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Hydrological impact assessment of climate change on water resources of the Niger River basin using a water balance model and ANNs

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Abstract The study explored and assessed the potential impacts of climate change on water resources of the Nigerian sector of the Niger River basin of sub-Saharan West Africa, with simulation models, the Thornthwaite water balance accounting scheme and artificial neural networks (ANNs). The water balance model uses mean monthly climate variables of precipitation, temperature, net radiation, as well as soil water holding capacity and potential evapotranspiration, for estimating water surpluses of five Niger sub-basins, linking the water surpluses of these sub-basins with the corresponding observed monthly average discharges using the ANNs model. Ninety-six months of data have been used for calibrating the ANNs and 24 months data were used for verification. Areally averaged temperature and precipitation changes from formulated climate change synthetic scenarios were imposed on each sub-basin for assessing climate change impacts on runoff (water surplus). ArcView GIS was vital for the hydrological modelling, especially the building of the grid containing the water holding capacity parameter of the soil, creating climatic surfaces and merging various spatial themes (data layers) that were useful in interpretation, analysis (soil water budgeting) and change detection of spatial structures and objects. Results show discernible evidence and the sensitivity of the Niger River basin to the changing climate; annual water surplus is highest over the south of Niger (1241.2 mm), followed by Lower Benue (973.6 mm), Lower Niger (729.4 mm), Upper Benue (495.3 mm) sub-basins and the least value is observed over Upper Niger sub-basin (360.7 mm). It is further observed that the water surplus is much more sensitive to the accuracy of potential evaporation estimate (that depends on temperature) in the humid climate than the arid climate. In addition, when temperature increases by 2°C, the mean monthly runoff on the average is expected to change by –10 to –50%, –5 to –40% and 15 to 60%, respectively, for precipitation changes of –20%, 0% and 20%. By implication then, water, hydro-power, health and food security of the country may be seriously threatened by climate change, unless rainfalls turnout to be on the increase and adequate management strategies are put in place. Necessary adaptation measures and nonconventional sources of water that can be exploited in the future are also highlighted.

Key words ANN; Niger River; water balance; climate change