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Preparation Geodatabase of Sedimentological and Geological Properties by Using GIS Technology: A Case Study

Basrah Province, Southern Part of Iraq

[1]**Wisam R. Muttashar**
(Corresponding author)
Marine Geology Dept./Marine Science Center/University of Basrah, Basrah, Iraq.
Email: wisam.muttashar@uobasrah.edu.iq
ORCID: https://orcid.org/0000-0002-1172-5328

[2]**Mushtak T. Jabbar**
Department of Geology, H. C., MS 29-3, 2400 S. 240th St., Seattle, Washington, 98198, USA.
Email: wisamuk82@gmail.com
ORCID: https://orcid.org/0000-0003-1747-4264

[3]**Dawod S. B. Almayahi**
Marine Geology Dept./Marine Science Center/University of Basrah, Basrah, Iraq.
Email: dowod.banay@uobasrah.edu.iq
ORCID: https://orcid.org/0000-0002-1902-4155

[4]**Qassim M. Al-Aesawi**
Marine Geology Dept./Marine Science Center/University of Basrah, Basrah, Iraq.
Email: alaesawi_2007@yahoo.com
ORCID: https://orcid.org/0000-0002-0309-0668

[5]**Meelad A. Hussein**
College of Marnie Science, University of Basrah, Basrah, Iraq.
Email: meelad.hussein@uobasrah.edu.iq
ORCID: https://orcid.org/0000-0001-8196-2399

[6]**Amel H. Ali**
Marine Geology Dept./Marine Science Center/University of Basrah, Basrah, Iraq.
Email: wrmgeo@yahoo.com

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Abstract

This study uses a combination of remote sensing and geographic information systems (GIS) to create a geodatabase file of geological features in the southern Iraq (Basrah region, as a case study). The geodatabase includes information about sedimentology, topography, structure, and a surface digital elevation model (topographic model). ETM+ Satellite Imagery group with a resolution of 28.5m was the primary data for which the Basrah map was created. Collected sediment data from literature and analysis in this study were inputted to plot geospatial sediment maps of the study area. The sediment maps were created using the SEDCLASS program developed by USGS, which uses of Shepard's and Folk's Schemes to classify the sediments. This geodatabase is a vital, essential step forward that offers a dynamic for future regional development. There is a crucial need to research and create models related to geo-environmental impacts.

Keywords: Digital Elevation Model; Geographic Information system; Geological map, Sediment map, Basrah; south of Iraq.

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1 1. Introduction

Changes to the Earth's surface have become significant concerns for the global population. Environmental deterioration and extensive deforestation resulting from industrialization, urbanization, warfare, and natural disasters such as floods and drought-induced by global warming are interconnected[1]. Surface Change has been a vital research field even from a worldwide viewpoint, and it was supported as a core project by the International prgrams such as International Geosphere-Biosphere and Global Environmental Change Human Dimensions Programs. The research on surface changes is an essential precondition for monitoring regional surface changes, driving factor analysis, and predicting surface changes[2][3]. The GIS technology in many studies is interested in the detection of land surface properties at spatial and temporal scales, as well as the GIS environment generally provides a flexible environment for entering, analyzing, and displaying digital data from various sources necessary for urban feature identification, change detection, and database development[4]. It integrates several elements that are required to be available. These essential elements are user efficiency, Software availability, and captured data. The purpose of creating a Geodatabase including themes and their attributes using the GIS system technique is to handle attribute data in conjunction with spatial features, which was impossible with manual cartographic analysis.

Iraq needs more long-term data. The magnitudes and trends of environmental changes often need more clarification due to the need for more reliable indicators[5][6]. Iraq's land use change process is complicated and it impacts on local and global scales. Consequently, it is crucial to examine the movement and changes of geological characteristics and the deterioration of the environment in Iraq. This examination should lead to the creation of

effective strategies that encourage the sustainable management of land and mitigate the adverse effects of unwanted alterations in land use.

This study aims to find a geodatabase of geological characterizations of the Basrah region, which refer to sedimentological, topographic, and structural settings, by integrating satellite imagery and geological features processed within a GIS environment.

2 Geologic features of Basrah Province:

According to the tectonic framework of Iraq suggested by [7], the Basrah region is located in the lower Mesopotamian zone and the Zubair subzone. The Mesopotamian zone comprises the Basrah block. The structural setting of the Study area is represented by subsurface anticline and broad syncline trending in NNW-SSE. These structures are not apparent on the surface. Geomorphologically, the study area is considered flat sedimentary soil in southern Iraq's lower part of the Mesopotamian floodplain. The climate in Basrah, like to other areas in the Arabian Peninsula, is characterized by a desert-type environment with hot, dry weather, and limited rainfall. The desert ecology in the western regions of Basrah Province is greatly affected by the limited and unpredictable rainfall, the presence of sand sources, and the high northwest winds. The terrestrial ecosystem of Basrah Province has been under significant strain for over twenty years due to urbanization, excessive resource usage, and military activities.

3 Materials and methods

3.1 Collecting data:

The Basrah Province was selected as a study area to prepare a geodatabase file of geological features. The province is situated in southern Iraq, near the northwestern shore

of the Arabian Gulf. It is located between longitude 46° 60′ to 48° 60′ E and latitude 29° 13′ to 31° 29′ N. The region's entire area is 19,070 km^2 (Figure 1).

This study employed Landsat 7 ETM images to build a base map. In addition, several data resources are used, including a structural map[8], a topographic map[9], and a Digital Elevation Model of southern Iraq. All the thematic layers were designed in a GIS background at a scale of 1:250,000.

3.2 Digitizing and Creating Geodatabase

The main objective of this research was to create a geodatabase file including geological information related to sedimentology, topography, structural setting, and surface elevation (topographic) model using a 1:250 000 mapping scale.

1- Sampling and GPS data of sites: sediment samples, such as grain-size data, were collected from several previous studies at some sites in Basra Province. Also, 25 samples from other sites were measured, covering sites in the region to be integrated with the collected data.

2- processing satallite Imagery: To retrieve sediments' boundaries proficiently, the pre-processing included geometric correction and ground control points that were chosen based on a topographic map of 1:250,000.

3- *captured elevation data;* two resources were utilized, first by scanning the raster topographic map of Basrah[9], where converted to digital data (GPS and elevations) and then mapped. The surfer program was used as a stage before that data was restored to the ArcGIS program. The second resource is collected elevations of data and GPS from different resources to map (vectorial) topographic layer. The two GPS resources and elevations of the Basrah region were used to compare the accuracy of both resources. Error

percent is (± 5m) of elevations relative to sea level. Also, topo layers were correlated with the DEM layer of the Basrah region. The created layer of the topographic map in a vector format is essential for overlaying the process with other layers and being available in future studies, especially relating to hydrological studies.

4- The SEDCLASS program is a custom tool that represents an extension within ArcGIS 9.3 Desktop application[10]. In this study, SEDCLASS was employed to analyze the sediment classification of the Basrah region. SEDCLASS, a program developed at the Woods Hole Science Center (WHSC), is designed to classify sediment grain-size distributions based on relationships between grain particle fractions. It is installed as a toolbar within the ArcMap window. It accepts two forms of input data: either a point data layer with field characteristics that include percentages of gravel, sand, silt, and clay or four raster data layers that reflect the percentage of sediment (ranging from 0 to 100%) for each sediment particle size analysis (gravel, sand, silt, and clay). The user may select either the Shepard (1954), as modified by Schlee (1973) or Folk (1954, 1974) classification[11] schemes (Figure 2). Both schemes were mapped in the Basrah region in the present study.

4 Results and discussion

4.1 Geological map

Structural geology and topographic themes are overlaid after several steps during digitizing processing, as shown in Figure 3. Generally, data were scanned and entered as raster layers processed in the ArcGIS system. The maps were scaled and resized, and all the layers were unified by rectifying the actual (coordinate system[12] according to the world coordinate system (Geodetic Datum WGS84 and map projection NUTM38). Figure 4 is a shape file of sedimentological units in the corrected Basrah region map.

The Basra region is part of the lower Mesopotamian basin, generally divided into two main sides: the western and eastern sides. The two sides have different sediment characterizations: coarse-grained and fine-grained deposits, respectively, as shown in Figure ٥.

The central sediment units can be classified into sub-divisions;

The eastern side sediments unit is a fine-grained zone with more than 75% mud deposits representing the Holocene deposits. Table 1 shows five types of subunits covering different percentages of areas as follows*:*

(1) Floodplain deposits account for 3886 Km2 (20.4%) of the Basrah area. They consist of sandy mud deposits and represent riverine deposits with a high silt content.

(2) Marsh deposits represent the southern part of Hammar and Qurna marshes sediments, where composite of Silty Clay and Clayey Silt with a small quantity of fine sand no more than (12%). It occupies about 3321 Km^2 (17.41%) of the Basrah area.

(3) Tidal flat deposits are called coastal sediments; they result from the Arabian Gulf Sea tidal processes, bringing mud deposits. They have 771 Km^2 (4.0%).

(4) Estuarine Sabkh deposits are occupied 785 $Km^{2,}$ with (4.1 %) of the Basrah area. It is also affected by marine deposits, which consist of silty mud deposits with high salt content.

(5) The Inland Sabkh deposits account for 175 Km^2 (0.91%) of the total Basrah area. They are mud deposits with the highest clay and salt content.

For the western side deposits unit, two types of subunits can be seen in Figure 4;

(1) Alluvial fan deposits represent Quaternary deposits mainly composed of sand and gravel, with 4220 Km2 (22.1%), Table 1. They are elevated "between" (9 – 85) meters above sea level (figures 8, 3, and 9).

(2) Sandy Dibdiba deposits, which occupy the east-south zone, are elevated (90 – 260 m) over sea level, with 5150 Km^2 of area (27%) of the Basrah region .Gravel and sand depositions are essential deposits in these sediment units and have a thickness of up to 300 – 400 meters[13]. This subunit, also named Dibdiba Formation, is one of the vital aquifers of groundwater in the Basrah region that recharge agricultural lands. Additionally, it is the region's leading source of primary construction materials, such as gravel and sand.

Table 2 shows in detail the geo-information of the west side of the Basrah region relating to slopes and their percents, as well as contour ranges and their areas percent. The western side has a slope of 1.8 meters per kilometer at the Dibdiba zone; it then gradually decreases to 1.3 m/Km at alluvial fan deposits toward the eastern side.

Also, according to Shepard sediment classification (1954) and Folk classification (1954, 1974), two model layers were created depending on the grain size analysis point's data. Figure 9 represents the classification layers of Shepard (1954) and Folk (1954, 1974). At both classification layers, the spatial distribution of sediment zones generally differs slightly from the modified sedimentological unit's layer. O'Malley[10] mentioned the importance of these models' sediment maps with corporation geophysical information to analyze and interpret the geological setting of the region.

4.2 Surface modeling

Figure 6 shows topographic themes (maps) created from different data sources: Google Earth program and raster data map, which are converted to vector maps. A little difference was observed between the two topographic (vector) maps. Based on these cartographic elements of topographic features (elevation points), a 3D topographic model (Figure 7) and a Digital Elevation Model (DEM) were plotted in the Basrah region. The elevation points

are classified into ten classes according to contour interval using the equal interval method and displayed as a color scale of the study area. It was overlaid with a structural map layer (Figure 3), which was included within the geodatabase file of the study area, Basrah region. The Basrah region elevations range between 0 to 260 meters above sea level. The eastern side is about 0 to 5 meters, while the western side of Basrah starts at 5m elevation in the Khor Azubair channel and reaches 260 meters, Figure 7. This 5-meter-contoured line presented the primary interface between the eastern and western sides of the Basrah region, which agreed with several previous studies. This editable, dynamic vectorial topographic feature within the geodatabase can be a crucial help in analyzing hydrogeologic models and evaluating harvesting freshwater systems needed in this region, specifically on the western side. The surface model created using the Triangulated Irregular Network method (TIN) is the first step to building the surface model of the Basrah western side, which consists of two layers: the sandy Dibdiba and Alluvial fan zones. These two themes are merged as one layer within the Geo-processing wizard; then, the TIN theme is created, as shown in Figure (8). The TIN method is essential to creating hydro-geological features that include ground or surface water flow direction, Sink, flow accumulation, and stream network themes.

4. Conclusion

Employing remote sensing data as the main source of information and utilizing GIS technique as a tool for analytical processing of geologic data of Basrah area was both practical and efficient. This approach facilitated the construction of theme layers in a raster format. This data provide comprehensive modeling for layers analysis for particular purposes, i.e., assessing the sediment data and mapping the geological areas. From the

above studies, we can conclude that: (1) it successfully created a geodatabase of the Basrah region's geological properties despite multiple and different collected data sources. It is also possible to exploit the GIS environment to demonstrate geological databases in the Basrah region; hence, the resulting themes will be the basis of digital geo-information in the Basrah area. These themes have the flexibility to update and modify, and they are saved as a "project file, "which is used whenever the need to carry out a specific analysis, which could service geo-environmental and engineering purposes. (2) The surface layer has been prepared as a flexible grid of the Basrah region, which attributes table is used to analyze within the Arc GIS environment.

Acknowledgments

Authors gratefully acknowledge the Marine Science Center at the University of Basrah for funding and technical support of this work.

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List of Tables

Table 1 represents the sedimentological unit areas of Basra Province.

Zones	Area (Km^2)	% Area
Marsh deposits	3321	17.41
Flood plain deposits	3886	20.4
Inland Sabkh deposits	175	0.91
Estuarine Sabkh deposits	785	4.1
Tidal flat deposits	771	4.0
Marine water	322	1.68
Freshwater	441	2.3
Alluvial fan deposits	4220	22.1
Debdiba deposits	5150	27

Table 2: Geo-information data of the western side of Basrah Province.

Deposits	Contour lines range (m)	Area (Km^2)	Slope (m/ Km)	Contours range (m)	Area (Km^2)	Total Area (western Side) (Km^2)
Alluvial Fan	6 – 34	3269	1.3	6 – 90	6601	11263
	34 - 85	3332	1.3			
Dibdiba	85 - 140	2088	1.7	90 - 260	4661	
	140 – 200	1694	1.8			
	200 - 260	880	0.98			

Figures captions:

Fig.1: Location of the study area in southern Iraq.

Fig.2. Shepard and Folk classification schemes for mapping of sediments models of Basra region.

Fig. 3. Topographic and structural layers of Basra region.

Fig. 4: Sedimentological units layers of Basrah region.

Fig. 5: Basrah region themes in ArcGIS window with two sides and their attributes tables after geoprocessing.

Fig. 6: Left view: topo theme using raster map after (Yasin, 1998), Right view: topo theme using Google Earth data.

Fig. 7: 3D elevation model of Basrah region.

Fig. 8: The left side shows the topo theme of the western side of the Basrah area, while the right view shows the TIN layer.

Fig. 9**:** The left side shows sediment classification models of the Shepard (1954), while the right side shows Folk (1954, 1974).

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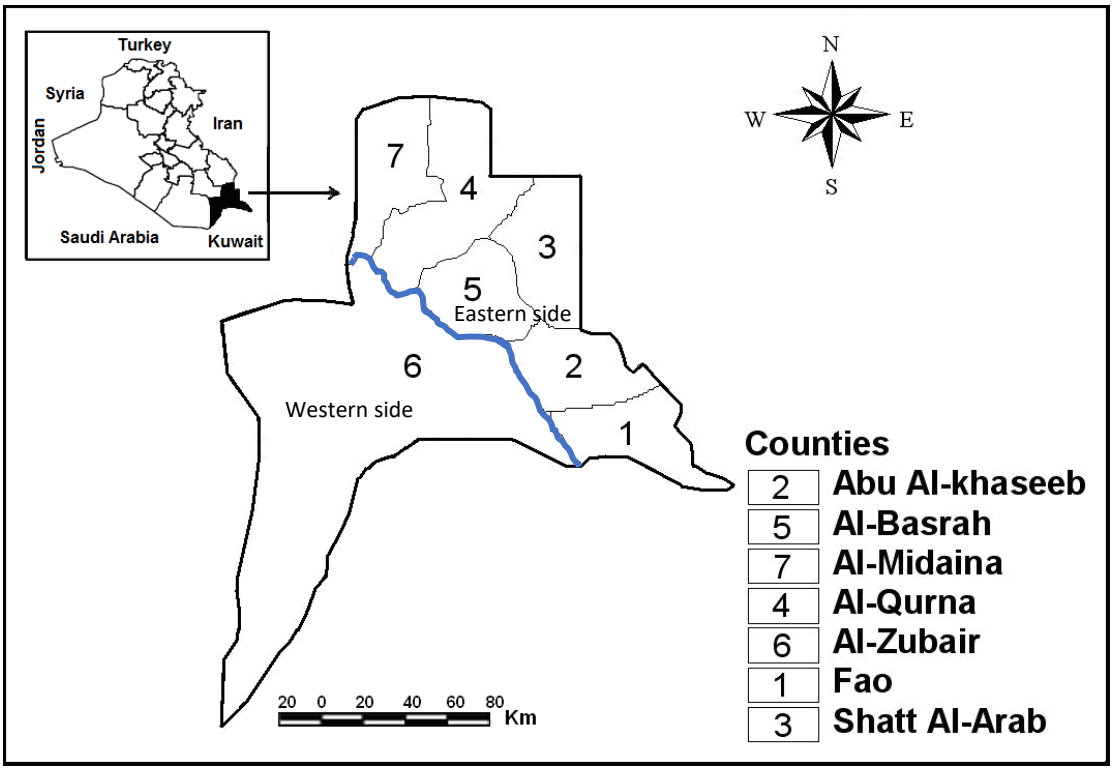

Figure ١ Location of the study area in southern Iraq.

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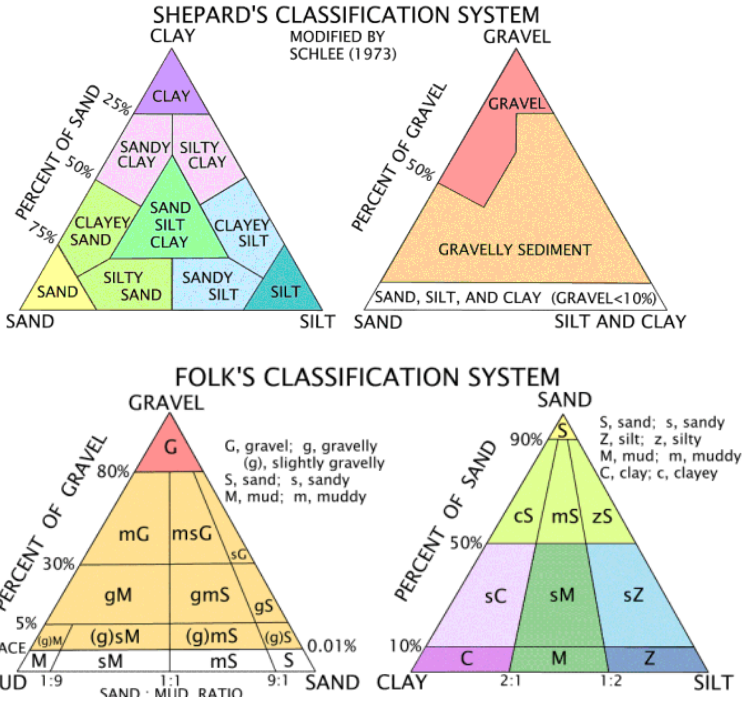

Figure٢ Figure (2) Shepard and Folk classification schemes for mapping sediment models of Basra region.

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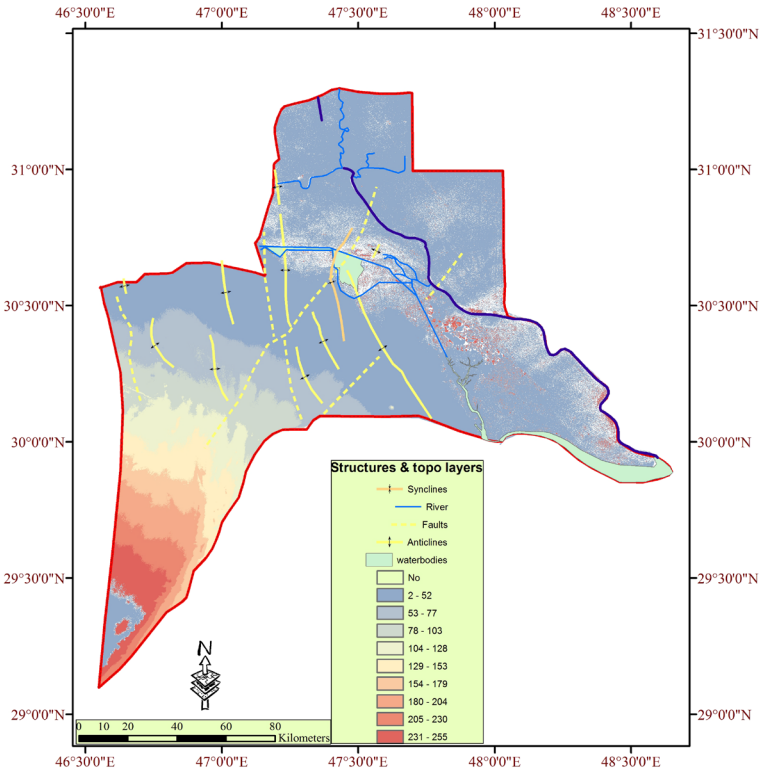

Figure 3 Topographic and structural layers of Basra region.

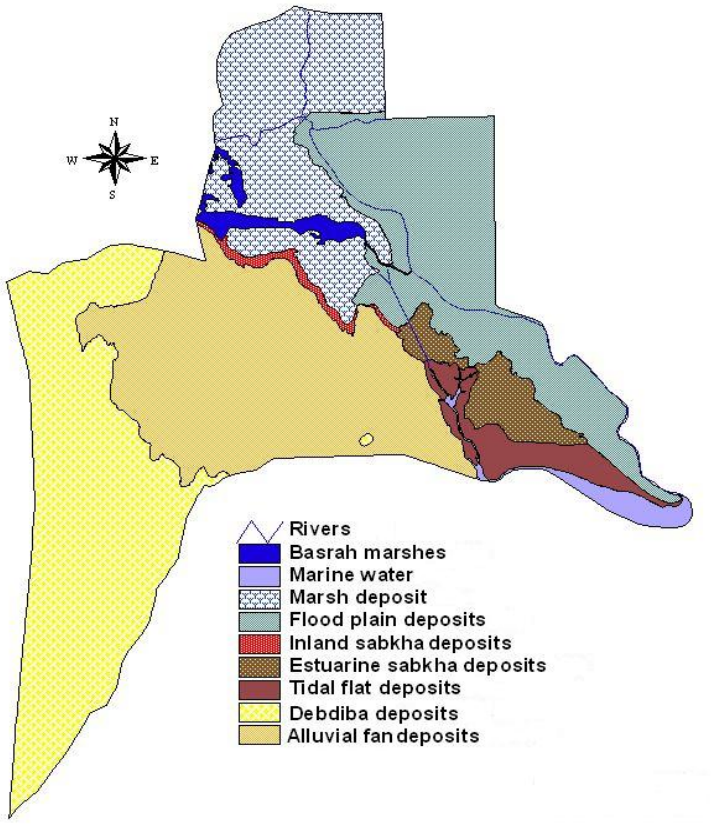

Figure 4 Sedimentological units layers of Basrah region.

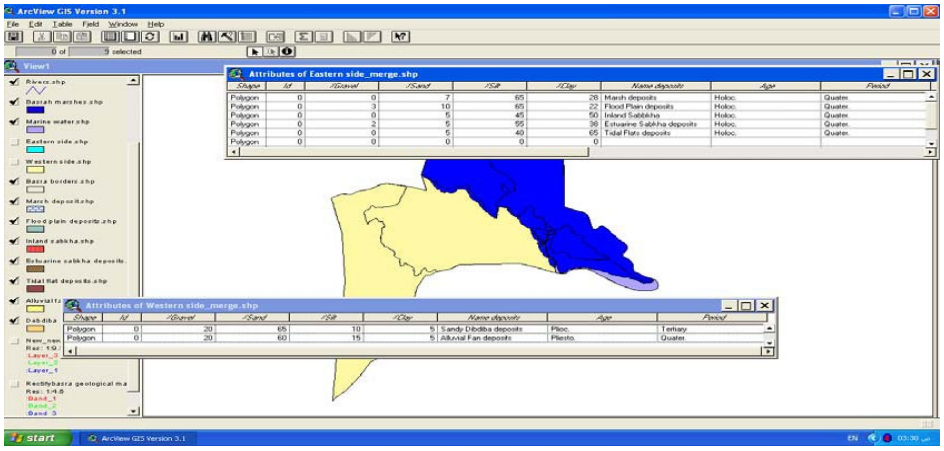

Figure 5 Basrah region themes in ArcGIS window with two sides and their attributes tables after geoprocessing

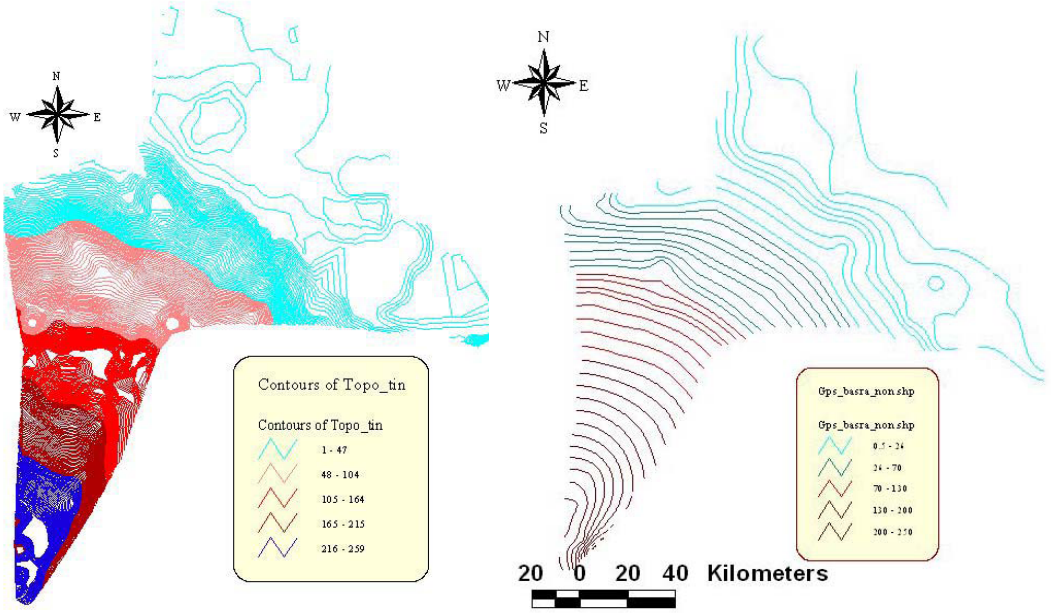

Figure 6: Left view: topo theme using raster map after (Yasin, 1998); Right view: topo theme using Google Earth data.

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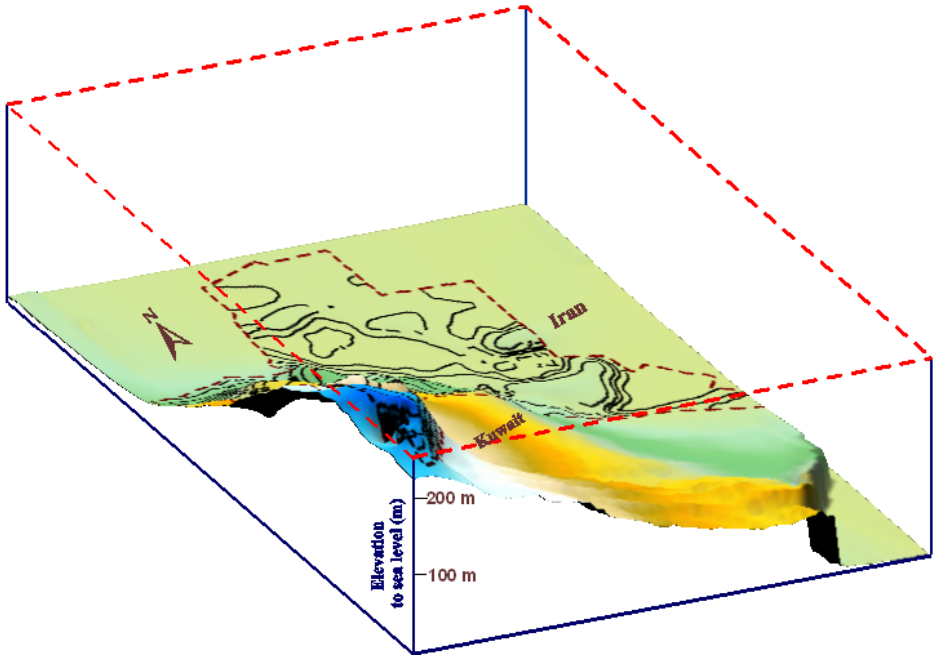

Figure 7 3D elevation model of Basrah region.

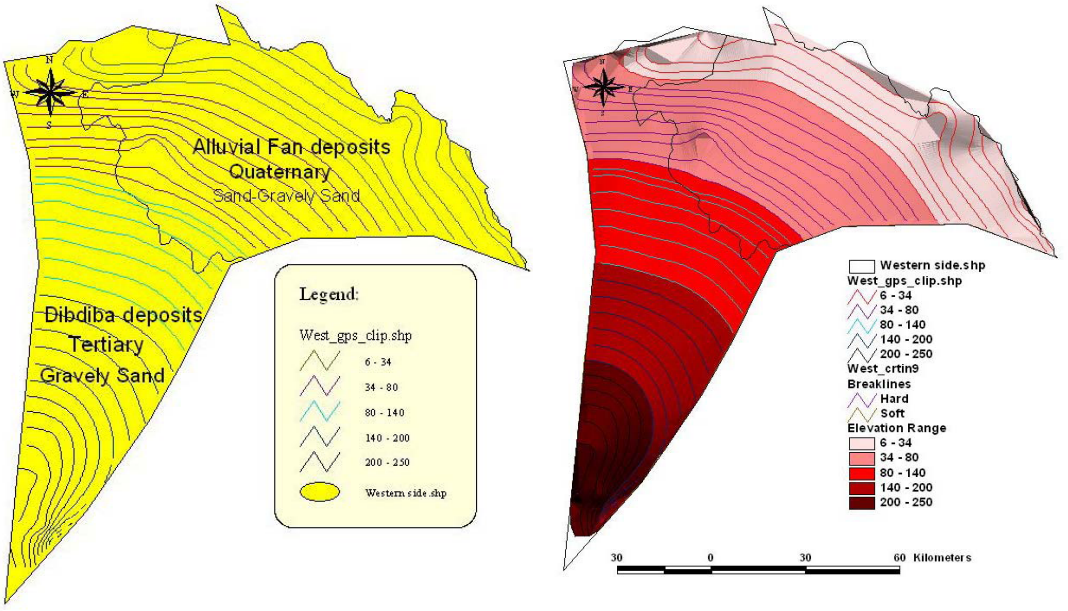

Figure 8: The Left side shows the topo theme of the western side of the Basrah area, while the right view shows the TIN layer.

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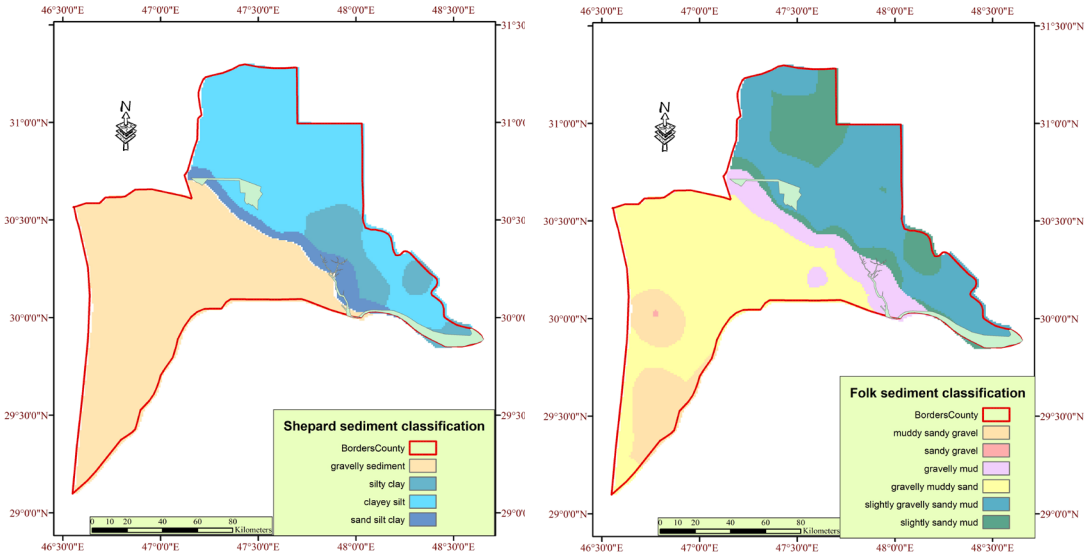

Figure 9: The left side shows sediment classification models of the Shepard (1954), while the right side shows Folk (1954, 1974).

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اعداد قاعدة بيانات بالخصائص الجيولوجية والرسوبية من خلال استعمال تقنية الـ GIS دراسة حالة منطقة البصرة جنوب العراق

وسام رزاق مطشر ،مشتاق طالب جابر، داود سلمان بناي ، قاسم مزعل فليح ، ميلاد علي حسين ، امل حسين علي
قسم الجيولوجيا البحرية /مركز علوم البحار / جامعة البصرة
Email: wisam.muttashar@uobasrah.edu.iq

المستخلص:

استخدم في هذا البحث التكامل بين نظم المعلومات الجغرافة وتقنية التحسس النائي لاعداد قاعدة بيانات رقمية لمنطقة البصرة تشمل على الوضع الطوبوغرافي والوضع التركيبي وموديل الارتفاعات الرقمية بأستعمال مقياس ١:٢٥٠٠٠٠. وقد اعتمدت مجموعة المرئيات نوع +ETM بقوة تمييز ٢٨.٥ متر لتغطية منطقة البصرة بعد تجميعها وتحديد منطقة الدراسة (البصرة)، لتمثل الخارطة الاساس المعتمدة لعمل الطبقات. تضمنت البيانات التي تم تجميعها ذات مصادر متعددة ومتنوعة استخدمت لتمثيل طبقات السمات المطلوبة. وقد استخدم برنامج SEDCLASS لتصنيف الرواسب والمطور من قبل المسح الجيولوجي الامريكي، ٢٠٠٧ والذي يعتمد على تصنيف (شيبارد، ١٩٥٤) و (فولك، ١٩٥٤، ١٩٧٤) للرواسب، حيث يعمل البرنامج ضمن بيئة نظام الـGIS من خلال استخدام بيانات التحليل الحجمي للرواسب لمواقع تم تحليلها موزعة على منطقة الدراسة حيث تُمثل بشكل خرائط لكلا التصنيفين وبأستخدام مقياس التغاير اللوني في وصف انواع الرواسب. الطبقات او الشرائح تعرض بيانات الوحدات الترسيبية في المنطقة وطبقة للوضع الجيولوجي التركيبي، وطبقة الموديل السطحي الطوبوغرافي وطبقات تصنيف الرواسب. ان هذه الطبقات تمثل قاعدة معلومات مرنة قابلة للتطوير والتعديل والتحديث بالمستقبل كما ان هذه المعلومات الرقمية ستكون متطلب اساسي كبيانات يتم ادخالها عند عمليات التحليل ضمن بيئة الـGIS والتي تخدم الاغراض البيئية والهندسية لا سيما نمذجة الظروف الهيدروجيولوجية.