IDRC CRDI

Modelling the Hydrological Balance in the Zou Catchment at Atcherigbe Outlet (Bénin Republic): Contribution to the Sustainable Use of Water Resources

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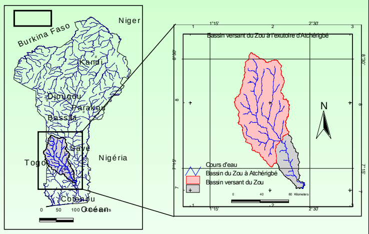
Introduction

As sub-Saharan (West Africa) catchments, the Zou catchment suffers water stress caused by climate and anthropogenic influences. Such situations raise important issues for sustainable development and lead to further consequences including aquatic ecosystem degradation, additional costs for the drinking water production, and damages to homes and roads. This study interest is to implement a physics-based model to increase the reliability of physical processes, climate and human influences in the estimation of water balance and soil loss through the basin.

Study area

This modelling study of the hydrological balance was conducted in the zou catchment at Atchérigbé outlet, stretching over a total area of approximately 6980 km² in the center of Benin.



Major soil types

-Tropical ferruginous soils, leached, with concretions, on embrechite (20%);
-Hydromorphic soils, leached, on embrechite and gneiss (19%).

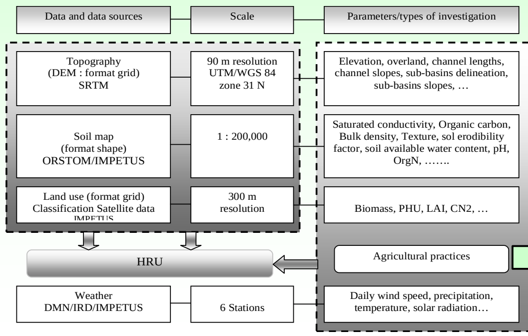
Vegetation cover

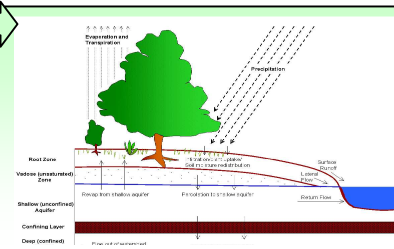
-Crops / Fallows (45%);
-Brush/Grass savannah (24%).

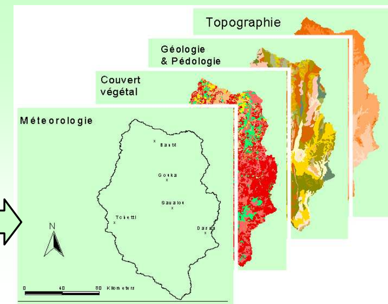
Average annual rainfall : 1060 mm

Modelling approach

SWAT model has been calibrated and validated for that watershed. The Hydrologic Response Units generated by the model SWAT are the units space where the various components of the water balance and the amount of transported sediment were evaluated. The run-off was estimated by the method of Curve Number (SCS, 1972, 1986), which depends on the soil permeability, soil moisture condition and its vegetation cover. The soil water has been assessed according to the soil moisture (saturated or unsaturated) by the method of path with storage (Sloan and Moore, 1984). The actual evapotranspiration was assessed by Penman's method (1956). As for the erosion, the Modified version of the Universal Soil Loss Equation of Williams (1975) was used. The main data used were DEM of the region, soil characteristics, soils maps, land cover/land use maps, climate and cultivation practices.



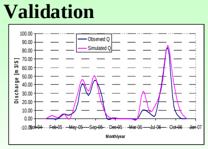


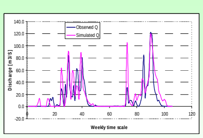


Sensitivity analysis

Parameters	Sensitivity rank	Mean	Parameter description
CN2	1	1.96	SCS runoff curve number for moisture condition II.
GWQMN	2	1.75	Threshold water depth in the shallow aquifer for flow (mm)
SOL_AWC	3	1.70	AWC of the soil layer (mm/mm soil)
ESCO	4	1.52	Soil evaporation compensation factor
sol_z	5	0.43	Soil depth (mm)
sol_k	6	0.25	Soil hydraulic conductivity (mm.h-1)
rchrg_dp	7	0.15	Deep aquifer percolation fraction
Canmx	8	0.04	Maximum canopy storage (mm)
ALPHA_BF	9	0.04	Base flow alpha factor (days)

Validation





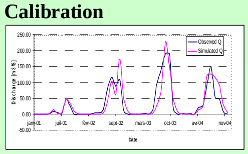
monthly average (m^3/S)		Statistical indicators		
Observed Q	Simulated Q	R^2	ME	IA
13.76	17.54	0.87	0.82	0.95

Weekly average (m^3/S)		Statistical indicators		
Observed Q	Simulated Q	R^2	ME	IA
13.55	17.3	0.65	0.54	0.86

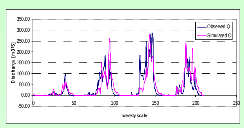
Conclusion

The results showed an acceptable scale of spatial integration of landscapes properties and agricultural practices. The productivity of water systems in the Zou basin is important, far above needs, but varies in space and time due to climate variabilities, the strong anthropogenic pressure and the local soil conditions. The results showed also spatial disparities of sediment losses between sub-basins and between types of vegetation are high, with an overall rate of about 5 tonnes / ha / yr.

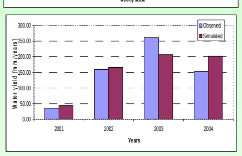
Calibration



Monthly average (m^3/S)		Statistical indicators		
Observed Q	Simulated Q	R^2	ME	IA
32.46	33.7	0.79	0.79	0.94



Weekly average (m^3/S)		Statistical indicators		
Observed Q	Simulated Q	R^2	ME	IA
32.98	33.21	0.66	0.64	0.90



Annual water yield average (mm)		Statistical indicators		
Observed	Simulated	R^2	ME	IA
151.65	153.75	0.79	0.79	0.93

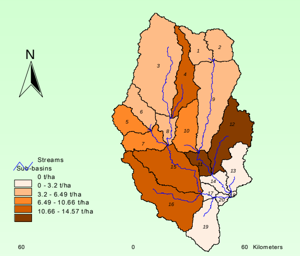
The adjusted water balance shows a coefficient of surface runoff of 7%, a total of groundwater recharge (shallow and depth aquifer) of about 18% and an actual evapotranspiration of 72%. Regarding erosion in the basin, the average annual losses are in the order of 5 tons/ha and presents disparities depending on the type of land cover: approximately 17 tons/ha/yr in the agricultural HRUs and about 0.6 tons/ha/yr in the classified forests and woodlands.

Hydrologic balance component	Quantities
Total precipitations	1023 mm
Overland flow	75 mm
Lateral flow	8 mm
Contribution of shalow aquifer to the stream discharge	71 mm
Deep aquifer recharge	17 mm
Total recharge of aquifers (Deep and shallow)	187 mm
Total flow	152 mm
Transmission loss	2 mm
Actual evapotranspiration	741 mm
Soil water variation	12 mm

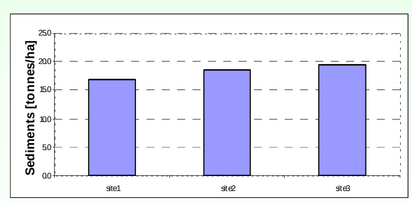
Sediments loss according to land use types

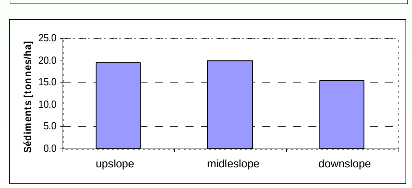
Land use	Crops/ fallows	Brush Savannah	Grazing	Forest/ zoo lands
Sediments [|t/ha/y]	17.22	1.95	0.76	0.61

Sediments loss per sub-basins



Figures below show the issues of trapped sediments in cotton field for August-September 2007 (sub-basin 10)





Acknowledgements

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