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Empirical models for the assessment of specific sediment yields in reservoirs of North and Central Morocco

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Introduction

Changes in land use result in erosion and silting up of reservoirs and dams in Morocco. The dimensions of the reservoirs and dams are in most cases determined by estimating the volumes of runoff water from the water supplying catchments.
Because all dams were silted up to more than 10% of their capacity during the first two years after their construction, the dimensions and life-time of the reservoirs and dams are underestimated. From the total capacity of the reservoir storage (10 billion m³) about 0.5% equivalent to 50 million m³ is lost annually (deposition of sediment).

In order to assess the amount of sediment arriving in the reservoir during a certain period of time after the construction of the dam, the erosion and sediment delivery processes occurring in the contributing catchment, need to be described and assessed as well as the parameters governing the processes.
Parameters as the rainfall aggressivity, the soil erodibility, the topography and the morphology of the catchment, the vegetation cover and land use and management are among the most important ones.

Direct or indirect empirical relationships and interrelationships are sought between climate factors and the amount of sediment deposited in the reservoirs of 24 selected dams in North and Central Morocco.

2. Materials and Methods

24 dams were selected of which their contributing watersheds are situated in 5 regions of Morocco and of which also the specific degradation SEa (t/ha/yr) is reported in table 1.

Table 1: The 24 dams under study

Region	Dam (watershed)	Specific degradation SEa (t/ha/yr)
Souss, Issen, Massa Draa, Guir, Ziz	Abdelmoumen	1.23
	Aoulouz	4.27
	Y.B.Tachfine	3.38
	Mansour Eddahbi	5.12
	Hassan Eddakhil	4.37
Moulouva	Mohamed V	3.71
	M. Homadi	3.07
Oum Er Rbia, côtier Atlantique and Tensift	S.M.B. Abdellah	4.08
	Bin El Ouidane	11.25
	Moulay Youssef	27.76
	Hassan Premier	23.95
	Sidi Driss	2.21
	Al Massira	1.74
	Lalla Takerkoust	1.87
Bassin du Nord Loukkos, Côtiers Méditerranéens, Neckor	Oued El Makhazine	28.13
	Ibn Battouta	53.94
	Nakhla	29.90
	Smir	42.67
	M.B.A.Al Khattabi	20.51
Sebou	Idriss Premier	8.26
	Allal Al Fassi	9.98
	Al Wahda	28.61
	Sidi Echahed	17.46
	El Kansera	4.22

The SEa will be related to climatic factors as annual precipitation *(P)*, the Fournier Index *(FI)* (Fournier, 1960) the Modified Fournier Index *(MFI)* (Arnoldus, 1980) and the Aridity Index *(A I)* (De Martonne (1923).

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According to the available data sets, two different procedures were used to calculate (FI), and *(MFI)*

- In the first procedure the monthly rainfall amounts are averaged over a number of years. The *(FI)* and *(MFI)* are then calculated from this averaged rainfall data set and reported as *(FI)1* and *(MFI)1*.
- In the second procedure the *(FI)* and *(MFI)* are calculated from the monthly rainfall amounts of each individual year and the *(FI)* and *(MFI)* are averaged over a number of years. Those long term average values are reported as *(FI)2* and *(MFI)2*.

The dams (watersheds) are classified according to the Aridity Index (De Martonne, 1923) and are as such situated in humid (9 dams), semi-arid (6 dams), arid (7 dams)or hyper-arid (2 dams) regions.

The highest SEa values are found in the humid areas where also (P), (FI), (MFI) are the highest, while in the arid regions (P), (FI) and (MFI) are the lowest.

Table 2 contains the regression coefficients (r) between SEa and the climatic factors (P), (FI) and (MFI) and this for all the 24 dams.

Table 2: Correlation coefficients between SEa and the climate factors

Correlation	SEa (t/ha/an)	FI (mm)	MFI (mm)	P (mm)
SEa	1.00	0.61	0.66	0.66
IF		1.00	0.94	0.87
IFM			1.00	0.97
P				1.00

Table 3 shows the regressions (with highest r^2) between SEa and the climate factors for the humid, semi-arid, arid and hyper-arid regions and the combined arid and hyper-arid region.

Table 3: Regressions between SEa and climatic factors for different aridity regions

Humid region (9 dams)
$SEa = 0.44\, e^{0.01\,(P)}$ $r^2 = 0.58$
$SEa = 0.05\,(FI)^{1.54}$ $r^2 = 0.69$
$SEa = 7.61\, 10^{-5}\,(MFI)^{2.65}$ $r^2 = 0.77$

Semi-arid region (6 dams)
$SEa = 12.43\,(P)^{-0.10}$ $r^2 = 0.13$
$SEa = 3.5610^{5}\,(FI)^{-2.94}$ $r^2 = 0.77$
$SEa = 3.50 \times 10^{4}\,(MFI)^{-1.91}$ $r^2 = 0.37$

Arid region (7 dams)
$SEa = 0.12\,(P)^{0.63}$ $r^2 = 0.05$
$SEa = 3.02 \times 10^{3}\,(FI)^{-1.97}$ $r^2 = 0.40$
$SEa = 34.85 \times 10^{3}\,(MFI)^{-2.30}$ $r^2 = 0.22$

Arid region and hyperarid (9 dams)
$SEa = 1.68\, 10^{2}\,(P)^{-0.76}$ $r^2 = 0.41$
$SEa = 52.86\,(FI)^{-0.85}$ $r^2 = 0.32$
$SEa = 73.43\,(MFI)^{-0.82}$ $r^2 = 0.41$

For the humid regions the best correlation is obtained between the specific degradation SEa and (MFI) or (IF); for the semi-arid and arid regions between SEa and (IF). Combining the arid and hyper-arid regions results in an improvement of the correlations between SEa and (P) or (MFI)

4. Conclusions

For the humid regions there is a direct relationship between SEa and (P), (FI) and (MFI) while for the semi-arid and arid regions there is a direct relationship between SEa and (P) and an indirect relationship between SEa and (FI) and (MFI). This means that when taking only the climatic factors (FI) and (MFI) into account, the higher the rain aggressivity, the lower the specific degradation SEa (t/ha/yr) in the semi-arid and arid regions.

5. References

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