ABSTRACT

A distributed parameter model, the SWAT (Soil and Water Assessment Tool) was tested on daily, monthly and seasonal basis and used for developing management scenarios for the critical sub-watersheds of a small agricultural watershed (Nagwan). The watershed and sub-watershed boundaries, drainage networks, slope, soil series and texture maps were generated using Geographic Information System (GIS). Supervised classification method was used for land use/cover classification from satellite imageries.

Manning's roughness coefficient 'n' for overland flow and channel flow and Fraction of Field Capacity (FFC) were calibrated for monsoon season of 1991. The model was validated for the year 1996 and 1997 using the respective rainfall and temperature data. Calibration and validation results revealed that the model was predicting the daily, monthly and seasonal surface runoff and sediment yield satisfactorily. Sensitivity analysis showed that the annual sediment yield was inversely proportional to the overland and channel 'n' values whereas, annual runoff and sediment yields were directly proportional to the FFC. Nutrients such as organic nitrogen and phosphorous in sediment and NO_3-N and soluble P in runoff were also considered for model validation. The observed and simulated nutrient losses were compared for twelve events during the monsoon season of 1997. Observed and simulated means of organic nitrogen, phosphorous, NO_3-N and soluble P showed good agreement.

Simulated monthly runoff and sediment yield for the intermediate period between calibration and validation (1992-1995) compared well with their observed counterparts. Capability of the model for generating rainfall was also evaluated for the period of 1996 through 1998. The model simulated daily rainfall was having close agreement with that of observed rainfall. Also the model predicted daily and monthly runoff and sediment yield using generated daily rainfall compared well with observed runoff and sediment yield during simulation period of 1996 through 1998. The effect of storage structure in a sub-watershed on runoff and sediment yield at the watershed outlet was also evaluated. A reservoir in the sub-watershed (WS4) was found to reduce the average annual runoff by 10 mm at the outlet of the Nagwan watershed and was able to trap sediment of about 1.5 t/ha/yr from sub-watershed WS4.

The critical sub-watersheds were identified on the basis of average annual sediment yield and nutrient losses during the period of 1996 through 1998. The calibrated and validated model was used for planning and management of critical sub-watersheds. The ranking of different critical sub-watersheds was done according to the annual sediment losses for developing management plans. The sub-watersheds WS12, WS9, WS7, WS10 and WS6 were found to be critical. For all critical sub-watersheds, runoff, sediment yields and nutrient losses showed similar trend. WS7 was selected as a sample critical sub-watershed for evaluating the management scenarios.

Sixty combinations of treatment options were considered which included selected crops (rice, maize, groundnut and soybean), tillage (zero, conservation, field cultivator, M. B. plough and conventional) and levels of fertilizer (existing, half of recommended and recommended). The existing management practice was considered as the base for evaluating other management practices for rice crop. The results showed that rice crop can not be replaced by other crops since these crops resulted in higher sediment yield as compared to rice.

M. B. plough had considerable impact on sediment yield and nutrient losses since it increased sediment yield by about 39 % and decreased nutrient losses by about 22 % N, 50 % P, 3% NO_3-N and 37 % soluble P as compared to the conventional tillage for the existing level of fertilizer treatment. The decrease in sediment yield as compared to conventional tillage was found to be about 19%, 11 % and 10 %, respectively for zero tillage, conservation tillage and field cultivator. The impact of zero and conservation tillage on nutrient losses for all levels of fertilizer doses was found to be more than that of the other tillage treatments. Considering both sediment and nutrient losses together, field cultivator followed by conventional tillage was found to be better than the other types of tillage considered. Field cultivator gave sediment losses less than the conventional tillage and nutrient losses within the permissible limit. A dose of 40:30 kg/ha of N:P fertilizer proved to be appropriate for rice with either conventional tillage or field cultivator.

KEY WORDS: Watershed, Hydrology, Water quality, SWAT, Remote Sensing, GIS, Management, Modelling.