the High Dam Lake can lose up to 10% of its volume to evaporation annually (Mutua & Mtalo, 1, Bauwens, W., 2005). According to Hassan (2013), the rate of evaporation over the northern region of Lake Nasser is higher than the rate of evaporation in the south- ern part of Lake Nasser (Fig. 9). The calculations revealed a rate of 7.64 mm per day as the annual mean evaporation rate with a max- imum value in June of 10.63 mm per day and a minimum in December of 4.25 mm per day. The mean evaporation losses are estimated to be 7.4 mm per day, equal to 2.7 m per year. The annual water loss by evaporation was in order of 10.6 billion m3 (Elsawwaf & Willems, 2012). Water seepage from High Dam Lake For the High Dam Lake, there are three main geological regions. The basement complex is in the first 50 km south of the High Dam. The Nubian sandstone occupies 300 km at the middle of the Lake. The extreme southern 150 km is a granite basement (Zaghloul et al., 2012). Hamdan, Selim, and Zaki (2013) referred that the water seepage changes from year to another, depending on the Lake's level (Fig. 10) and the groundwater in the area (Abdel Moneim, Zaki, & Diab, 2014). They calculated the mean water seep- age from Lake Nasser of about 47.5 million m3 per year. Rainfall over High Dam Lake Lake Nasser is located on the eastern side of the great Saharan belt. It receives rare rainfall through occasional thunderstorms, which sporadically penetrate the area (Elshemy & Meon, 2011). El-Bakry (1993) reported that the rainfall during 30 year is grouped in 6 categories as shown in table 2.The climate of the Lake area is extremely arid with negligible rainfall of less than 5 mm annually. Water budget of the High Dam Lake Determining the water budget could help in understanding the impacts of several variabilities and obtaining better management scenarios for the Lake (Abdel-Latif & Yacoub, 2011). The water Table 2 The rainfall categories for a period of 30 years over Lake Nasser (Egyptian Metrological Authority, EMA). Number of Year Rain in mm 80 11 Trace 5 11 3 1to1.6 2 7.2 1 27.3 balance of a lake as generally applied to the hydrologic cycle is actually a statement of the law of conservation of mass. It is based upon the hydrologic equation as follows: Inflow 1/4 Outflow þ DStorage ð1Þ The High Dam Lake is located in a subtropical and arid zone, the rainfall is nearly rare, and therefore the water budget of the High Dam Lake can be summarized as follows (Hamdan & Zaki, 2016): I1/4OþE þ S DV ð2Þ where, I is the water inflow, O is the water outflow, E is the water loss due to the evaporation, E is the water loss due to the seepage and DV is the changes in water storage of the Lake. The DV is pos- itive value when water gained by the inflow is higher than water lost by the outflow, the evaporation and the seepage and vice versa. Bathymetric study of some khors in Lake Nasser The bathymetric information on Lake Nasser is an important issue. One of the most concerning features of the Lake is the com- plex nature of its shoreline, which depends on the change in its water level (Mostafa and Soussa, 2006; Elba, Farghaly, & Urban, 2014). Lake Nasser is a basic need in environmental planning, restoration and management. Knowledge of Lake Nasser is on observation of the dimensions of its water basins. Concerning the bathymetry of the lake, the changing conditions in the water body; such as the water level, are the results of the rapidly change of bathymetric conditions. Abd Ellah and El-Geziry (2016) reported that, the Lake's Khors may have fluctuated in its area and morpho- metrical features, with water level (Fig. 11). Toushka project (The New Valley) The New Valley is located in the northwest of Lake Nasser. It constitutes a major Egyptian project to claim a huge area of the Egyptian Western Desert for agriculture and industry by diverting freshwater from Lake Nasser

Summarized by © lakhasly.com

(Elsawwaf, Feyen, Batelaan, & Bakr, 2014). In 2000, a pumping station and canal were constructed to convey water into the region. Fig. 7 shows the location of the Pumping Station on Lake Nasser and the spillway to the New Val- ley. A part of the 50-kilometerlong main canal is called the Sheikh Zayed Canal. Networks of canals were made to continue carrying Lake Nasser water to the new reclamation lands in the Western Desert (UNEP, 2010; Sparavigna, 2011). Toushka Project takes about 5 billion m3 of water from Lake Nasser each year. Toushka Project was planned to reclaim more than 3360 million m2 of empty desert and create a series of settlements for about 6 million Egyptians (Smakhtin, Molden, & Cascao, 2012). Conclusion In the present time, available freshwater all over the world is an essential issue and one of the most important challenges facing humanity, and increasingly in to the future. The Egyptian water Fig. 12. Global freshwater availability (World Resources Simulation Center, WRSC). resources system is complex and uncertain. Availability of water in Egypt is highly variable and is considered as one of the biggest obstacles to socio-economic development. According to UNEP (2010), by 1990s, Egypt became under danger of water scarcity (Fig. 12). Egypt as a barren country depending on the Nile River as its main water resource is suffering water stress due to the lim- ited supplies and growing population, as well as increased compe- tition for water from the upper Nile Basin's countries. The climate change influences on the Nile discharge and can be considered as another challenge for water resources in Egypt. Since 1990s, the rapidly increasing gap between the limited water resources and the escalating demand for that water became the major challenge that faces Egypt. Water resources in Egypt are limited, either conventional water resources or non-conventional water resources. In general, the main challenges regarding freshwater in Egypt are as following: & The rapidly growing population and increased water demand for public water supplies that are related to this increase. (Pop- ulation of 100 million in 2020). & TheincreasedcompetitiononwaterfromtheNileBasin'scoun- tries and the expected Nile flow reduction because of the rapid implementation plans of the Grand Ethiopian Renaissance Dam. & The expected impacts of climate change on the River Nile Basin and its flows, which are considered as the main freshwater source. & The low rate of renewable water resources, high rate of con- sumption, and the seepage of drainage water in to aquifers. & Egypt is an arid country and the rainfall is very low, except in narrow bands along the northern coastal areas. & There are environmental problems with drainage water reuse. & The high cost of the seawater desalination wastewater treat- ments processes. To improve the management of the main water resource in Egypt, the Aswan High Dam was constructed at southern Egypt. The Dam aims to control the discharges and fluctuations in the Nile River water, create water storage up stream as a reservoir of fresh- water, and produce hydroelectric power. Lake Nasser represents the national freshwater bank of Egypt. Finally, the major part of Egypt is desert (more than 95% of total area). Most of the develop- ment concentrates in the Nile valley and Delta. Toushka is consid- ered one of the Projects to improve management of the main water resource in Egypt. The Toushka project is part of a national scheme to reform this pattern of skewed population and distribution potential. The Project (New Valley) depends on conveying Nile River water from Lake Nasser to the newly reclaimed lands in the Western Desert. References Abd Ellah, R.G., 2009. Thermal stratification in Lake Nasser (Egypt) using field measurements. World Applied Sciences Journa 6 (4), 546–549. Abd Ellah, R.G., El-Geziry, T., 2016. Bathymetric study of some khors

Summarized by © lakhasly.com

in Lake Nasser, Egypt, Lakes, Reservoir and ponds. Roman Journal of Limnology 10 (2), 139–158. Abdel Moneim, A.A., Zaki, S., Diab, M., 2014. Groundwater conditions and the geoenvironmentalimpactsofthe recent development in the south eastern part of the western desert of Egypt. Journal of Water Resource and Protection 6, 381– 401. https://doi.org/10.4236/jwarp.2014.64040. Abdelhaleem, F., Helal, E., 2015. Impacts of Grand Ethiopian Renaissance Dam on different water usages in Upper Egypt. British Journal of Applied Science & Technology 8 (5), 461–483. Abdel–Latif, M., Yacoub, M., 2011. Effect of change of discharges at Dongola station due to sedimentation on the water losses from Nasser Lake. Nile Water Science & Engineering Journal 4 (1), 86–98. Abdel–Maksoud, B.M., 2018. Estimation of air temperature and rainfall trends in Egypt. Asian Journal of Advanced Research and Reports 1 (4), 1–22. Abdel–Shafy, H., El–Saharty, A., Regelsberger, M., Platzer, C., 2010. Rainwater issue in Egypt: Quantity, climatic effect and future overlook. J. Medit. Mar. Sci. 11 (2), 245–257. Abdin, A. E., Gaafar, I. R., 2009. Rational water use in Egypt. In Moujabber M. (ed.), Mandi L. (ed.), Trisorio–Liuzza G. (ed.), Martin I. (ed.) Rabi A. (ed.) Rodriguez R. (ed.). Technological perspective for rational use of water resources in the Mediterranean region. Bari: CIHEAM, 2009. 17p. Abo–El–Fadl, M.M., 2013. Possibilities of groundwater pollution in some areas, east of Nile Delta. International Journal of Environment 1 (1), 1–21. Abou Rayan, M., Djebedijian, B., Khaled, I., 2004. Evaluation of the effectiveness and performance of desalination equipment in Egypt. Eight. Intern. Water Techn. Conf., IWTC8, Alexandria, Egypt, 653– 668. Abu–Zeid, K., Elrawady, M., CEDARE, 2014. 2030 Strategic vision for treated wastewater reuse in Egypt. Water resources management Program. 48p. Allam, M.N., Allam, G.I., 2007. Water resources in Egypt: Future challenges and opportunities. Water Inter. 32 (2), 205–218. Awadallah, A., Magdy, M., Helmy, E., Rashed, E., 2017. Assessment of rainfall intensity equations enlisted in the Egyptian code for designing potable water and sewage networks. Hindawi Adv. in Meteoro., ID 9496787, 10 p.https://doi. org/10.1155/2017/9496787. Batisha, A. F., 2007. Water desalination industry in Egypt. Eleven. Intern. Water Techn. Conf., IWTC11, Sharm El–Sheikh, Egypt, 337–349. Bengtsson, L., 2010. The global atmospheric water cycle 5–025202, 8p Environmental Research Letters. https://doi.org/10.1088/1748–9326/5/2/ 025002. Benveniste, J., Berry, P., 2004. Monitoring river and lake levels from space. ESA Bulletin 117, 36–42. Christensen, J., Hewitson, B., Busuioc, A., Chen, A., 2007. Regional climate projections. In Climate change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., M. TignorandH.L. Miller,, . (Eds.), Kingdom and. Cambridge University Press: Cambridge, United, New York, NY, p. 94p. Conway, D., 1997. A water balance model of the upper Blue Nile in Ethiopia. Hydrological Sciences Journal 42 (2), 265–286. https://doi.org/10.1080/ 02626669709492024. Conway, D., 2005. From headwater tributaries to international riverbasin: Adaptation to climatevariability and change in the RiverNile basin. Global Environmental Change 15 (2), 99–114. https://doi.org/10.1016/j.gloenvcha. 2005.01.003. Di Baldassarre, G., Elshamy, M., van Griensven, A., Soliman, E., Kigobe, M., Ndomba, P. Uhlenbrook, S., 2011. Future hydrology and climate in the River Nile basin: A review. Hydrological Sciences Journal 56 (2), 199–211. https://doi. org/10.1080/02626667.2011.557378. Djuma, H., Bruggeman, A., Eliades, M., Lange, M.A., 2016. Non–

Summarized by © lakhasly.com

conventional water resources research in semi-arid countries of the Middle East. Desalination and Water Treatment 57 (5), 2290–2303. https://doi.org/10.1080/ 19443994.2014.984930. Ebaid, H., Aziz, M., 2017. Integrating radar altimetersand optical imagery data for estimating water volume variations in lakes and reservoirs (case study: Lake Nasser). International Journal of Geographical Information Systems 9, 648–662. https://doi.org/10.4236/jgis.2017.96041. El Bedawy, R., 2014. Water resources management: Alarming crisis for Egypt. Journal of Sustainability Science and Management 4 (3), 108–124. Elba, E., Urban, B., Ettmerand, B., Farghaly, D., 2017. Mitigatingthe impact of climate changeby reducing evaporation losses: Sediment removalfrom the High Aswan Dam reservoir. American Journal of Climate Change 6, 230–246. https://doi.org/ 10.4236/ajcc.2017.62012. Elba, E., Farghaly, D., Urban, B., 2014. Modeling High Aswan Dam reservoir morphology using remote sensing to reduce evaporation. International Journal of Advanced Geosciences 5, 156–169. https://doi.org/10.4236/ijg.2014.52017. El-Bakry, M., 1993. Hydrometeorological measurements over the Lake of Aswan High Dam and evaporation estimate. Nile 2002 Conf., Aswan, Egypt, February 1- 6, III (2), 1- 21. Elnashar, W., 2014. Groundwater management in Egypt. J. of Mech. and Civil Eng. 11 (4), 69–78. Elsawwaf, M., Willems, P., 2012. Analysis of the climate variability on Lake Nasser evaporation based on the Bowen ratio energy budget method. Journal of Environment Biology 33, 475–485. Elsawwaf, M., Feyen, J., Batelaan, O., Bakr, M., 2014. Groundwater- surface water interaction in Lake Nasser, southern Egypt. Hydrological Processes 28, 414–430. https://doi.org/10.1002/hyp.9563. Elshemy, M., Meon, G., 2011. Climate change impacts on water quality indices of the southern part of Aswan High Dam reservoir, Lake Nubia. Fifteenth Intern. Water Techn. Conf., IWTC-15, Alexandria, Egypt, 17p. Ferrari, E., McDonald, S., Osman, R., 2013. Grand Ethiopian Renaissance Dam: A global CGE model to assess the economic effects on the Ethiopian economy, 16thammual conference on global economic analysis, "new challenges for global trade in a rapidly changing world". Information building, Shanghai Institute of Foreign Trade, p. 13p. Ferrari, E., McDonald, S., Osman, R., 2014. Water scarcity and irrigation efficiency in Egypt. 17th annual conference on global economic analysis, "new challenges in food policy. Trade and economic vulnerability ". June 18–20. Dakar, 28p. Fried, A., Serio, B., 2012. Water industry segment report desalination. World Trade Center, San Diago- Desalination Industry Report, p. 35p. Gleick, P., 1993. Water in crisis: A guide to the world's fresh water resources. Oxford University Press, New York, Oxford, p. 473p. Hailea, A., Akawkab, A., Berhanua, B., Rientjes, T., 2017. Changes in water availability in the Upper Blue Nile basin under the representative concentration pathways R.G. Abd Ellah / Egyptian Journal of Aquatic Research 46 (2020) 1–12 11 12 R.G. Abd Ellah / Egyptian Journal of Aquatic Research 46 (2020) 1–12 scenario. Hydrological Sciences Journal 62 (13), 2139–2149. https://doi.org/ 10.1080/02626667.2017.1365149. Hamdan, A., Selim, S., Zaki, M., 2013. Estimation of seepage loss from Nasser Lake to the adjacent Nubian sandstone aquifer, southern Egypt. International Journal of Science and Research 4 (9), 1106–1116. Hamdan, A., Zaki, A., 2016. Long-term estimation of water losses through evaporation from water surfaces of Nasser Lake reservoir, Egypt. International Journal of Civil Engineering 16 (5), 13–23. Hassan, M., 2013. Evaporation estimation for Lake Nasser based on remote sensing technology. Ain Shams Engineering Journal 4, 593–604. https://doi.org/ 10.1016/j.asej.2013.01.004. Heikal, M.T., 2010. Impact of water level fluctuation on water quality and

Summarized by © lakhasly.com

trophic state of Lake Nasser and its khors, Egypt. Egyptian Journal of Aquatic Biology and Fisheries 14 (1), 75–86. Ibrahim, M., Al-Zyoudand, S., Elhaddad, E., 2018. Surface water quality monitoring for RiverNile, Egypt using GIS-techniques. The Open Geology Journal 8, 161– 173. https://doi.org/10.4236/ojg.2018.82010. Iglesias, A., Garrote, L., Flores, F., Moneo, M., 2007. Challenges to manage the risk of water scarcity and climate change in the Mediterranean. Water Resources Management 21, 775–788. IPCC, 2007. Climate change 2007: the physical science basis, summary for policy makers. Contribution of working group 1 to the fourth assessment report of the intergovernmental panel on climate change, WMO. UNEP, 18 p. Khordagui, H., 2007. Climate change in ESCWA region: reasons for concern. In: proceedings of an expert group meeting on trade and environment priorities in the Arab region. Cairo, Egypt, 11– 13 November, 17p. Koutsoyiannis, D., 2011. Scale of water resources development and sustainability: Small is beautiful, large is great. Hydrological Sciences Journal 56 (4), 553–575. https://doi.org/10.1080/02626667.2011.579076. Koutsoyiannis, D., 2013. Hydrology and change. Hydrological Sciences Journal 58 (6), 1177–1197. https://doi.org/10.1080/02626667.2013.804626. Mostafa, M., Soussa, H., 2006. Monitoring of Lake Nasser using remote sensing and GIS techniques. Conference: ISPRS, At the Netherlands, 5p. Mostafa, M., Peters, R.W., 2015. Use river pollutant modeling to simulate and predict the change in the Damietta Branch water quality before and after construction of the Ethiopian Dam. Indian Journal Of Environmental Protection 6, 935–945. https://doi.org/10.4236/jep.2015.69083. Moussa, A.M., 2013. Predicting the deposition in the Aswan High Dam Reservoir using a 2-D model. Ain Shams Engineering Journal 4 (2), 143–153. https://doi. org/10.1016/j.asej.2012.08.004. Moustafa, S.M., 1991. Hydrology and hydrogeology investigation in the Kalabsha area at Aswan. M. Sc. Thesis, Fac. of Sci. Qena, Assiut Univ., 146p Muala, E., Mohamed, Y., Duan, Z., van der Zaag, P., 2014. Estimation of reservoir discharges from Lake Nasser and Roseires reservoir in the Nile basin using satellite altimetry and imagery data. Remote Sensing 6, 7522–7545. https://doi. org/10.3390/rs6087522. Mulat, A.G., Moges, S.A., 2014. Assessment of the impact of the Grand Ethiopian Renaissance Dam on the performance of the High Aswan Dam. Journal of Water Resource and Protection 6, 583–598. https://doi.org/10.4236/ jwarp.2014.66057. Mutua, F., Mtalo, 1., Bauwens, W., 2005. Challenges of modeling the flows of the Nile River. Proceedings of international conference of UNESCO FlandersFust friend/ Nile project towards A better cooperation and the 5th project management meeting and 9th steering committee meeting,12– 15. Robinson, S., Strzepek, K., El-said, M., Lofgren, H., 2008. The High Dam at Aswan. In: book: Indirect economic impacts of dams: Case studies from India, Egypt and Brazil. Chapter, TheHigh Dam at Aswan, The World Bank and Academic Foundation, pp. 227–273. Rosegran, M., Cai, X., Cline, S., 2002. World water and food to 2025: Dealing with scarcity. Intern. Food Policy Res. Inst, Washington, D. C.. Schuol, J., Abbaspour, K., Srinivasan, R., Yang, H., 2008. Estimation of freshwater availability in the West African sub-continent using the SWAT hydrologic model. J. Hydrolo. 352, 30–49. https://doi.org/10.1016/j.jhydrol.2007.12.025. Shiklomanov, I., 1998. World water resources. A new appraisal and assessment for the 21st century. Sci. & Cultur. Organ. 7 Place de Fontenoy, 75352 Paris 07 SF, 37p. Sircoulon, J., 1991. Climate, water development. Climate change: science, impacts and policy. Second World Climate Conf., 243–252 Smakhtin, V., Molden, D., Cascao, A., 2012. The River

Summarized by © lakhasly.com

Nile basin water, agriculture, governance and livelihoods. First edition, Routledge 2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN, 346p. Soliman, A., Soliman, M., 2017. Groundwater potential in the new valley south west of the Nile Delta in Egypt. In: Negm A. (eds) Groundwater in the Nile Delta. Handbook of Envir. Chem., 73, 585– 621. Sparavigna, A., 2011. The satellite archaeological survey of Egypt, 31 May 2011, Geophysics (physics.geo-ph), arXiv, 1105.6315, 9p. Sugita, M., Matsuno, A., El-Kilani, R., Abdel-Fati, A., 2017. Crop evapotranspiration in the Nile Delta under different irrigation methods. Hydrological Sciences Journal 62 (10), 1618–1635. https://doi.org/10.1080/02626667.2017.1341631. Sutcliffe, H., Hurst, S., Awadallah, A., Brown, E., Hamed, K., 2016. Harold Edwin Hurst: The Nile and Egypt, past and future. Hydrological Sciences Journal 61 (9), 1557–1570. https://doi.org/10.1080/02626667.2015.1019508. Swain, A., 2011. Challenges for water sharing in the Nile basin: Changing geo- politics and changing climate. Hydrological Sciences Journal 56 (4), 687–702. https://doi.org/10.1080/02626667.2011.577037. Tawfik, R., 2015. Revisiting hydro-hegemony from a benefitsharing perspective: The case of the Grand Ethiopian Renaissance Dam. Discussion Paper/Deutsches Institutfür Entwicklungspolitik I1860–0441, 66p. Tesfa, B. C., 2013. Benefit of Grand Ethiopian Renaissance Dam Project for Sudan and Egypt. Energy, Water, Env. & Econ., 1 (1), 1– 12. UNEP, 2010. Africa Water Atlas. ISBN: 978-92-807-3110-1, Job Number: DEW/1313/NA, 314p. Zaghlou, S., Pacini, N., Schwaiger, K., Villeneuve, P., 2012. Towards a Lake Nasser management plan results of a pilot test on integrated wa

Summarized by © lakhasly.com