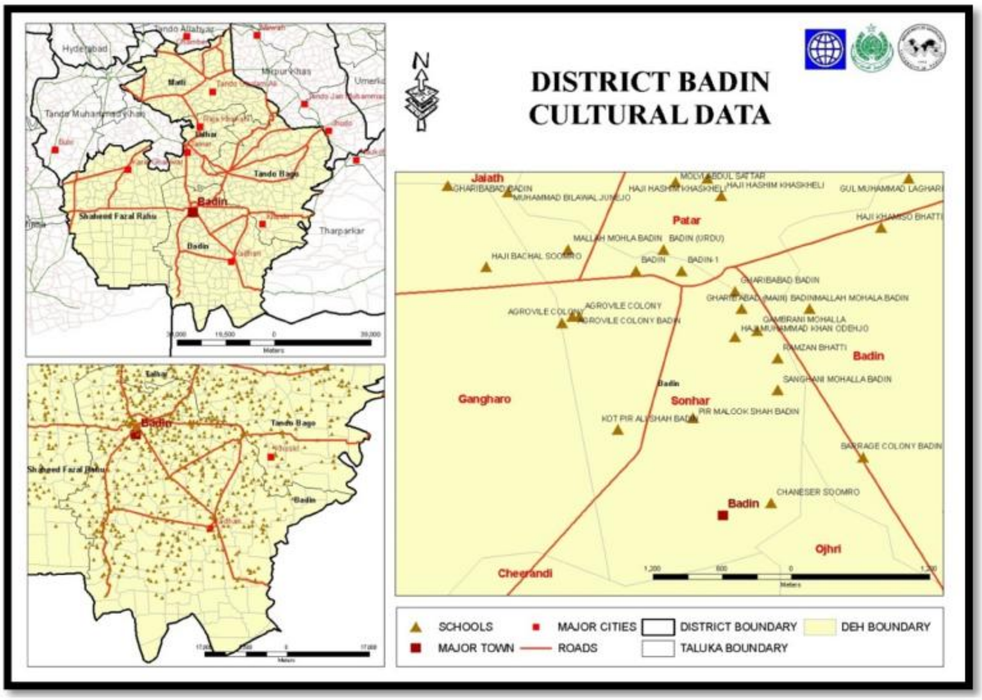


Figure 33: District Badin Cultural Data

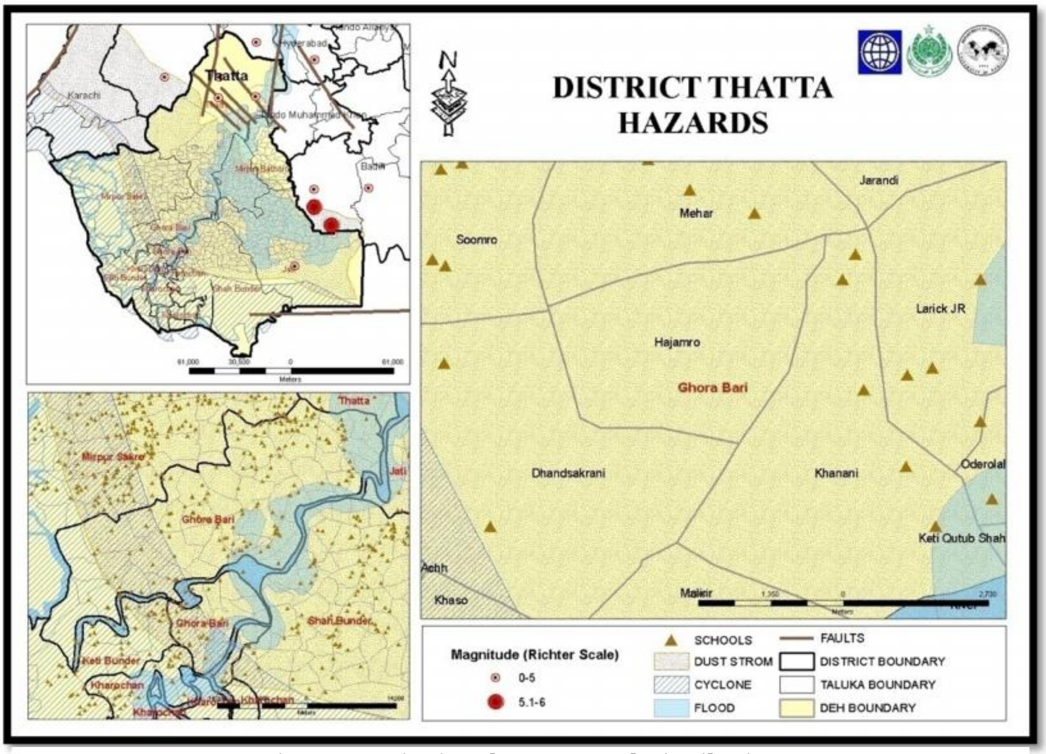


Figure 34: District Thatta Hazard Distribution

9. TRANSFORMATION OF COLLECTED DATA

Both hard copy and digital data have been obtained from different sources and were on different geometric system, all of which are projected on an identical projection system (WGS-84) as agreed in the TOR. Data transformation on these coordinates has been performed both on raster and vector datasets (Figuer-20).

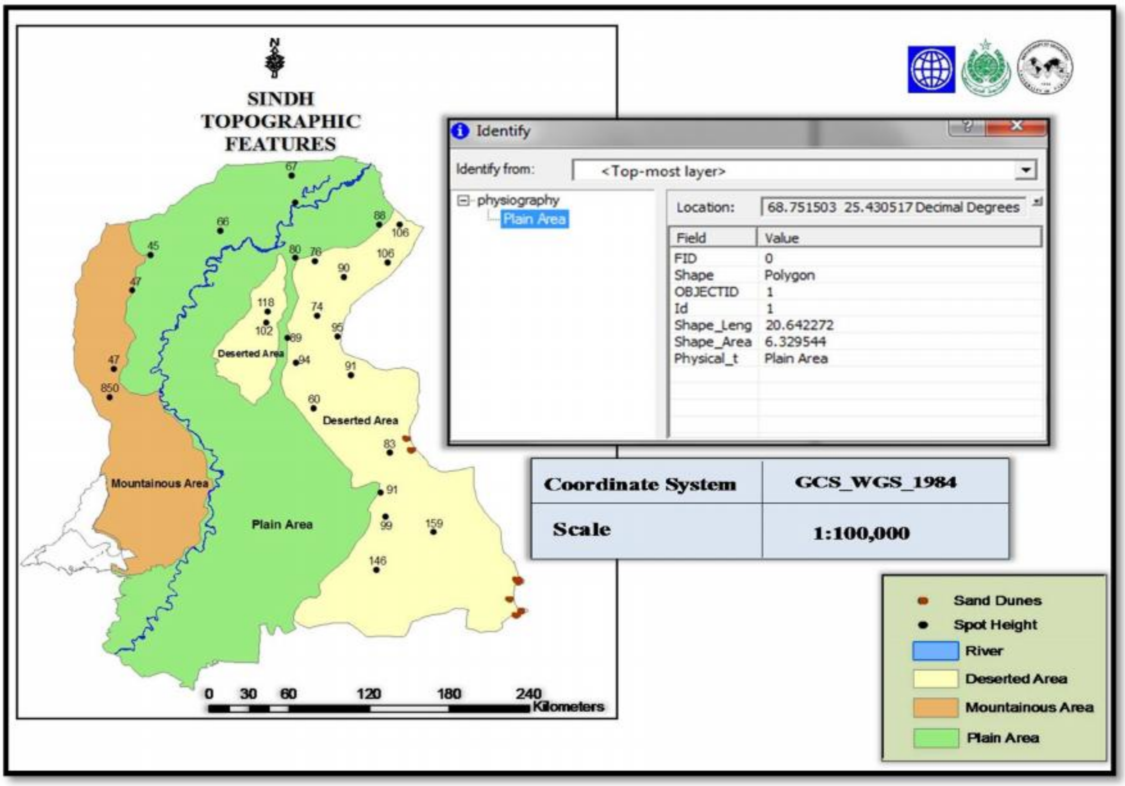
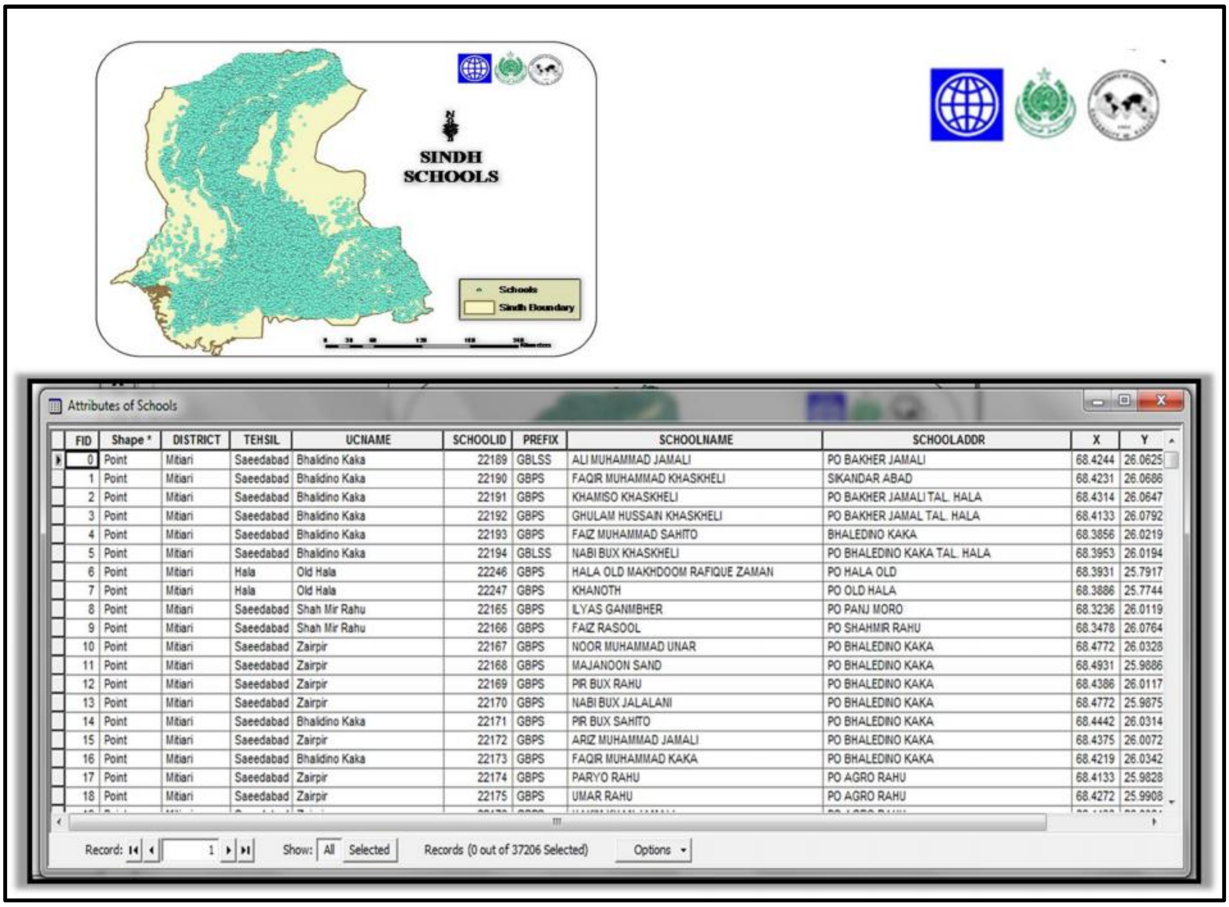


Figure 35: Transformation of Collected Data

10. ATTRIBUTE DATA DEVELOPMENT

In a vector-based GIS system, digitization (geometry) alone without attributes is not sufficient for the spatial analysis. Therefore, tabular data structure along with appropriate data is added in each shape file. The data obtained from other sources also scrutinized and standardized to make it compatible with our data. The attribute data development is highly helpful in the formation of cartographic data.



FID	Shape *	DISTRICT	TEHSIL	UCNAME	SCHOOLID	PREFIX	SCHOOLNAME	SCHOOLADDR	X	Y
0	Point	Mitiari	Saeedabad	Bhalidino Kaka	22189	GBLSS	ALI MUHAMMAD JAMALI	PO BAKHER JAMALI	68.4244	26.0625
1	Point	Mitiari	Saeedabad	Bhalidino Kaka	22190	GBPS	FAQIR MUHAMMAD KHASKHELI	SIKANDAR ABAD	68.4231	26.0686
2	Point	Mitiari	Saeedabad	Bhalidino Kaka	22191	GBPS	KHAMISO KHASKHELI	PO BAKHER JAMALI TAL. HALA	68.4314	26.0647
3	Point	Mitiari	Saeedabad	Bhalidino Kaka	22192	GBPS	GHULAM HUSSAIN KHASKHELI	PO BAKHER JAMAL TAL. HALA	68.4133	26.0792
4	Point	Mitiari	Saeedabad	Bhalidino Kaka	22193	GBPS	FAIZ MUHAMMAD SAHITO	BHALEDINO KAKA	68.3856	26.0219
5	Point	Mitiari	Saeedabad	Bhalidino Kaka	22194	GBLSS	NABI BUX KHASKHELI	PO BHALEDINO KAKA TAL. HALA	68.3953	26.0194
6	Point	Mitiari	Hala	Old Hala	22246	GBPS	HALA OLD MAKHDOOM RAFIQUE ZAMAN	PO HALA OLD	68.3931	25.7917
7	Point	Mitiari	Hala	Old Hala	22247	GBPS	KHANOTH	PO OLD HALA	68.3886	25.7744
8	Point	Mitiari	Saeedabad	Shah Mir Rahu	22165	GBPS	ILYAS GANMBHER	PO PANJ MORO	68.3236	26.0119
9	Point	Mitiari	Saeedabad	Shah Mir Rahu	22166	GBPS	FAIZ RASOOL	PO SHAHMIR RAHU	68.3478	26.0764
10	Point	Mitiari	Saeedabad	Zairpir	22167	GBPS	NOOR MUHAMMAD UNAR	PO BHALEDINO KAKA	68.4772	26.0328
11	Point	Mitiari	Saeedabad	Zairpir	22168	GBPS	MAJANOON SAND	PO BHALEDINO KAKA	68.4931	25.9886
12	Point	Mitiari	Saeedabad	Zairpir	22169	GBPS	PIR BUX RAHU	PO BHALEDINO KAKA	68.4386	26.0117
13	Point	Mitiari	Saeedabad	Zairpir	22170	GBPS	NABI BUX JALALANI	PO BHALEDINO KAKA	68.4772	25.9875
14	Point	Mitiari	Saeedabad	Bhalidino Kaka	22171	GBPS	PIR BUX SAHITO	PO BHALEDINO KAKA	68.4442	26.0314
15	Point	Mitiari	Saeedabad	Zairpir	22172	GBPS	ARIZ MUHAMMAD JAMALI	PO BHALEDINO KAKA	68.4375	26.0072
16	Point	Mitiari	Saeedabad	Bhalidino Kaka	22173	GBPS	FAQIR MUHAMMAD KAKA	PO BHALEDINO KAKA	68.4219	26.0342
17	Point	Mitiari	Saeedabad	Zairpir	22174	GBPS	PARYO RAHU	PO AGRO RAHU	68.4133	25.9828
18	Point	Mitiari	Saeedabad	Zairpir	22175	GBPS	UMAR RAHU	PO AGRO RAHU	68.4272	25.9908

Figure 36: Attribute Data Development

11.IDENTIFICATION OF TOPLOGICAL ERRORS

Various errors have been encountered in obtained and developed GIS data, which were identifying by running the Topological routines in ArcGIS software. Most common errors were duplicate points, overshoots, undershoots, slivers, dangling arcs etc. (Figuer-22).

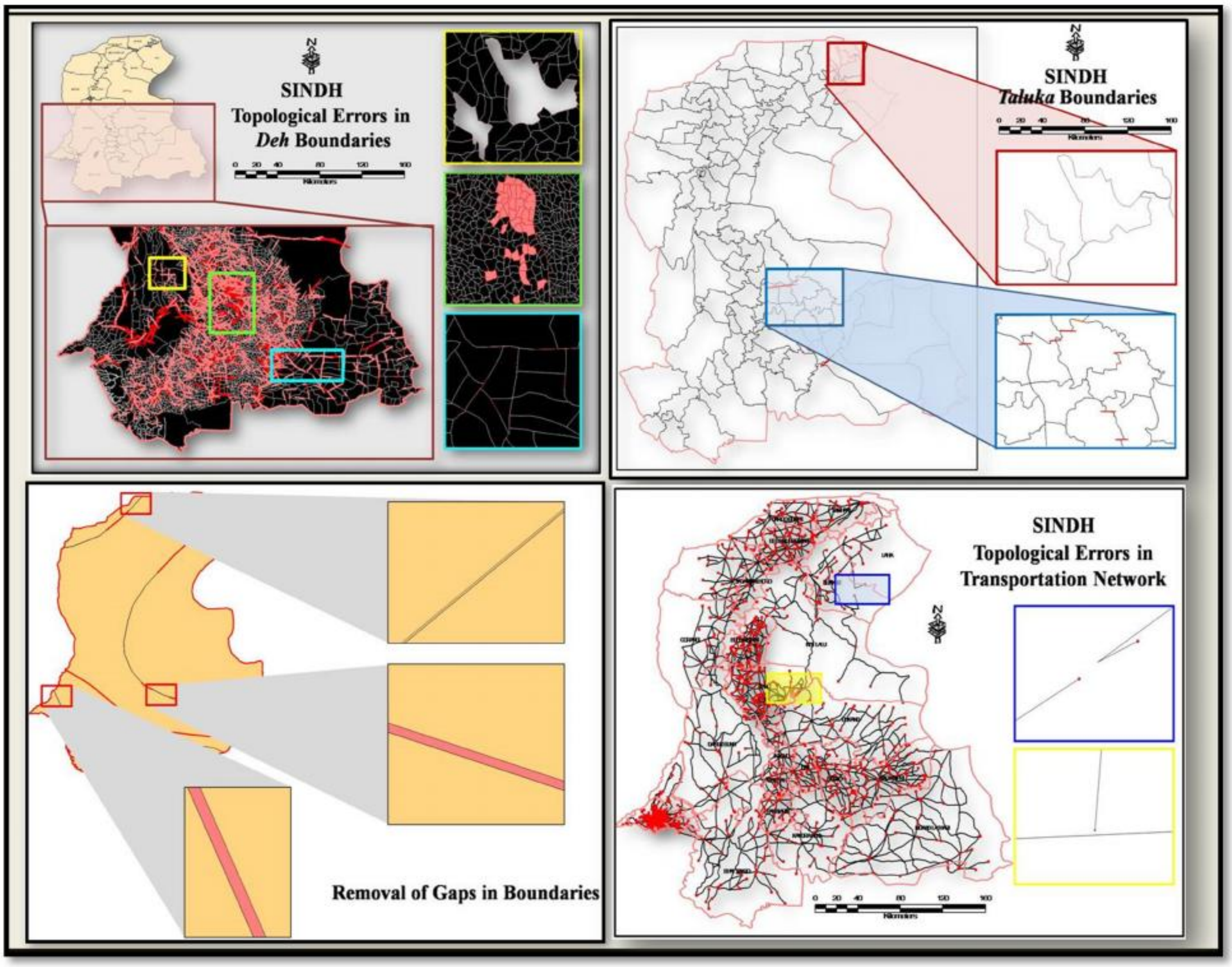


Figure 37: Rectification of Topological Layers

The identified errors have been removed from the shape files with the help of topological editor.

12.IDENTIFICATION OF ISSUES AND ACTIONS TAKEN

12.1 Resolution of the data (Data uncertainty and quality)

One of the critical issues for any GIS data development is the discrepancies in the secondary data, obtained from different sources. These can be categorized mainly into following actions, details of which would be available in the next report:

12.1.1 Application of the Snapping

12.2 Data standardization (normalization of the attributes)

12.3 Application of Topological Logics to remove the errors

13. HYPER LINKING OF SCHOOLS IN A GIS SYSTEM

To monitor the existing situation or past conditions the photograph of each school is dynamically linked with the school point data, as shown in the Figure – 38.

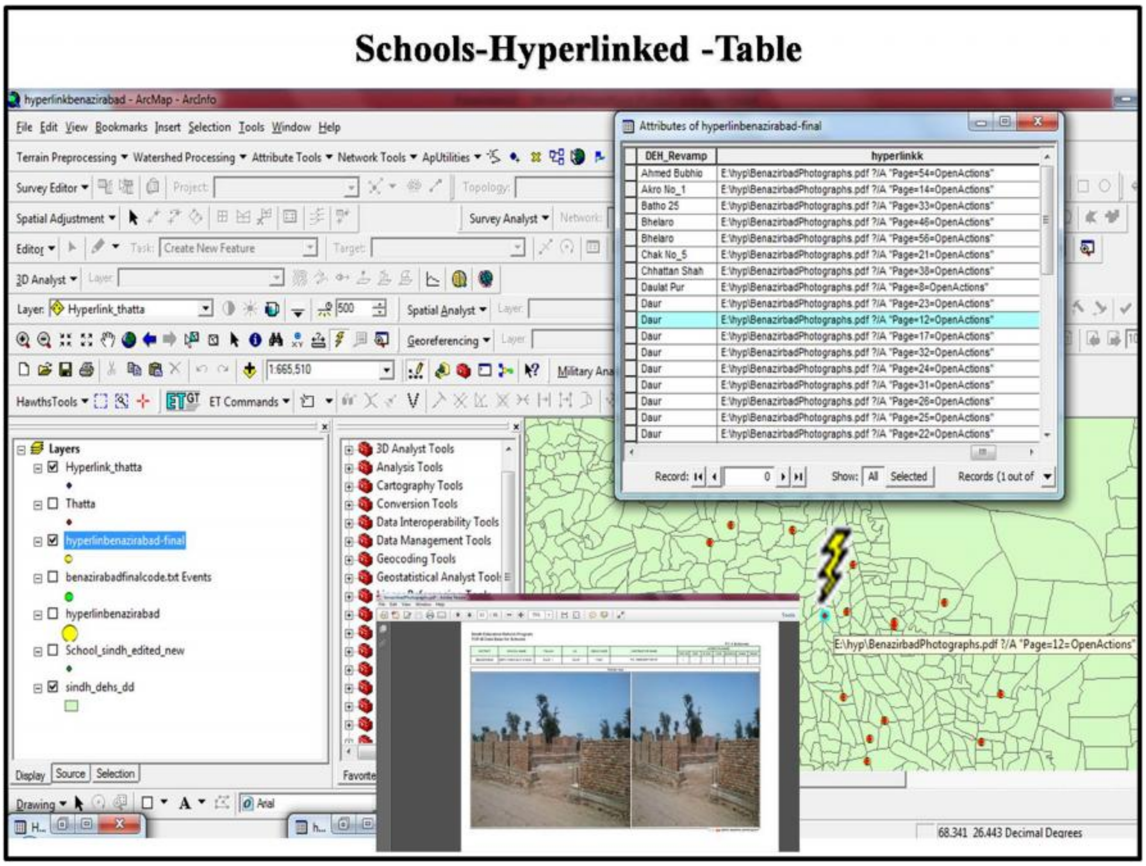


Figure 38: Hyper Linking of a School in Sindh

14.DEVELOPMENT OF CUSTOMIZATION LAYERS

One of the main components of the TOR is to develop tailor-made GIS application that would facilitate the end-user with user-friendly tools to access this system. In this context, two tools have been developed on Python/ArcObjects templates (Figuer-39).

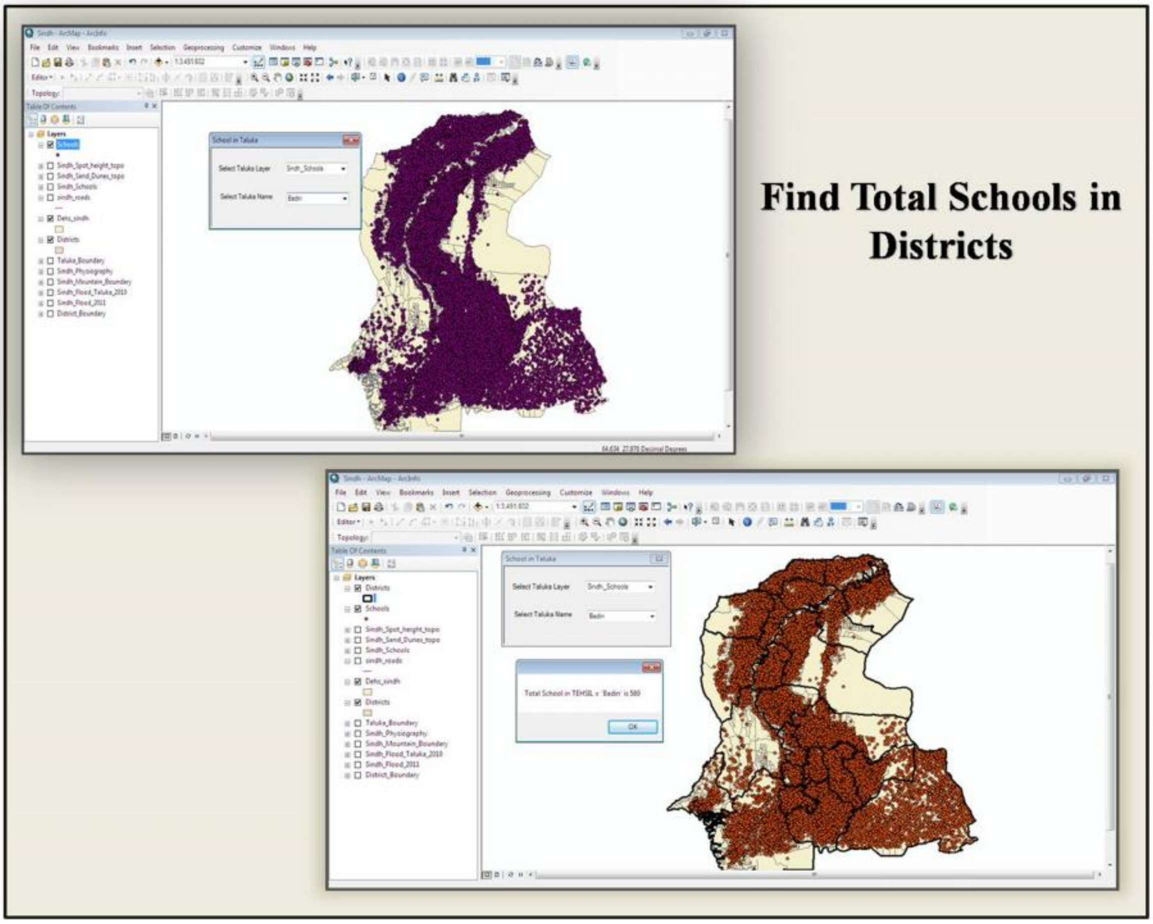


Figure 39: Developed Tool to Find the Schools in a District

15.CONCLUSION

The deteriorating conditions of schools, especially in the context of recent environmental hazards needs attentions of decision-makers. This GIS Project initiated sponsored by the World Bank provides an array of vulnerable of information that could be highly helpful for the local decision-makers for the development, rehabilitation and improvement of schools. The GIS data provided the complete range of Physical and cultural geographical features. This has been further supplemented with the thematic layers of natural hazards, overlaid on these features. The composite weighted overlay has computed the risk of each school. Finally, the risk exposure of each school has been produced both in geometric (Graduated dots) and in tabular (attributes) format.

References

1. **Bigman, D. and Fofack, H.** (Eds.). 2000. Geographical Targeting for Poverty Alleviations: Methodology and Applications. Regional and Sectoral Studies. The World Bank: Washington, D. C.
2. **Environmental System Research Inc. (ESRI).** 2012**.** The GIS Dictionary. Retrieved from http://support.esri.com/en/knowledgebase/GISDictionary/term/waterfall%20model, on November 20, 2012, at 3:45 p.m.
3. **Government of Pakistan,** 2001. District Census Reports: Islamabad
4. Government of Sindh (GOS). 2011. Some Basic Facts about Sindh http://www.sindh.gov.pk/aboutsindh.htm
5. **Khan, J.** A., 2007. General Climatology. Department of Geography, University of Karachi: Karachi
6. **NASA.,** 2012**.** SRTM DEM Data (30m). Retrieved from http://www2.jpl.nasa.gov/srtm/. on October 5, 2012, at 9:00 a.m.
7. **NASA.,** 2012. MODIS 250.721 Data. Retrieved from http://lance-modis.eosdis.nasa.gov/imagery/subsets/?project=aeronet&subset=Karachi.2012331.terra.721.250m. on September 20, 2012, at 11:00 a.m.
8. **Pakistan Agricultural Research Council (PARC).** 2000. Agro-Ecological Zones of Sindh. Retrieved from http://www.parc.gov.pk/Maps/AgroEcoSindh.html. on September 20, 2012. at 2:00 p.m.
9. **Rehman, U. M.**, 1975. A Geography of Sindh Province, Pakistan. The Geographers Association. Publication No. 12: Karachi
10. **Water and Power Development Authority (WAPDA)**, 1989. Hydrogeological Map of Pakistan; Rawalpindi District, Director General of Hydrology: Islamabad.

11. **Water and Power Development Authority (WAPDA)**, 1989. Hydrogeological Map of Pakistan; Bahawalnagar District. Director General of Hydrology: Islamabad.

12. **Water and Power Development Authority (WAPDA)**, 1989. Hydrogeological Map of Pakistan; Bannu District. Director General of Hydrology: Islamabad.

13. **Water and Power Development Authority (WAPDA)**, 1989. Hydrogeological Map of Pakistan; Ghotki District. Director General of Hydrology: Islamabad.

14. **Water and Power Development Authority (WAPDA)**, 1989. Hydrogeological Map of Pakistan; Lahore District. Director General of Hydrology: Islamabad.

15. **Water and Power Development Authority (WAPDA)**, 1989. Hydrogeological Map of Pakistan; Mirpurkhas District. Director General of Hydrology: Islamabad.

16. **Water and Power Development Authority (WAPDA)**, 1989. Hydrogeological Map of Pakistan; Multan District. Director General of Hydrology: Islamabad.

17. **Water and Power Development Authority (WAPDA)**, 1989. Hydrogeological Map of Pakistan; Shakargarh District. Director General of Hydrology: Islamabad.

18. **Water and Power Development Authority (WAPDA)**, 1989. Hydrogeological Map of Pakistan; Sukkur District. Director General of Hydrology: Islamabad.