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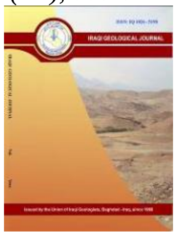

Geometric Analysis of the Suggested Derlock Dam, DuhokReservoir using a Digital Elevation Model

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Abstract

Several application programs, including Global Mapper, Surfer and GIS, which deal with spatial analysis and extract spatial data and information for land features, were used to extract geometric elements of the proposed Derlock Dam reservoir based on the digital elevation model (DEM) with a discriminating ability of 10 m. It started at a level of 740 m at the site of the dam and reached a height of 900 m above sea level with an interval of 10 m. The relationship of the level with the negative volumetric and negative spatial elements showed that there is a large difference in the values of Negative Volume (NV), Negative Planar Area (NPA), and negative surface area (NSA) at the level of the reservoir (900 m), which is a positive factor in choosing the topograph Negative Surface Area depression, as it shows a significant decrease in the surface area (evaporation area) and the wet area (the area of penetration). This corresponds to a significant increase in the volume of the reservoirs, and indicates that the depression is deep and small in area, as well as the final economic feasibility of the project. It consists of two reservoirs, which will allow a strategy to maneuver the amount of water storage, as well as reduce the risks of flood waves and sediments that will be deposited behind the dam gate. The reservoir volume reached 900 m, 3611048537 billion m^3, distributed among reservoirs near the dam with volumes of 445189305 million/m^3 and 3166195232 billion/m^3 for the reservoir far from the dam site, because the Upper Zab River does not have dams, so it will be able to build important reservoirs and control the river water during floods.

Keywords: Hydrology; Applied Geomorphology; Digital Elevation; Geometrical Elements; Upper Zab River

1. Introduction

The term "geometry" has been dealt with since antiquity and pre-Greek times, meaning "measurement" of the earth, where it overlaps in its use. Irregular shapes become regular geometric shapes through the use of mathematical and geometric laws (Oliver, 1995). By using it, it is possible to calculate and measure the size and area of the figor the relevant feature (the topography of the earth's surface) as its reality on the ground, as modern advanced technologies from remote sensing data and computer application programs have allowed the use of the geometric concept, its applications, and laws in the study of land shapes and features, including water reservoirs.

In order to achieve optimal planning and sustainable development, it puts geomorphology in competition with the quantitative studies of the spatial sciences, and emphasizes the significance of its

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role. The shape of the terrain and the land appearance that dominates and imposes itself in this process, by defining the dimensions, area, and volume of the reservoir and drawing the geometry and appearance of the reservoir with all its outputs (Philip et al.,1992).

International and local studies and reports indicate that Iraq faces a drought and decrease in water quantity due to climatic changes and fluctuations, in addition to the pressures of the (riparian) countries in the region with the tributaries of the Tigris and Euphrates rivers, through the position of Iraq as an estuary country, where Iraq is exposed to a major water crisis and may reach the level of disaster that will befall it and lose its ability to achieve water and food security. Because the upper tributary of the Upper Zab River is difficult to complex and exploit due to mountainous terrain sites, the problem of organizing and managing this important water resource arises, which is out of control, especially during regular and extreme flood periods, posing many risks, and a large of water is wasted. Building dams on the upper Zab River, even if they are small, will increase the size of the contribution that the construction of this dam will add in all its aspects to Iraq's potential for water resources. (The Erbil Water Resources Department, affiliated to the Iraqi Ministry of Water Resources).

1.1. Study Approach

The study is organized in terms of its ideas and the way it deals with the variables related to the subject using the following: The barometric approach is concerned with using the digit language by applying a series of different calculations, equations, and statistical analyses to achieve the precision of the expression language of spatial variables. A landscape approach: This will result in a thorough geomorphological, hydrological, and geometric assessment of the dam reservoir basin.

1.2. Study Area Location

The study area (reservoir) is located geographgically in the northeast Iraq, about Northeast of Dohuk City. It lies between longitudes 43°20′32″- 43°43′10″ East, and latitudes 37°18′50″- 37°46′20″ North (Fig. 1).

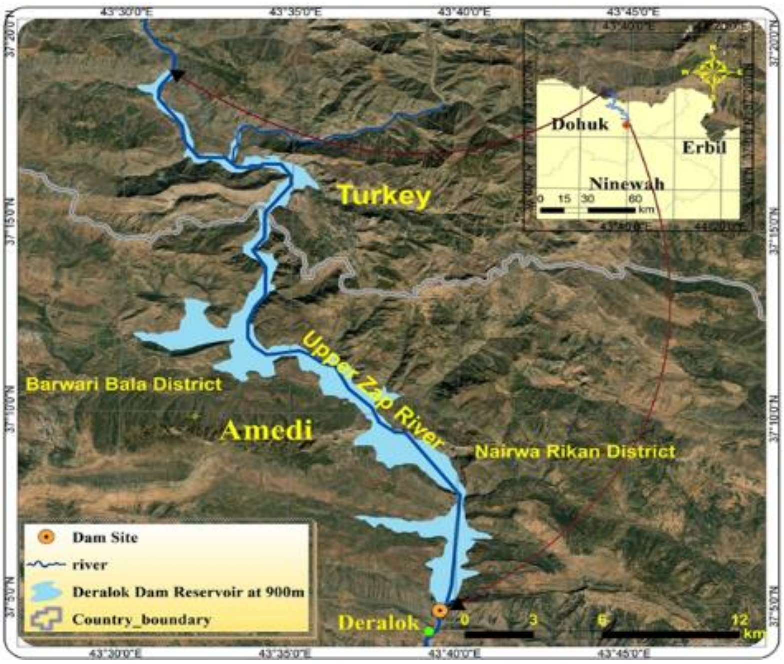

Fig. 1. Location map of the study area (the supposed Derlock reservoir and dam)

it extends with the course of the Upper Zab River in a direction that cuts off the direction of the folds axes close to the dam site, northeast of Dirluk, and then heads with the direction of the folds axes in the region (northwest). The northeastern province of Dohuk is Amadiyah district, bounded on the west by Barwari Bala and on the east by Narwa Rikan; in the south and southwest by Derlok; and extending towards the north and northwest towards the international border with Turkey. The selected high mountains area occupies 38.1 km^2. Its elevation ranges between 740 at the presumed dam site and 900 m a.s.l.

The supposed Derluk Dam reservoir derives its water from a basin extending from Iraqi territory to Turkish territory (the upper basin) of the Upper Zab River. The annual water revenue is estimated at 6 billion m3, and the highest annual water revenue was recorded at the Dirluk drainage station, which amounted to 9.28 billion m^3 in the year 2019; the highest monthly water discharge is concentrated in the period of peak rainfall in March, as well as the periods of snowmelt in April and June (The Erbil Water Resources Department, affiliated to the Iraqi Ministry of Water Resources).

1.3. Study Justifications

One of the most important justifications for the study is the development and good management of water resources in Iraq in order to rationalize their consumption and reduce the waste of massive amounts of water, coming to that region in particular and Iraq in general during the rainy season, particularly during the winter and spring seasons, which go without benefiting from (irrigation, tourism, water storage, and energy production), not to mention the treatment of drought.

The study aims to analyze and survey the dam reservoir (Dirlock) geomorphology and geometric to determine its relationship with the hydrological and hydraulic valley, represented by the size of the reservoir surface area (evaporation area), the area of the bottom of the reservoir (wet space), and the areas of the islands and the corresponding bays for each level of the dam's reservoir, as it will be represented. A database that the designer can rely on in determining the designs of the dam's body and its optimal location and the comparison between the topographical depressions to reach the optimal and economic level of the dam, which will lead to achieving investment and good management of the wasteful water capabilities for the purpose of addressing the water management crisis.

1.4. Programs used in the Study

Programs that were used in this study are ERDAS Imagine 9.2., Arc GIS 10.6.1., Surfer 13, and Global Mapper 13.

2. Geological, and Geomorphology of the Study Area

It represents the structural, geological, and geomorphology of the land on which the dam project will be established, one of the most prominent natural ingredients on which the dam's structure and reservoir of the dam's body are established, as the dam may be exposed to collapse or failure after its creation if these elements are neglected by the foundations and engineering studies, so several preparatory studies must be carried out associated with the process of planning, implementing, and maintaining the dam (Zhazhlayi and Surdashy, 2022).

The study area is located on the northeastern edge of the Nubian Arabian Platform (the edge of the unstable sidewalk, the regional concave area, and the Thrust area), specifically at the edge of the southwestern part of the Zagros thrust belt and the edge of the northeastern part of the northern thrust zone within the Iraqi border. in the far north of Iraq, near the Turkish border, according to the tectonic divisions of Iraq (Jassim and Goff, 2006). It reflects the development of a series consisting of high, rugged and narrow folds extending from northwest to southeast and formed as a result of alpine movements and as a result of the thrust of the Arab shield against the Iranian and Turkish shields. The

Zab that cuts it, as well as the reservoir dam, is located with the extension of the Upper Zab River valley to the northwest, between the folds of Banbeh in the east and Siri in the west (Al-Ta and Omer, 2005).

2.1. Geological Formations Exposed within the Dam Reservoir's Boundaries

The importance of studying geological formations in terms of their impact on the hydraulic properties of the layers and their hydrogeological nature, as well as the properties and hydrochemistry of the water that flows in the sloping valleys towards the reservoir and inside it moves vertically or horizontally through the levels of the water reservoir of the dam.

The Paleozoic deposits extended from the Upper Permian to the Late Permian (Buday, 1980), which included the Jia Ziri limestone formation, while the upper Jurassic period included the formations Giakara, Parsian, and Naukalkan until the upper Cretaceous which represented by the Aqrah Bakhmeh Formation, while the Cenozoic was represented by the Tertiary Age - Paleogene of the Upper Eocene which included the Pilaspi Formation (Fig. 2). The following is a description of these exposed geological formations within the Table (1)(Buday, 1980).

The importance of studying geological formations in terms of their impact on the hydraulic properties of the layers and their hydrogeological nature, as well as the properties and hydrochemistry of the water that flows in the sloping valleys towards the reservoir and inside it moves vertically or horizontally through the levels of the water reservoir of the dam.

The Paleozoic deposits extended from Late Permian which included the Chiazairi limestone Formation, while the Late Jurassic period included the Chia Gara, Barsarine, and Naokelekan formations and the Late Cretaceous which represented by the Aqra and Bakhma formations, while the Cenozoic was represented by the Paleogene to Late Eocene which included the Pila spi Formation(Fig. 2). The following is a description of these exposed geological formations within the Table (1) (Buday, 1980).

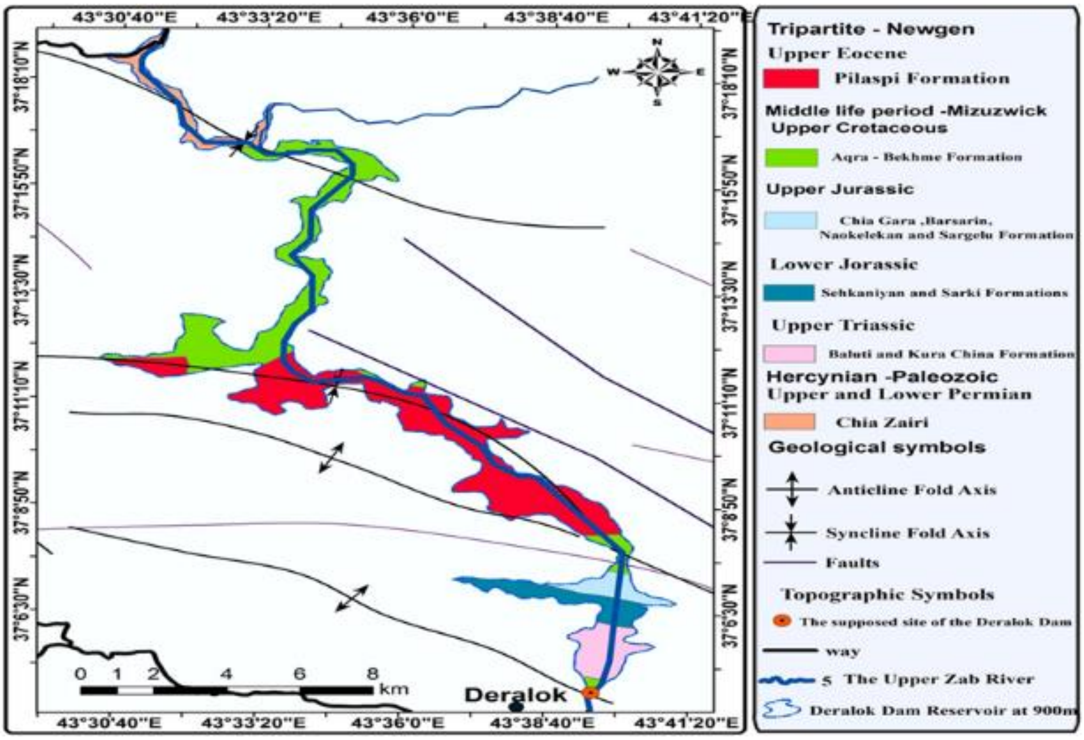

Fig. 2. The exposed geological formations of the Derluk Dam reservoir. Source: Based on the geological age maps of Erbil and Sulaymaniyah (Sissakian and Fouad, 2015).

Table 1. represents the exposed geological formations of the Derlock Dam reservoir, its age, and its lithological description (Sissakian and Fouad, 2015)

s	Formation name		Age	Rocky description
1	Pilaspi	period of modern life -Cenozoic	Upper Eocene	Mainly well bedded limestone's
2	Aqra-Bakhme	middle- life Era period – Mesozoic	Upper Cretaceous	Mainly Well-bedded massive limestone's (Marly limestone's
3	Chia Gara, Barsarin, and Naokelekan		upper Jurassic	Mainly bedded to massive dolomites, limestone's and marl
4	Sehkaniyan and Sarki		Lower Jurassic	Mainly limestone, dolomite, thin bedded limestone and shale
5	Baluti and Kura China		Upper Triassic	Shale and black limestone and dolomite
6	Chia Zairi	Hercynian- Paleozoic	Upper and Lower Permian	Limestone and Shale

2.2. Geomorphology of the Study Area

The shape and appearance of the surface of the Earth in the region reflect the structure and tectonics of the region, in general. The location of the study area (Derlock Reservoir) at the edge of the southwestern part of the Zagros Thrust Belt and parts of the Northern Thrust Zone makes it includes several ridges and chains. The mountains are high, part of which extends east to west and another part northwest to southeast, represented by folds (convex and concave) consisting of solid lithological units and others fragile, resulting in variation in the morphology (Al-Kubaisi and Ali, 2002).

Geomorphological factors and processes worked to modify and form various landforms in the reservoir area, including destructive and structural ones, which reflected the activity of those processes and their predominant type (esoteric movements, weathering, sculpture, settlement, erosion, and avalanches (slides and landslides) where various geomorphological forms emerged. (Hostani and Hamasur, 2022). Mountains, folds, cracks, structural barriers, and erosion, particularly those with high height (folds) at the rocks that are most resistant to erosion and erosion processes with highly inclined layers, as well as the units of Dahr Al-Halouf (hog back) that extend at the wings of the eastern folds and where tabular and groove erosion are active (Hamza, 1997).

Also, the processes of water erosion and physical weathering of various types led to the formation of different drainage systems, such as parallel and orthogonal drainage systems. As their valleys penetrated the bodies of the folds (convex and concave) and cut them perpendicularly towards their axes, especially the convex ones, and descended in the form of tributaries that meet with the Upper Zab River within the boundaries of the reservoir. (Mustafa and Tobia, 2020) As for the synclines folds, they represent the narrow, low topography from which the axes of the folds extended, including some parts of the dam water reservoir. The assumed height of the Derlock reservoir ranged between 730 and 900 meters above sea level, and its boundaries were determined and deduced from satellite imagery (DEM) (Hamza, 1997).

3. Climate of the Region

Rain participates with a large proportion and is a major source of feeding the Tigris River and its tributaries, as well as snow and groundwater, in north and northeastern Iraq , where annual rates range between 300 and 1000 mm in those areas and exceed 1200 mm inside Turkey in the highlands. The Upper Zab Basin and rainfall rates decrease in the dry and fluctuating years in the countries of the feeding basin of the Tigris River (Iraq, Turkey, and Iran) to approximately 389.8 mm compared to the base rate of 502.2 mm, and the dry and semi-arid climate prevails in most areas of Iraq. Dryness increases the annual evaporation rates, reaching a rate of 2737 mm, which is caused by high temperatures and their extremes from the natural rates of 13.3 °C, reaching 14.9 °C, with a difference of +1.6°C. (Nomas, 2013)

This is attributed to the effects of climatic changes and fluctuation over periods. All these climatic variables effectively contribute to the decrease and increase in the annual revenue rate of the Tigris River in Iraq according to the increase and decrease for each of them, so that the total discharge of the Tigris River incoming into Iraq in rainy years until 2013 was 33 billion m^3 (Nomas, 2013).

For drought periods, the discharge amounted to 19 billion m3, while the contribution of the basin countries amounted to Turkey, Iraq and Iran, with an annual discharge rate of 56, 32, and 12 billion m^3, respectively. The increased consumption of the increasing water revenue in the upper Tigris Basin resulted in a decrease in the rate of revenue by approximately 7 billion m^3 per year and is likely to reach in the future more than 17 billion m^3 per year. The water revenue reaching Iraq within the Tigris River will decrease from 33 to 23 billion m^3 per year. Thus, requires Iraq to seriously redress the matter and conclude new agreements between these parties in order to ensure that the water share that Iraq needs is not damaged in light of the increasing drought years (Ministry of Water Resources, 1990-2013).

The climatic station was chosen as the most suitable and closest meteorological station to represent the climate data for the study area, which is the Amdiya station of the Dohuk governorate, located to the west of the reservoir at a distance of 15 km, and Table 2 shows the annual and monthly rates for a number of climatic elements recorded over a period of 15 general as provided by the weather monitoring station of the approved station.

Table 2. Annual and monthly averages of a number of climatic elements for the study area (2005-2020)

Climate element	Annual average	Highest monthly average	Lowest monthly average
Temperature (°C)	15	30 July and August	0 January and February
Rainfall (mm)	753	January 180	July, August and September
Relative humidity (%)	44	58 January	26 July and August
Wind speed (m/s)	1.6	June 2	December 1.1
Evaporation (mm)	1.6	Jul 9.7	Jan 1.1

4. Materials and Methods

The geometric elements of the Derlock Dam reservoir were extracted from a digital elevation model (DEM) with a discriminant capacity of 10 meters. Using spatial analysis software that processes spatial data and transforms it into numbers representing dimensions of the ground shape (2D-3D), the geometric elements were extracted from the 740 to 900 m above sea level for every 10 meter level. where the outputs of the digital processing process were obtained for the geometric elements, including surface area and water levels in the tank, positive volume (PV), negative volume (NV), positive surface area, negative surface area, positive planar area, negative planar area, average depth, and average thickness of the island, as shown in Figs. (3 and 4).

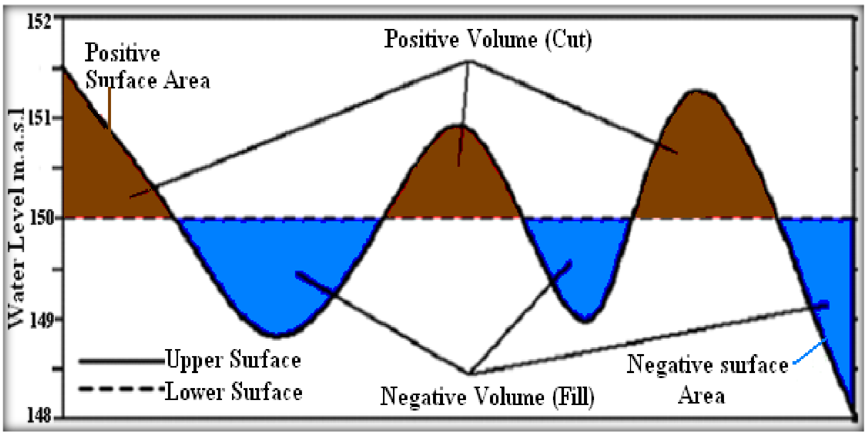

Fig. 3. The geometric elements

The surface area of the water inside the water tank is equal to the area of the islands falling within the boundaries of the tank (the "positive" planner area) and the surface area of the water in the tank's "negative" planner area. The surface area (topography) of the bottom of the tank covered by the water. The volume of the islands surrounded by the submerged part at each level (Positive volume). The volume of water that fills the tank (negative volume Nv) at each level of the topographic depression. The average depth of the tank is the depth of the water level in the tank at each level of each ground point (XY) inside the flooded part of the tank, which varies according to the topography of the bottom of the tank and is calculated by dividing the tank volume (negative volume) by the negative flat area of the tank for each submerged level with water. The average island thickness (average island thickness) is extracted by dividing the volume of islands (positive volume) by the flat positive area.

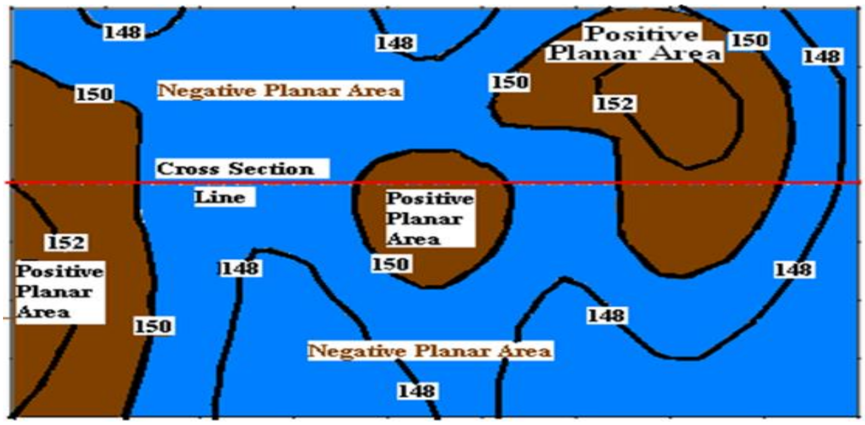

Fig. 4. The geometric elements

4.1. Extraction and analysis of geometric elements

Through the field study and review of the dam archive reports in the General Authority for Dams and Reservoirs, the actual level was selected at the beginning of the dam body site, which is 740 m above sea level, as well as the highest level of the assumed reservoir, which is 900 m above sea level. The limits of the reservoir were determined and deduced at the indicated level by the Digitizer tool in the Global Mapper 13 program and exported in Grid format (XYZ) to the Surfer 13 program and used as a base database so that we can extract the different geometric elements for each 10 m at the water levels of the reservoir and through the Grid-Volume tool as shown in the program work steps.

Subsequently, the geometric elements of the 16 assumed levels were extracted and their data were collected in a table to create a database of engineering measurements for dimensions and measurements representing the geometric elements of the geomorphology and topography of the Derlok Dam reservoir.

5. Results and Discussion

Those geometric elements are as in Table (3). Analyze the geometric elements of the reservoir and determine the relationship between them.

Table 3. Represents the results of the variables of the geometric elements extracted from the Surfer 13 program

EASL 10 m	Positive Volume (m^3)	Negative Volume (m^3)	Positive Planar Area(m^2)	Negative Planar Area(m^2)	Positive Surface Area(m^2)	Negative Surface Area(m^2)	Average Depth (m)	Average Island Thicknes s (m^2)
740	148738	95662437	7979	1654258	8634	1755102	58	19
750	36448	120720170	4450	1880346	4670	2012571	64	8
760	133704	148503017	8686	2223858	9158	2397883	67	15
770	82815	179302367	5265	2505479	5566	2703214	72	16
780	1080	211843613	12	2799363	13	3011198	76	88
790	158411	254424206	3029	3147572	3684	3446704	81	52
800	125477	294792182	2193	3461381	2490	3796517	85	57
810	52375	336430202	533	3842087	675	4194110	88	98
820	293015	391981123	8482	4174932	9908	4625835	94	35
830	621918	445189305	13902	4552035	17488	5085647	98	45
840	1074313	1610990281	24702	20169048	29866	21664547	80	43
850	172757	1847194570	1867	22542663	2179	24056023	82	93
860	1789831	2170798336	32788	25119855	45159	27215507	86	55
870	1098595	2482973248	28318	27767213	33831	29982529	89	39
880	1977316	2831627247	44428	30526135	54951	33085293	93	45
890	186811	3170849245	3433	33290001	3838	35839897	95	54
900	871617	3611384537	37040	34922109	41859	38093871	103	24

The results of the geometric relationship vary between the different levels, with different values at each level, as it varies in depth and in the amount of water stock and is governed by a direct relationship. It will result in the elimination of agricultural areas as well as the displacement of a large number of residents from residential areas, and the expected results of the reservoir's establishment will have a negative impact due to the extent of the damage caused by the water flooded by the dam reservoir; on this basis, the reservoir's and thus the canal's future operational policy is designed, and it determines the changes that will occur on the canal.

It represents the relationships between the geometric elements of the dam reservoir, especially between area, volume, and water level, which are essential in the geometric studies derived before starting the construction of the dam, in order to use the information derived from this analysis for a database that the designer can rely on in developing designs for the dam and highlighting its non reservoir uses. such as tourism, irrigation projects, and hydropower. The curves of the relationship between the area and the capacity of the reservoir are usually used to follow the floods in the reservoirs, determine the surface area of the reservoir, predict the reservoir capacity at any water level, and determine the classification of the reservoir, as in Fig. **(**5).

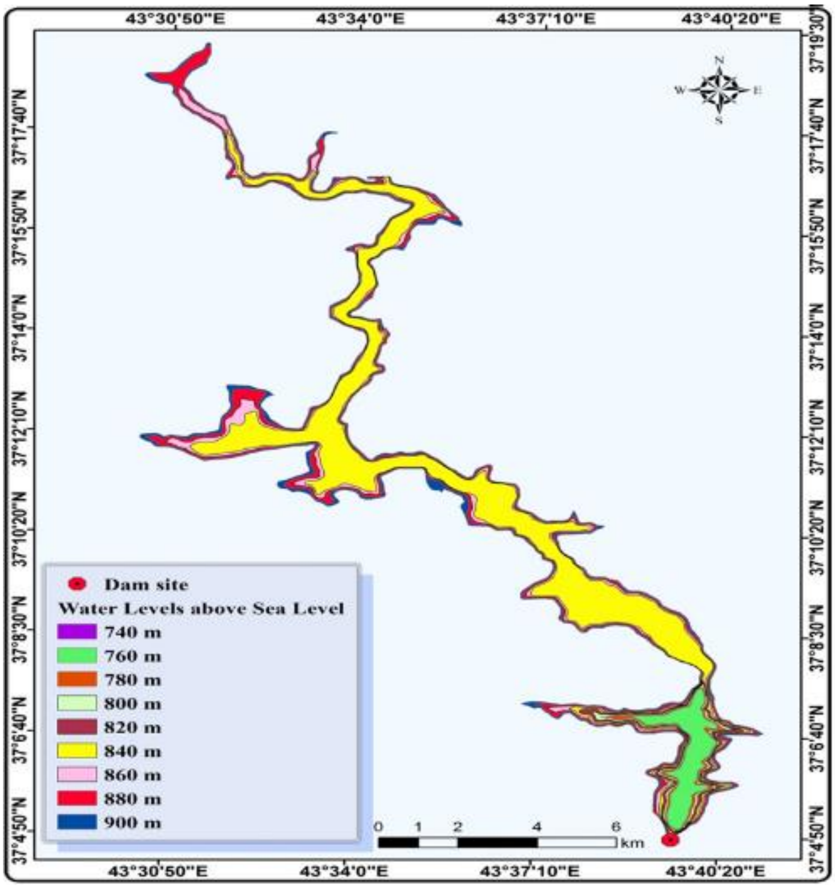

Fig. 5. Some elevations of Derlock Reservoir

Determine the future operational policy of the reservoir and the prediction of the distribution of sediments on the reservoir floor (Habili et al., 2009). It also determines the changes in land uses that will occur after the start of storage at each level by varying the volume of the water reservoir at each level to ensure the continuity of the flow of water towards the river channel and the continuity of revenues. Economic results of the construction of the dam.

Therefore, the aim of this axis is to derive the relationship between the volume of the storage (the submerged or negative volume of the topographic depression, negative volume (NV)), which is the main geometric element, and the water level in the tank. As for the second geometric element, which represents the positive PV volume, it represents the volume. The islands are surrounded by the submerged part, and this volume usually fluctuates with the change in the level, due to the submergence of some islands and the emergence of new islands with the rise in the level. This element has its importance through the future uses of these positive parts, as well as in the future maintenance work inside the tank and the method of movement and movement between its parts, and the problems that may arise possible due to the positive portions sliding toward the negative portions. Geometric elements such as positive and negative planner area, positive and negative surface area, water column depth rate, and island thickness rate, which represent the most important information, are relied upon in determining the optimum level of project operation.

5.1. Geometric Analysis

Relationship of the level with the volume of the reservoir with the positive volume (islands) and the negative volume (storage). It can be seen in the Figs. (6 and 7) that show the variation of the relationship between the water level and the positive and negative volume. During the gradual addition or submersion of new islands with an increase in the level, the relationship between the level and the storage (negative volume) appears in contrast to the previous relationship between the level and the positive volume (the islands) 840 m, an exceptional increase was recorded in the volume of the reservoir as a result of the new addition of the second reservoir of Derlouk Dam.

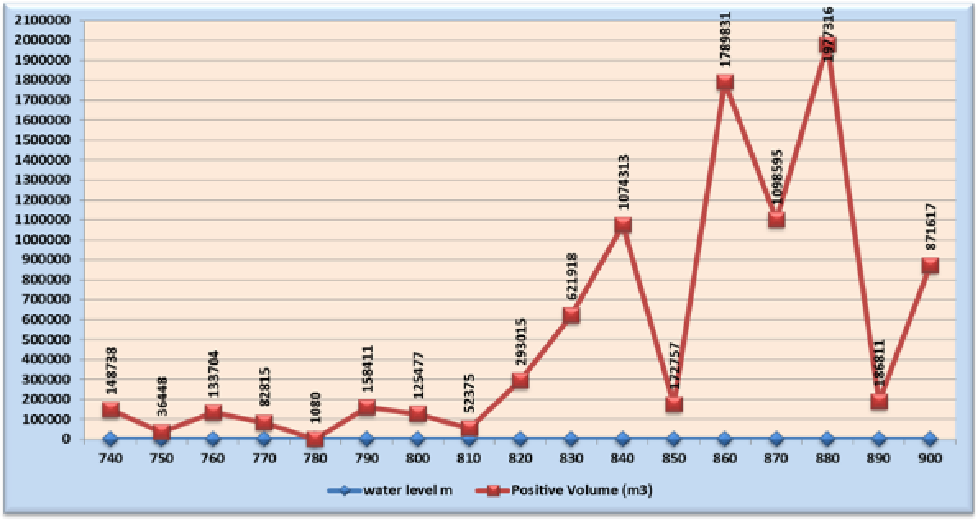

Fig. 6. The curves of the relationship between PV and WL

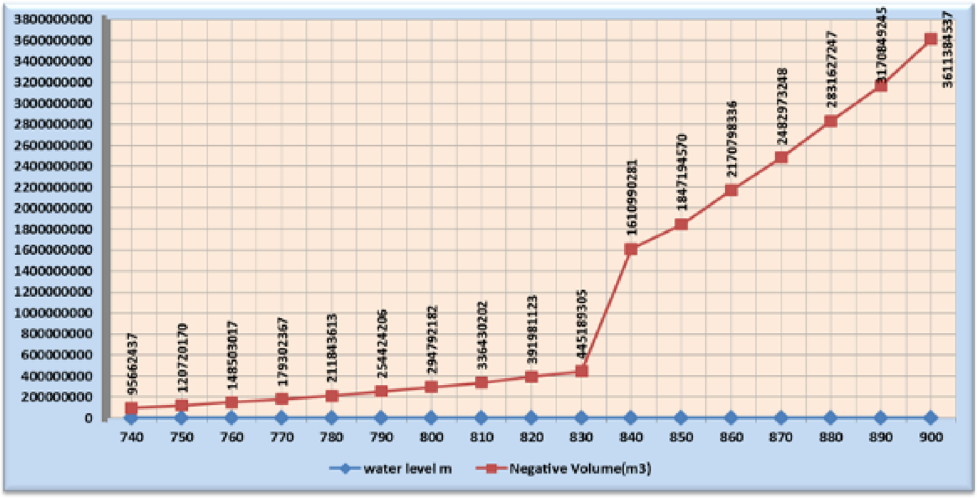

Fig. 7. The relationship curves between (NV-WL)

5.2. Relationship between the Ratio and the Negative Volumetric and Spatial Elements

When the variance of each of the volumes of water that fill the tank at each level of the topographic depression is compared to the negative water surface area in the uneven tank and the wet uneven area of the bottom of the tank at each level of the negative surface area, we find that there is a significant difference in the values of (NV) of 361,384537 billion/ m^3 against the other racists (NPA) of 34922109 million m^2 and (NSAThe topographic depression, when the increase in the flat surface area (evaporation area) and the wet area (area of penetration) is a small increase in relation to the large increase in the volume of storage, gives an indication of the shape of the depression (the reservoir), which suggests that the depression is deep and small in area.

where it reduces the losses of the lands that will be flooded by the water of the reservoir and thus reduces the compensatory material expenses for it and in the final economic feasibility of the project, and it represented only the relationship of the level with the negative flat area and the negative surface area, and the relationship was close between them as in Fig (8), where their values gradually increased. Levels 83-840 m are relatively balanced, with steady change.

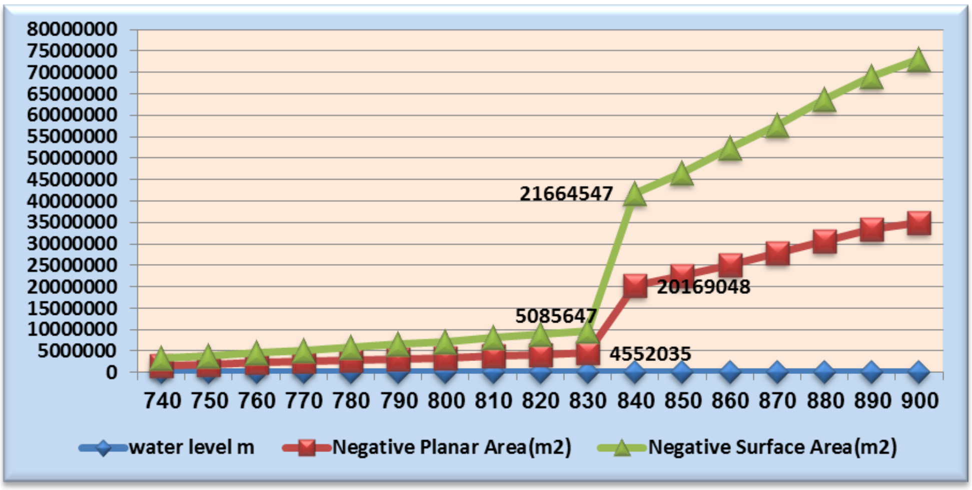

Fig. 8. The ratio curves with negative volumetric and negative spatial elements

5.3 The Level's Relationship to Positive Surface Area

The positive surface area (PSA), which represents the uneven area of the islands (the area of the islands falling within the boundaries of the reservoir), gradually increases with increasing levels inside the reservoir, accompanied by steady exceptions of increasing and decreasing in some levels that are shown in the Fig. (9) in accordance with the increases and decreases with the volume.

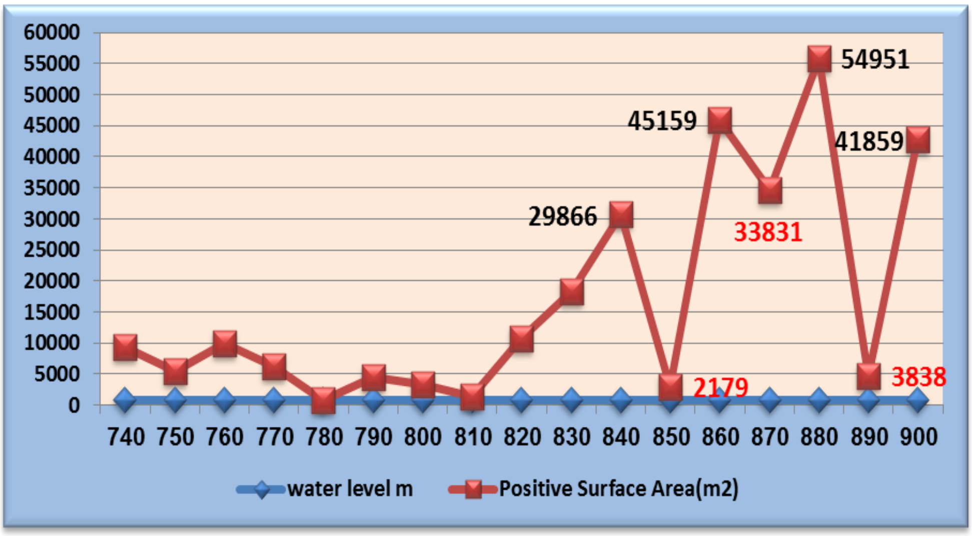

Fig. 9. The relationship curves between PSA and WL

The positive surface area of the islands, as becomes clear, is an intuitive relationship, especially given the small size of the tank and the absence of extended areas far from the tank body, as well as the lack of islands within the tank. The limits of the reservoir, especially at higher levels, also generally decrease in a balanced and natural manner with the positive volume decreasing, which indicates the closure of the reservoir and the non-extension of its water to new areas next to the reservoir area, which will result in a decrease in the submerged areas of the lands, whether residential or agricultural, and others in the vicinity of the reservoir, which in turn reduces compensation expenses, population displacement, and other environmental problems such as reducing evaporation through the limited surface area of the reservoir water.

5.4. The Level's Relationship to the Negative Surface Area

The negative surface area (NSA) represents the uneven area of land (submerged) with water; its value gradually increases in a balanced and increasing manner until the level is 830 m with an area of 50855647 m2 and a steady increase. It reached 216645447 m^2 at a level of 840 m due to the water passing towards the second tank and flooding it with larger areas; it will continue after that in the same pattern to increase until the higher levels of the tank, as shown in the Fig. (10) of the relationship, in addition to the increase in the submerged area of the land for the water of the tank with the increase in the volume of the tank as well as parallel to the increase in the negative water surface area in the tank.

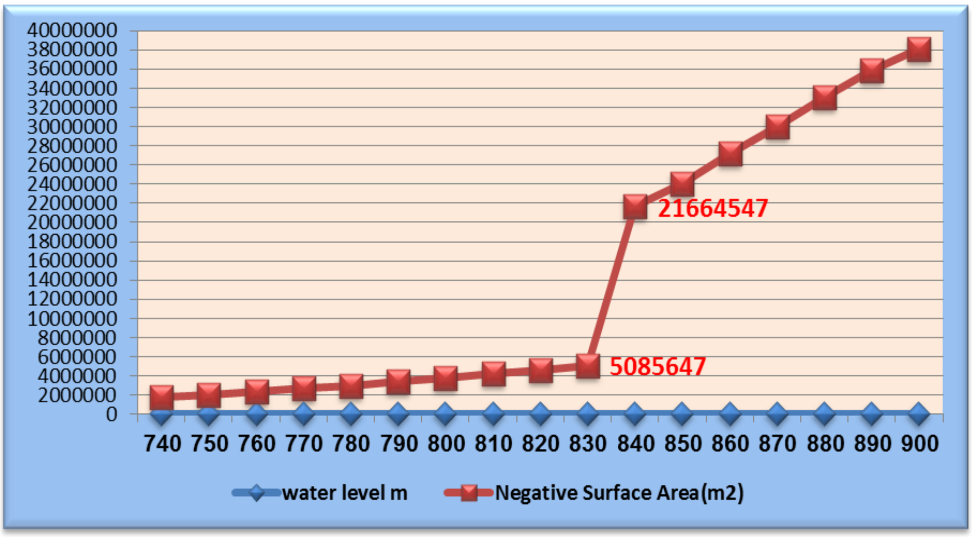

Fig. 10. The curves of the level relationship with the negative surface area.

5.5. The Level's Relationship to the Positive Plane Area

The positive flat area (PPA) is the flat area of the islands, whose values are generally large in the upper levels of the reservoir and gradually decrease in the lower levels, and is depicted as varying in their values from one level to the next, accompanied by steadily increasing and decreasing exceptions at some levels that coincide with the increases and decreases with the positive size of the islands, as shown in Fig. (11).

5.6. The Level's Relationship to the Negative Plane Area

The negative planar area (NPA) represents the flat area of the wetland (the surface area of the water in the tank). It behaves similarly to the negative submerged surface area in the water of the tank, as its value increases gradually with the increase in levels, and the slope of the increase curve is small in low levels, but the slope of this curve increases steadily after the level 840 m above sea level for the same reason as mentioned in the negative submerged surface area (NSA) relationship due to the exit of the water of the reservoir body toward the second reservoir, which is illustrated in Fig. (12), where its values begin with a gradual increase in a balanced and increasing manner, especially at that level, with an area of 20169048 m^2 over the previous level, and a steady increase of 16,517.

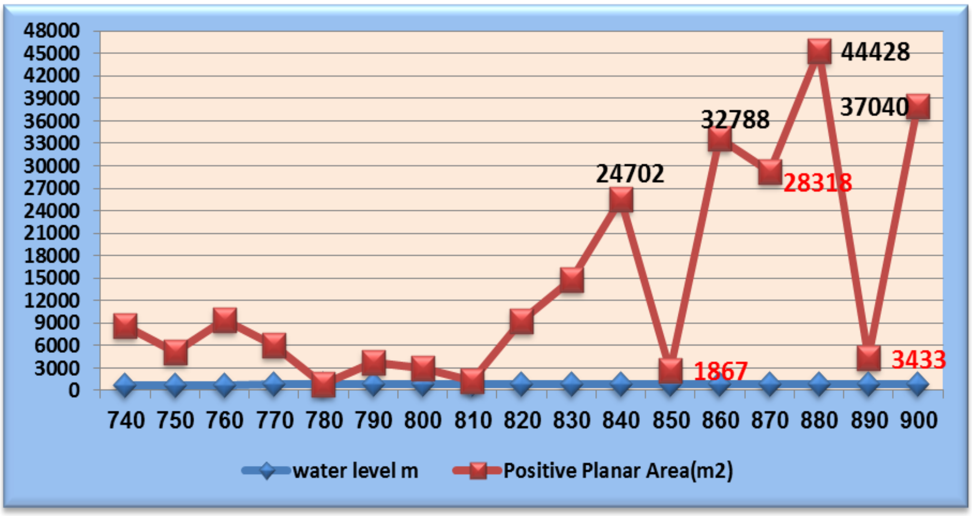

Fig. 11. The curves of the level relationship with the positive plane area

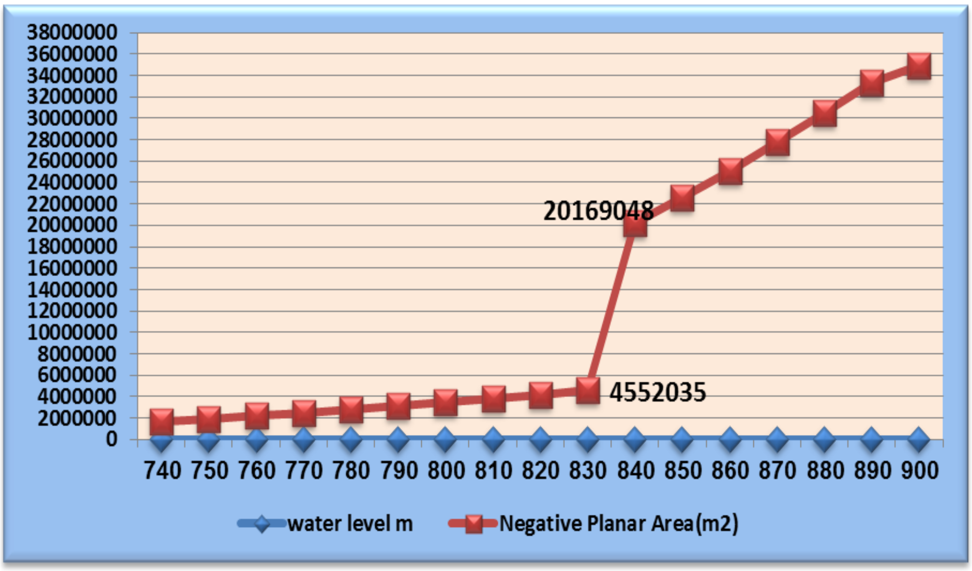

Fig. 12. The curves of the level relationship with the negative plane area

5.7. Average Reservoir Depths and Island Thicknesses at Different Levels

Through maps of the depths of the dam reservoir, it is possible to know and determine the areas suitable for river navigation, such as by tourist boats. Furthermore, anglers or dam fishermen can determine the best levels for fishing or feeding fish. This database is important for all these profitable projects with economic returns as well as in determining the height of the gates The dam also chooses and knows the size and area of the dead storage of the dam, and the Fig. 14 shows the depths of water at selected levels of the reservoir.

The negative (stock size) of the corresponding flat area at each level. The average island thickness was calculated by dividing the positive volume by the corresponding flat positive area at each level. These results were represented graphically in Fig. (10), where we find that the average thickness of the islands at the level of 770 m was 16 m, then it rose to 88 m at the level of 780 m, and this is evidence of the acquisition of new islands After that, it began to decline at a level of 790 m, implying that most of the islands are small and low in height and were submerged when the level was raised by 10 m. The water gained new islands at these levels.

The average depth of water began at 58 m at level 740 m and gradually increased to level 830 m, when it began to decrease 840 m by 18 m to a level increase of 10 m due to the addition of new lands to the reservoir. The second, then, continues to rise to the highest level of the reservoir at the same pace as before, as shown in the table and in the Fig. (13), indicating the severe decline and gradient of the lands of the reservoir at those levels. Fig. (13) shows the curves of the relationship between AD and AI.

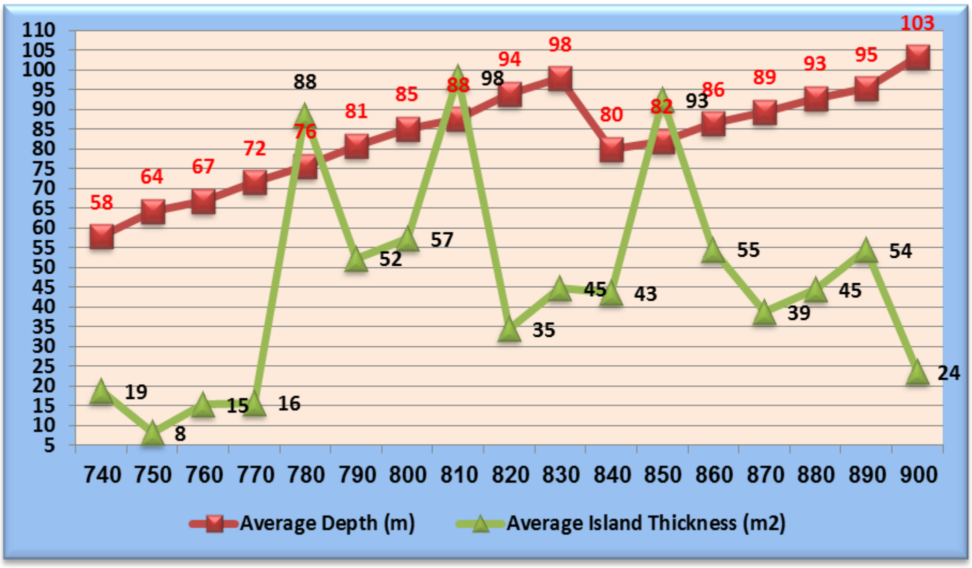

Fig. 13. Relationship between Average depths and average thickness

6. Conclusions

The current study showed that one of the most important pieces of data and information on which determining the optimal level for reservoir operation depends is the study and analysis of the geometric elements for each level of the dam reservoir. Well it has been highlighted the map of the elevation of the Derlok Dam reservoir showed the extension of its height with the course of the upper Zab River and towards the higher areas, and longitudinally with the topographic depression surrounded by folds with the extension of the river valley.

The results of the geometric analysis of Derlok Reservoir are shown it started with the depth level of the reservoir changes with a greater increase at the 750 m, with an estimated increase of an average of 6 m for each increase in the level of 10 m, which gives an indication of the decline and severe slope of the reservoir at these levels, and this is due to the slope, topography and geomorphology of the region.

The relationship of the level with the negative volumetric and negative spatial elements indicated that there is a large difference in the values of NV, NPA and NSA at the level of the reservoir 900 m, and this is a positive factor in choosing the topographic depression, when the increase in the flat surface area. The evaporation area and the wet area (the penetration area) are small in relation to the large increase in the volume of storage, which will give an indication that the depression is deep and small in area, as it reduces the losses of the lands that will be flooded by the water of the reservoir, thus reducing the compensatory material expenses for it and the final economic feasibility of the project.

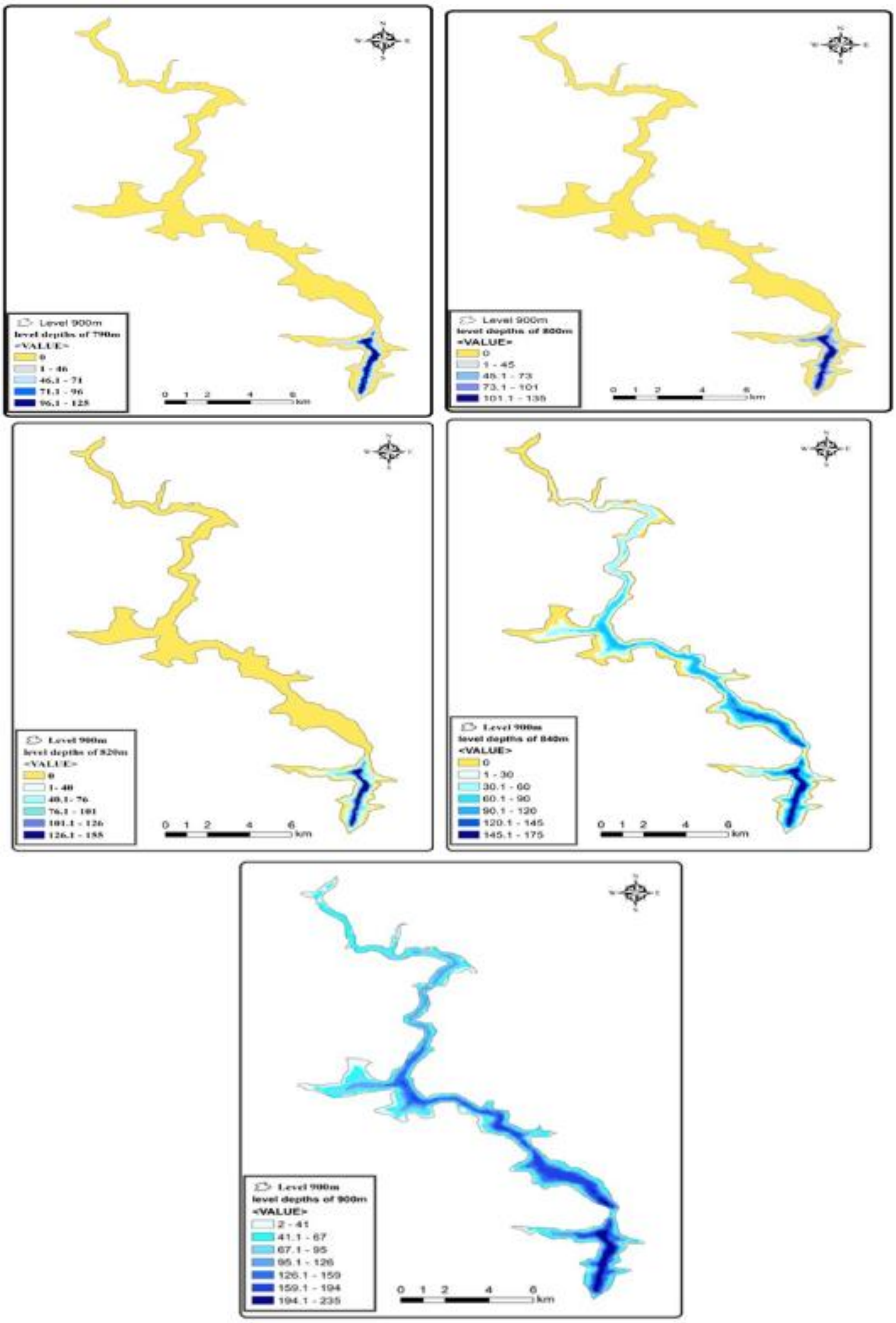

Fig. 14. Maps of some depth levels of the reservoir

It was found through the value of the storage volume of 3.6 billion cubic meters at the higher levels of the reservoir that the reservoir can accommodate a good volume of surface runoff during the flood period of the upper Zab River, which will limit and reduce in a controlled manner the flooding of the Upper Zab and Tigris rivers. Due to the construction of the Derlok Dam, as well as due to the presence of this dam on the Upper Zab River, which does not have a dam, and because of the important benefit of the dam's reservoir in supplying the Tigris River with water resources, especially during periods of drought.

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