Assessing the impacts of environmental change on the hydrology of the Nzoia catchment, in the Lake Victoria Basin

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The main objective of this study was to assess the past and potential future environmental changes, and their impact on the hydrology of the Nzoia catchment. More specifically, the study has analyzed the historical climatic (1962-2004) and land cover changes (1973-2001) that have taken place in the Nzoia River catchment in Kenya, and the effect these have had on the hydrology of the catchment. It has also made use of land cover and climate change scenarios for the future to determine the potential effects these will have on the catchment. The Soil and Water Assessment Tool (SWAT) model was used to investigate the impact of land cover and climatic change on streamflow of the study area. The model was set up using readily available spatial and temporal data, and calibrated against measured daily discharge. The land cover changes within the watershed were examined through classification of satellite images and a land cover change model generated the land cover change scenarios for the year 2020. Climate change scenarios were obtained from general circulation models (GCMs) for the period 2010-2039 (i.e. 2020s) and 2040-2069 (i.e. 2050s). The climate change IPCC SRES scenarios A2 and B2 were selected. To this purpose, rainfall and temperature scenarios based on the GCMs CCSR, CSIRO, ECHAM4, GFDL and HADCM3 were superimposed on the calibrated SWAT model.

Trend analysis of rainfall shows that, in general, the annual rainfall has increased by about 2.3 mm/year between 1962 and 2004. Although this is not statistically significant, analysis of monthly rainfall has shown that out of a total of 14 stations, four have shown significant trends at 5% significance level. An important observation is that out of 10 rainfall stations that show an increasing trend, eight are found in the highland areas. The lower catchment receives much less rainfall and some stations exhibit decreasing rainfall trends. The variation of trends on a monthly basis, show that the months May to September and December have shown decreasing amounts although not statistically significant. Temperature shows increasing trends, though not statistically significant, with higher increases in the lowlands (0.79°C) than in the highlands (0.21°C) between 1978 and 2003.

Land cover change analysis has shown that the agricultural area has increased from about 39.6 to 64.3% between 1973 and 2001, while forest area has decreased from 12.3 to 7.0%. Results from the calibrated model showed that generally, runoff was
highest from agricultural lands, followed by shrubland, grasslands and forest. Considering the land cover changes between the two time periods, 1970-1975 and 1980-1985, the study has shown that without climate change, land cover changes would account for a difference in runoff of about 55-68%. On the other hand, change in climate without land cover change accounted for a difference in runoff of about 30-41%. This shows that land cover changes have resulted in greater runoff changes than changes in climate.

From the GCM future climate change scenarios, scenarios A2 and B2 indicate increased amounts of annual rainfall with variations on a monthly basis. All - but one - GCMs show consistency in the monthly rainfall amounts, indicating that the seasonal rainfall pattern will be maintained, but with higher amounts in the 2050s than in the 2020s. The monthly changes in rainfall range from -16 to +49%, while mean annual rainfall changes range between 2.4-23.2%. Temperature will increase in this region, with the 2050s experiencing much higher increases than the 2020s, with a monthly temperature change range of 0-1.7°C. Analysis of the impact of rainfall and temperature changes on surface runoff showed the highest and least increases in annual runoff by the ECHAM4 and CCSR models respectively. The monthly peak runoff would be observed in the months of April, May and November. The range of change in mean annual rainfall of 2.4-23.2% corresponded to a change in streamflow of about 6-115%. Monthly changes are much more variable and it follows that these figures would be much larger for monthly changes. The analysis has revealed important linear relationships between rainfall and runoff for certain months. These relationships have been derived from climate change scenarios and could be extrapolated to estimate amounts of streamflow under various scenarios of change in rainfall. Streamflow response was not sensitive to changes in temperature for the scenarios considered and no significant relationships were derived.

According to the future climate change scenarios, with all the other variables held constant e.g. land cover, population growth etc., a significant increase in streamflow may be expected in the coming decades as a consequence of increased rainfall amounts. Thus, to mitigate possible frequent flooding which has been a major problem in this region, there is need to reverse trends in land degradation. In addition, water harvesting of excess water could alleviate drought problems that may be experienced with a changing climate.