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Future Changes Downstream New Assiut Barrage

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Abstract :Morphological changes are important in preserving the Nile River due to the construction of hydraulic structures such as dams and barrages. The Delft-3D model was employed to evaluate, analyze, and predict morphological changes as a result of the construction of the New Assiut Barrage, which is located at the fourth reach of the Nile River. The bathymetric and topographic data, water levels, discharges, velocities, and bed levels were gathered from the Nile Research Institute for the study area in 2006, 2008, 2015, and 2017. The morphological changes were evaluated and analyzed in the period from 2015 to 2025. Results obtained indicate morphological changes around the Bani Mur and EL-Walidia Islands. There was sedimentation and erosion on both the eastern and western sides of Bani Mur Island, with sedimentation being more pronounced on the eastern side. So, dredging must be done continuously to avoid affecting the navigational path, where there are two navigational locks at the east of the Bani Mur Island. Also, erosion occurred on the left side of EL-Walidia Island.

Keywords: Assiut barrage, Morphological changes, Delft 3d, Deposition, Erosion..

1. INTRODUCTION

The Nile River is the main source of water and all man activities. There is no doubt that constructing the barrages is of great importance to conserve river water. The old Assiut barrage is located at the fourth reach of the Nile River and was constructed in 1902 at a distance of 544.78 km from Aswan Dam.

A decision was made to construct a new barrage about 400 m downstream of the old barrage in 2012, tested in 2015, and ready for operation in 2018. Mostafa A., 2010 [1] presented the problem of the Nile River's exposure to various low to high floods. The pump intakes areas can be reached to a level 14 meters below the lower water level as a sustainable approach to control sediment deposition around the entrance to the pumping station. As this solution costs less (2.6 million L.E.) than the dredging to the 12.5 meters level, which costs 5.2 million L.E. fairy. A. Said, 2016 [2] studied the importance of Dahab Island in the fourth reach and used GIS to analyze and classify the main features of the island. It was concluded that the areas of the western side were exposed to sediments that obstructed the navigational path and recommended changing the navigational path to the eastern side. A. Ayman and A. Fawzi, 2011 [3] used remote sensing and GIS to know the impact of meandering and bank erosion of the river Nile. The study showed that the lateral erosion led to a decrease in the agricultural lands on the riverbanks and changed the shape of islands and recommended protecting the banks and islands. N. Kamal, 2019 [4] developed an application using a combination of a 2-D mathematical model Delft-3D and GIS for morphological change assessment. The numerical model provides simulation and prediction of the behavior of the Nile River's morphological and hydrodynamic changes. In addition, it supports the decision makers to alleviate the impacts on river navigation, where the efficiency of the navigational path can be promoted by increasing the maintenance operation rate in front of water intakes to decrease the deposition rate. For navigation safety, a modification study of the navigation path is to be accomplished in the outer curve of El-Dahab Island area. M. A. Refaey, et al., 2020 [5] assessed the morphological transformations within the Nile River as it flows through Egypt following the construction of the Aswan High Dam. Their research uncovered locations where erosion and sedimentation occurred, while also quantified the impact of the volume of suspended materials passing through the High Dam. Furthermore, the extent of the influence of the intervention of various human factors was detailed. M. B. Ezzat, et al., 2012 [6] studied the effect of the new barrages through the Delft-3D Model, which was calibrated through the measured velocities and morphological data. The model concluded that the best distribution of the flow is 40% and 60% for the eastern and western branches of Bani Mur Island. Alessandra Rosato, et al., 2010 [7] mentioned that erosion is a serious problem along the Nile River and its tributaries, soil erosion occurs mainly in the upper water sheds, and a certain water management policy is needed.

The main aim of this research is to predict the morphological changes as a result of the construction of the new Assuit Barrage from 2015 to 2025 by using Delft-3D. The bathymetric data, downstream water levels, and discharges were used for the spillway and hydropower plants. The manning coefficient was used to complete the calibration process. The outputs including velocities and bed levels were compared with the field survey.

2.Study Area

Assiut Barrage is located in the fourth reach, which has a length of 410 km. The old Assiut Barrage is located 544,78 km downstream of the Aswan Dam, whereas the new Assiut Barrage is located downstream of the old barrages by 400 meters. It has 111 vents, 8 vents spillway, and 3 vents for the power station. It has also 2 navigational locks on the eastern side and a closure dam on the western side. The research location, as shown in Figure 1 encompasses Bani Mur Island, which serves as a division point, directing 40% of the flow to the eastern side and 60% to the western side. Following Bani Mur Island, there is El-Walidia Island situated on the inner curve and upstream a bend in the river.

Fig 1. The location of the old and new Assiut barrages

3.Mathematical Model

A two-dimensional morphological numerical model was developed using the Delft-3D software package developed by Deltares to predict the velocities and bed levels. The model covers an area of about 5 Km along the Nile River. The model is about 0.50 Km wide; the size of the grid cell ranges from 5 to 30 m in the area of interest. The essential data needed to create the morphological model include flow data, bed data, bathymetric and topographic surveys, hydrographic surveys (comprising water levels, flow velocity, and discharge), as well as historical bathymetric data specific to the project site.

3.1 Model calibration before construction the new Assiut barrage

The model was calibrated for the velocities and bed levels from 2006 to 2008, for modelling purposes. The field survey was covered about 5 km downstream of the new Assiut Barrage. The field measurements were gathered from the National Research Institute, which included topographic data, bathymetric data, water levels, and discharges. Figure 2 shows the locations of the cross-sections for velocity and bed levels. Figure 3 shows the comparison between the measured and computed velocities for cross-sections 1(a) and 2(b). Figure 4 shows the comparison between the measured and computed bed levels. A comparison was made to the results of the calibration, where it was found that the points are comparable with small percentage differences less than 10%. The percentages for all points ranged between (0.5 and 6.5,1.36 and 5.9) % From Equation 1.

$$\%\,Error = \frac{Model - Measured}{Measured} x100 \qquad \text{Eq. (1)}$$

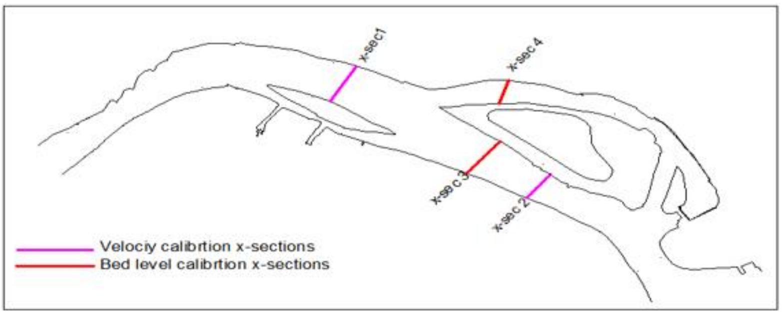

Fig 2. Locations of measured cross-sections in 2006

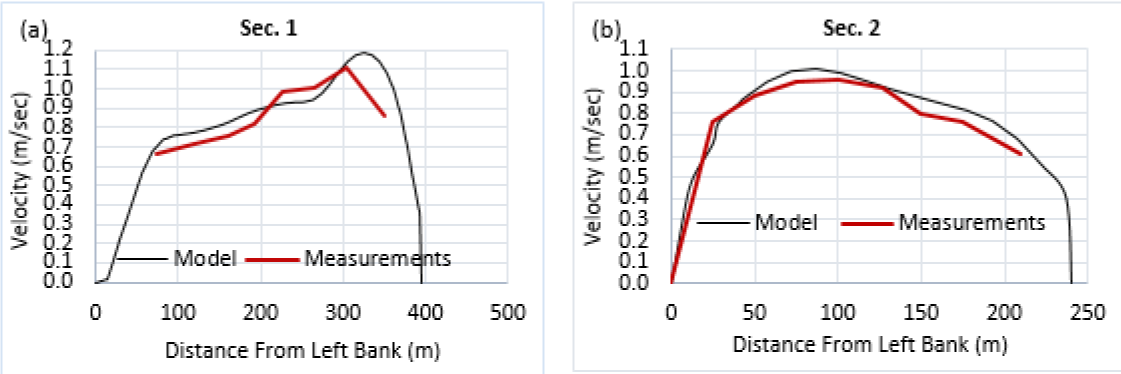

Fig 3. The velocity calibration

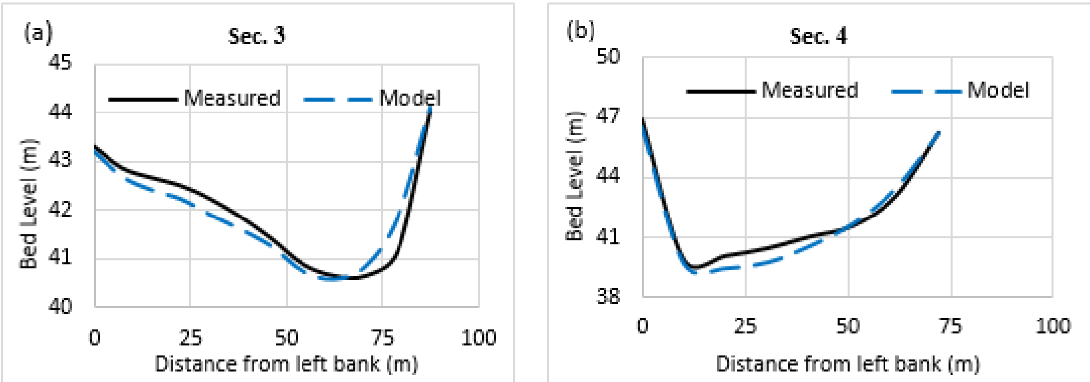

Fig 4. The bed level Calibration

3.2Model calibration after construction of the new Assiut barrage

The model was created and calibrated for velocity and bed level. The data were collected by the Nile Research Institute (NRI) and Hydraulics Research Institute (HRI) for the years 2015 and 2017 **Report, 2015, 2017 [8]**. Figure 5 shows the locations of the cross-sections for the velocity and the bed levels. Figure 6 (a) and (b) shows the comparison between the measured and computed velocities for cross-sections 1 and 2, and Figure 7 (a and b) shows the comparison between the measured and computed bed levels for cross-sections 3and 4. A comparison was made to the results of the calibration, where it was found that the points are comparable with small percentage differences less than 10%. The percentages for all points are less than 5% from Equation 1.

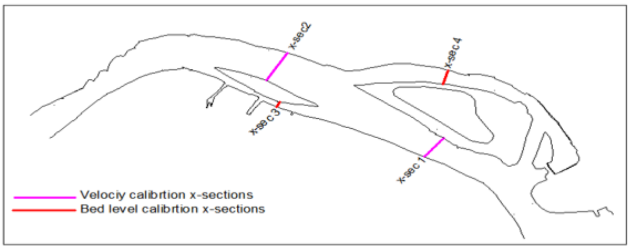

Fig 5. Locations of the measured cross-sections in 2015

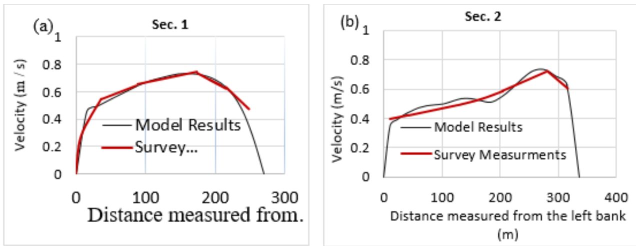

Fig 6. The velocity calibration

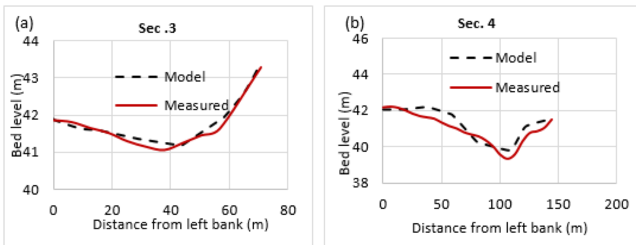

Fig7. The bed level calibration

4.Model results

Delft-3D was utilized to forecast morphological changes over a decade, spanning from 2015 to 2025, to demonstrate upcoming alterations. Subsequently, the results were subjected to analysis, incorporating data from three cross-sections to evaluate both velocities and bed levels.

4.1 Velocity

After completing the calibration process, the model gives accurate results because the error rates between the model results and the measurements do not exceed 10%, which were predicted from the morphological changes from 2015 to 2025. Figure 8 shows the locations of the cross-sections 1, 2, and 3 along the reach. Figure 9 shows the predicted velocity distribution in 2015 and 2025. In 2025, it was found that the velocity ranged between (0.36-0.50) m/sec at cross-section (1) on the eastern side of Bani Mur Island. The velocity ranged between (0.3-0.42) m/sec at cross-section (2) at the western side of Bani Mur Island. Finally, the velocity ranged between (0.45-0.55) m/sec at cross-section (3) at EL-Walidia island, as shown in Figure 10.

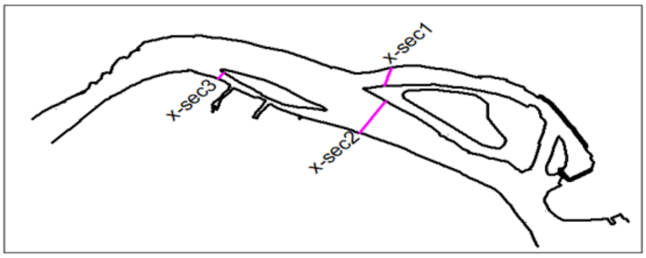

Fig 8. Locations of cross-sections for velocities and bed levels

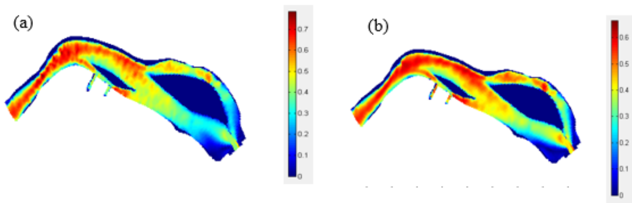

Fig 9. Predicted velocity distribution: (a) 2015, (b)2025

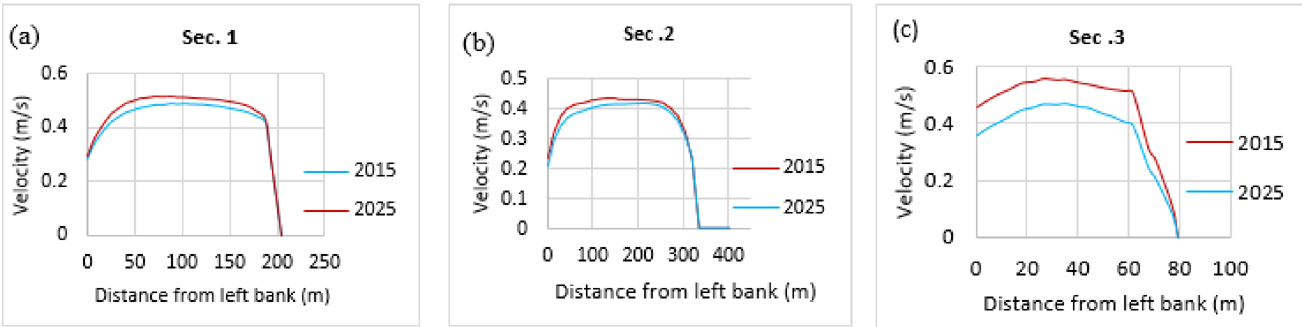

Fig 10. The predicted velocity

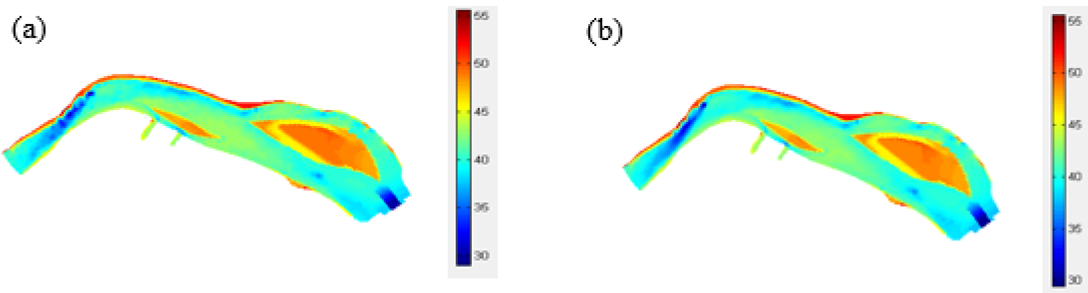

Fig 11. Predicted bed level distribution: (a) 2015, (b) 2025

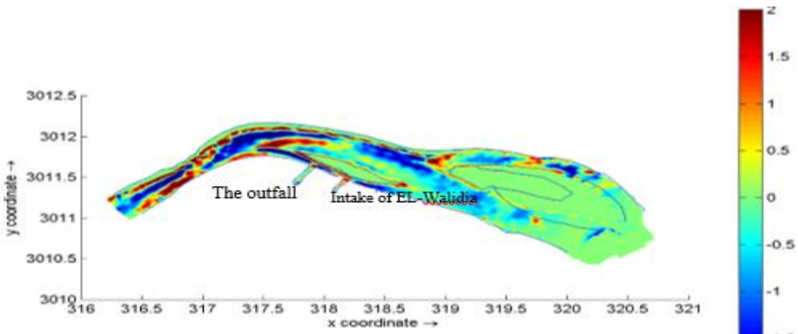

Fig 12. deposition and Erosion from 2015 to 2025 (+deposition, -erosion)

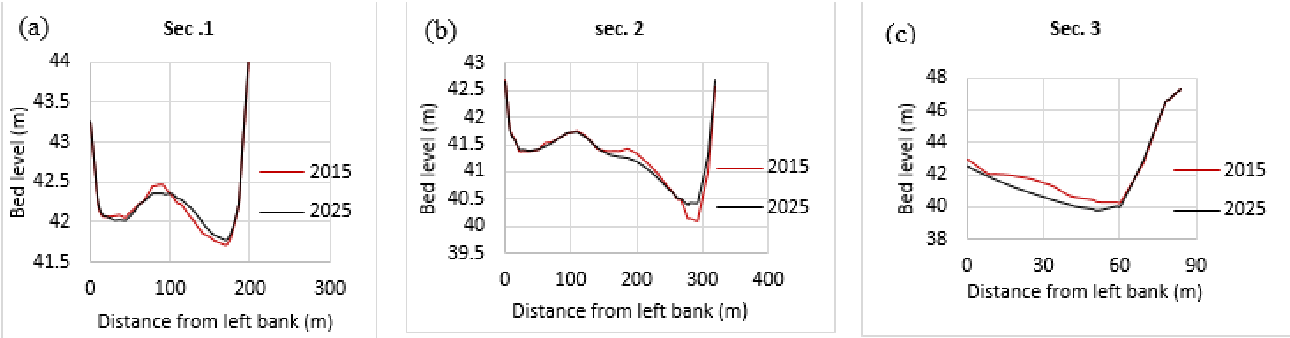

Fig13. The predicted bed levels

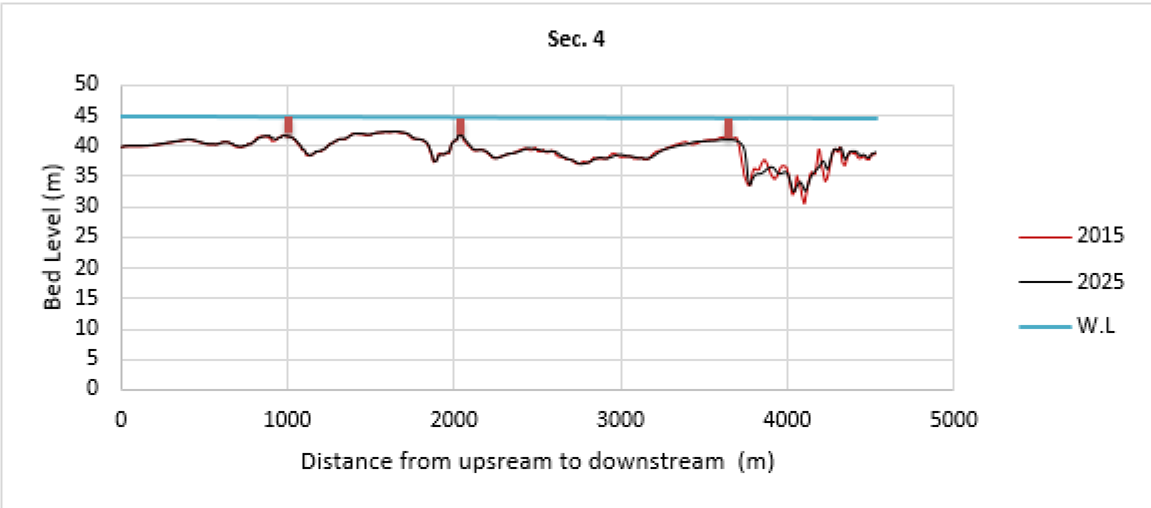

Fig 14. Predicted cross sections of bed level from upstream to downstream

Old Assiut barrage (2006) New Assiut barrage (2023)

Figure 15. Difference between the morphological changes between 2006 and 2023 through Google Earth

4.2Bed levels

The Delft-3D model was employed to make predictions for ten years, spanning from 2015 to 2025, forecasting future morphological changes. Figure 11 illustrates the projected distribution of bed levels in both 2015 and 2025. After 10 years the results from model showed the morphological changes as shown in Figure 12 showed the deposition ranged between (0.5-1 m) occurred at the tip of EL-Walidia Island from the upstream direction and at the inlet of the intake of EL-Walidia Power Plant, while erosion ranged between (0-1m) occurred downstream the outfall of the plant and continued for the end of EL-Walidia island downstream direction, while Figure 13 provides insights into the morphological alterations at cross-sections 1, 2, and 3. At cross-section 1 at km 380, situated on the eastern side of Bani Mur Island at a distance of 100 meters along its width, there was an observed erosion of approximately 30 cm. Conversely, at a distance of 180 meters along the section width, a deposition of about 20 cm occurred. In cross-section 2 at km 380, positioned on the western side of Bani Mur Island, at a distance of 200 meters, erosion of around 30 cm took place, while at a distance of 300 meters, a deposition of roughly 40 cm was recorded. Finally, at cross-section 3 at km 378.8, located on El-Walidia Island, erosion occurred to a depth of approximately 40 cm. The longitudinal cross-section as shown in figure 14 showed the depths of water. There are 3 locations where navigational bottlenecks occur, Because the navigational depth is greater than 1.8 m. Figure 15 showed the changes before and after construction of the New Assiut Barrage. The final form of the construction of the New Barrag shows the impact of the Barrag and their components, as a result of the construction and human interventions that were studied and predicted. Figure 15 showed that after construction of the New Assiut barrage, the erosion occurred at the upstream of Bani Mur Island, as well as the erosion in the outer curve of Bani Mur Island at downstream of the island in 2023 from 2006, and sedimentation occurred at the upstream of EL-Walidia Island, with deposition occurred at the western side of EL-Walidia Island in the direction of the intake of The power station in 2023. From the human interventions was the construction of the EL-Walidia water station, which was built after construction of the New Assiut barrage in 2019. These Sedimentations and erosions led to change in the shape of the islands.

5.Conclusions

The 2-D morphological model analysis has unveiled several significant findings concerning the effects of the new Assuit Barrage construction on the Nile River. Notably, the shape around both Bani Mur and El-Walidia Islands has undergone alterations. Additionally, there has been a discernible decrease in the bed level of the left branch of El-Walidia Island. Remarkably, these morphological changes do not appear to impact the discharge upstream of Bani Mur and El-Walidia Islands. Also, the model's results do not reveal the presence of high velocities in the studied area. Furthermore, At km 380 in the fourth reach sediment deposition, reaching depths of up to 20 cm, has been concentrated on the eastern side of Bani Mur Island, specifically at a distance of 180 m. While there was an observed erosion of approximately 30 cm at a distance of 100 m. At km 380 in the fourth reach on the western side of Bani Mur Island, erosion of around 30 cm took place at a distance of 200 m, while deposition of roughly 40 cm was recorded at a distance of 300 m. At km 378.5 in the fourth reach Beside El-Walidia Island, erosion occurred to a depth of approximately 40 cm. These findings collectively provide valuable insights into the evolving morphological dynamics brought about by the construction of the Assuit Barrage along the Nile River.

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