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BOOK REVIEW

Water Resources Systems of the Philippines: Modeling Studies[§]

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The Philippines has abundant water resources. There is, however, a growing trend of water supply shortages in major urban centers in the country—including Metro Manila. Uneven population distribution, along with climate change and deteriorating condition of watersheds, is some of the major drivers identified (Gleick 2013; Chang *et al*. 2013; Schnoor 2015, as cited by Rola *et al.* 2015). On one end, climate change and population growth increase the demand for water. On the other end, climate change and watershed degradation increase the uncertainties in the availability of water resources that makes the task of achieving water security more challenging than it is already. Forecasting and balancing of future demands and available water resources are more complicated now than it used to be. Bringing water to where it is needed requires a robust understanding of how much water is available and how much is the demand for it. In the past forecasting, water availability and demand were simpler than it is now. Understanding available water then was based mainly on physical factors (*i.e.* climatic and watershed geomorphic features) while demand was conveniently evaluated based mainly on population and economic growth. Today, the availability of water resources is additionally influenced by land use and land cover change, and climate change while water demand is further influenced by policies and development controls governing urbanization and industrialization (Rola *et al.* 2015). Consequently, it is now imperative to use—when available and practical—tools that are able to generate vital information on water availability and demand based on an array of biophysical, socioeconomic, and politico-institutional factors.

To robustly understand how the ever-growing complexity of the natural and human systems influence water resources systems—particularly watersheds, hydrological processes, water supply systems, and water demand management—systemic and integrated approaches and tools are indispensable. In view of the foregoing, this book is a timely reference on the use of models as a tool for integrative analysis and management of water resources systems in the Philippines. While the use of models in water resources management is not a common practice in the country, this book highlights the potential applications of models in water resources management in the Philippines. The book presents cases of model application in various aspects of water resources management and administration.

In Chapter 3, the book presents an overview of the applications of models in the Philippines in science and information-based policy and decision-making. Samples of applications of models for solving optimization problems are also described in this chapter. From Chapter 4–11, the book illustrates specific applications of models in water resources systems in the Philippines.

Chapter 4 discusses two cases of model application in surface and groundwater assessment in two major river basins. The Pampanga and Agno River Basins are vital sources of water for the irrigation of vast rice production areas. These river basins, however, are facing challenges to its ability to supply irrigation water sustainably amid increasing demand in the domestic and industrial sectors. In these cases, models were used to estimate the long-term average surface and groundwater resources as the basis for balancing supply and demand. For surface water estimation, the Sacramento model was used while MODFLOW was used for groundwater assessment. The results of the model runs were also used to identify potential sites for hydropower generation.

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Optimization-simulation studies in two existing and one proposed multi-purpose reservoirs are discussed in Chapter 5. The existing Angat and Upper Agno Reservoirs—along with the proposed Agos Reservoir system—are all intended for hydropower generation, water supply, and flood control. The Sacramento and WATPOW models were used in these three cases. As it is the task of optimizing the use of water resources in Angat and Upper Agno as is expected in the proposed Agos Reservoir is challenging that becomes more daunting with the dynamically shifting demands for water across sectors and hydrological processes governing water availability. Specifically, these cases illustrate how models can be used for optimum reservoir operations such as in setting schedule of releases and gate openings.

Application of models in sedimentation studies in the proposed Balog-Balog Reservoir and in the existing San Roque and Pulangi Reservoirs are reported in Chapter 6. The optimization-simulation model used in Chapter 4, together with the Sacramento model, was used for the Balog-Balog Reservoir to determine the better option between building a single high dam and multiple dam construction. The outputs of the modeling studies were used to minimize irrigation water supply deficits, maximize hydropower generation, and minimize spills. For the San Roque Reservoir, the two-dimensional (2-D) flow and sediment transport hydraulic model was adapted to study the impacts of sedimentation on the reservoir operations, hydropower generation, and overall service life of the reservoir. The 2-D hydraulic model was also used in the Pulangi Reservoir to determine the effectiveness of sediment flushing operations under various water inflow and water level conditions, and the corresponding optimum sluice gate openings.

For comprehensive water quality studies in Manila Bay and Laguna Lake, various models were used (Chapter 7). The Sacramento soil moisture accounting model with overland and channel flow routing models were used to simulate streamflows coming down from the major watersheds draining to Laguna Lake and Manila Bay. To calculate the depth and velocities of incoming flows to the bay and the lake, the hydrodynamic/hydraulic model was used. For describing the movement and evolution of water quality in the bay and the lake, an advection-dispersion model was used. The comprehensive water quality study illustrated in this chapter highlights a robust approach for addressing concerns on water quality in bays and lakes aided by modeling.

In Chapter 8, modeling studies in three areas and one dam break study in the Butas Dam of Cavite are discussed. Specifically, modeling was used to generate information that is needed for precision flood mitigation. In the Pasac Delta, the influence of storm rainfall movement on flooding was studied using two models. The UNET model—a one-dimensional, unsteady flow model through a network of open channels—was used to simulate streamflow behavior. To simulate the storm rainfall, a stochastic, space-time rainfall model based on the Neyman-Scott process was used.

The HEC-RAS model—an unsteady flow, network hydraulic model—was used to quantify the extent of flooding in the Pasig-Marikina River during TS Ketsana in 2009. In addition, the SWATCH model—a physically-based, continuous simulation watershed model—was used to calculate the flood hydrograph. The results of these simulations showed the flood stages in various locations along the Pasig-Marikina River that are a useful basis for retrofitting existing infrastructures, *e.g.* bridges, and boosting flood mitigation measures currently in place among other applications.

A 2-D flood inundation model with inflow flood hydrograph calculated using the Sacramento soil moisture accounting model was used to generate information that is a good basis for determining the best flood mitigation options for the lower Cagayan de Oro River Basin, which experiences flooding during heavy rainfall events.

The 2-D flow and sediment hydraulic model was used to simulate the erosion pattern of reservoir sediment deposits after planned and unplanned dam breaks. The modeling study on planned dam break or removal was hypothetical to illustrate how reservoir sediment deposits will erode during dam removal. The accidental dam break in the Butas Dam and the subsequent volume of sediments that were eroded from the dam and transported downstream was simulated using the same model. Results of simulation of dam breaks are useful in implementing appropriate anticipatory mitigation measures to minimize, if not totally avoid, damages to life and property in case of dam removal and accidental dam failure.

A sample application of the enhanced EPANET model with the COMPLEX optimization algorithm is presented below for model calibration to a portion of the pipe distribution network of MWSI located south of Manila is discussed in Chapter 9. The results of this sample application illustrate the ease and efficiency in model calibration and estimation of demand patterns of an actual pipe network problem using the said models. Other applications of the models, such as in monitoring and surveillance of non-revenue water and pipe network studies, were mentioned in this chapter.

Chapter 10 discusses the use of the Sacramento soil moisture accounting model along with the WATPOW model with the COMPLEX optimization in assessing the potential impacts of climate change on the reliability of two important reservoirs in two major river basins. The models were used to assess the impacts of future climate on the reliability of reservoir operations in the Upper Agno River Basin. In particular, the hydropower generation of the three reservoirs along Agno River under the current climate was compared with that of the 2050 climate. The same models were used to assess the impacts of climate in 2050 on the reservoir sedimentation in Angat River Basin and how it will affect the reliability of water deliveries and hydropower generation.

The applications of modeling in assessing water quality in Subic Bay and Novaliches Reservoir are presented in Chapter 11. The water quality in Subic Bay was assessed using the SWATCH watershed model to calculate the inflows of water from upstream into the bay. The three-dimensional (3-D) Princeton ocean model was used to calculate the water depths and velocities. To assess the water quality advection-dispersion model was used based on the estimated water depths and velocities. Particularly, the models were used to simulate the movement and describe the spatial distribution of biological oxygen demand (BOD) for various wastewater for the base case and three future scenarios of BOD loadings depending on the reduction measures adopted. Likewise, the models were used to simulate the oil spill movement of an actual oil spill incident in Subic Bay.

The FEMWATER is a 3-D saturated-unsaturated, finite-element groundwater flow and contaminant transport model that was used to assess the potential risk of contaminating the Novaliches Reservoir through groundwater flow and pollutant transport from the Payatas Dumpsite. While the results of this study showed that the risk of contaminating the Novaliches Reservoir is nil, the potential application of the models in the proper location of dumpsites in relation to existing and potential reservoirs is illustrated.

The book closes with Chapter 12 covering five major groups of topics related to modeling in water resources systems. The chapter compares the scientific and data analytic approaches to and the importance of integration of geomorphological, ecological, and hydrological interactions in water resources modeling. It also covers the importance of monitoring and data collection as well as of decision support tools in promoting science-based management of water resources in the Philippines. The chapter discussion ends with the importance of holistic and transdisciplinary approaches to water resources management, together with building urban resilience to water-related disasters.

Overall, this book is a good reference for water resource system managers and practitioners, students, researchers, and academics on the applications of models in various water resource system related studies in the Philippines. The book, to some length, cited other models that were used in previous studies not described in this book and presented guiding discussions on how to determine the models that are appropriate for a particular case. The various studies conducted by the author are good illustrations of what models may be considered in generating information that is vital to making science-based, water resource system-related decisions.

REFERENCES

CHANG H, JUNG I-W , STRECKER A, WISE D, LAFRENZ M, SHANDAS V, MORADKHANI H, YEAKLEY A, PAN YD, BEAN R, JOHNSON G, PSARIS M. 2013. Water supply, demand, and quality indicators for assessing the spatial distribution of water resource vulnerability in the Columbia River Basin. Atmosphere-Ocean 51(4): 339–356.

GLEICK PH. 2013. A drop in the bucket. Finance and Development 50(3). Retrieved on 15 Aug 2016 from http://www.imf.org/external/pubs/ft/fandd/2013/09/gleick.htm

ROLA A, PULHIN J, ARCALA-HALL R. 2015. Water Policy in the Philippines: Issues, Initiatives and Prospects. Springer-Verlag.

SCHNOOR JL. 2015. Water unsustainability. Daedalus, the Journal of the American Academy of Arts & Sciences 144(3): 1–11.