IMPETUS
Morocco

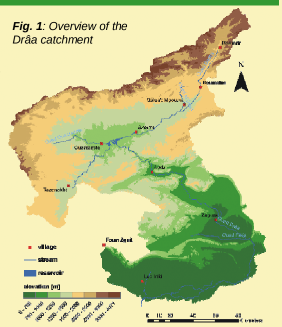
Soil information for the Drâa catchment – from point to regional scale

A. Klose, B. Diekkrüger
Department of Geography, University of Bonn, Meckenheimer Allee 166, Bonn

Introduction

- There is an urgent need for spatial soil information in the Drâa catchment for resource management and as input for various ecological models (hydrological models SWAT & Hydrus1D, vegetation dynamics models SAVANNA & BUFFER, soil erosion model PESERA).
- Soil data is only available in 2 % of the catchments surface, namely the agriculturally used oases areas
- The Drâa catchment (28 000 km²) is highly heterogeneous due to
  - Altitudinal range: High Atlas (4071 m) to Saharan Foreland (450 m)
  - Climate: semi-arid (precipitation 800 mm/a) to hyper-arid (< 50 mm/a)
  - Geology: highly heterogeneous (fig. 3)
  - Vegetation: palm and mountain oases (intensive irrigation agriculture, 2 % of the area), semi-natural, degraded steppes (mainly Hammada scoparia, Artemisia; fig. 2)
  - Soils: Leptosols, Regsols, Fluvisols, Cambisols and Calcisols; in the High Atlas also Luvisols and Kastanozems; in the Saharan Foreland also Arenosols

Fig. 1*: Overview of the Drâa catchment*



Method

CORPT - approach: Analysis of the relation between soil and the 5 soil-forming factors climate (C), organisms (O), relief (R), parent material (P) and time (T)

Statistical method: Due to missing spatial autocorrelation of the soil properties, MLR (Multiple Linear Regression) including dummy variables (binary variables indicating the membership to a category of a nominal CORPT - variable) was chosen.

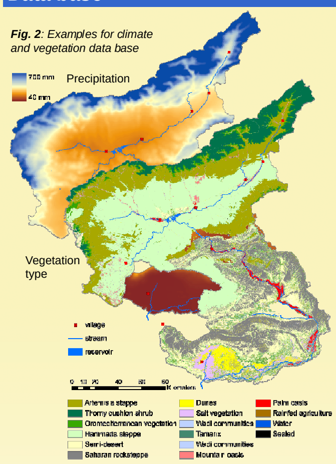
y = a + b*x + c*dv + b*x*dv
y = predicted value; a = regression constant; b, c = regression coefficients; x = metric variable; dv = dummy variable

Result evaluation:

$$r^2_F = \frac{\sum (deviations\,between\,the\,categories)^2}{\sum (total\ deviation)^2} \qquad MSE_{norm} = \frac{\frac{1}{n}\sum_{i=1}^{n}(predicted - observed)^2}{measured\ variance} \qquad RMSE_{norm} = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(predicted - observed)^2}}{measured\ mean}$$

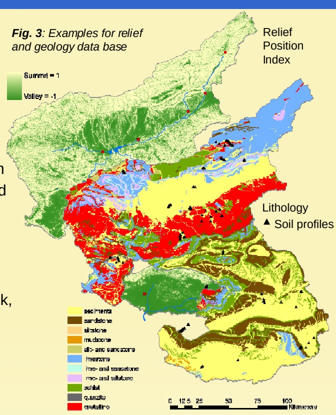
Data base

Fig. 2*: Examples for climate and vegetation data base*



- Climate: Regionalisation of mean annual temperature and precipitation
- Vegetation: Landsat TM vegetation classification
- Relief: Digital Elevation Model (resolution 90 x 90 m), calculation of various primary, secondary and tertiary terrain attributes
- Geology: Geological maps 1:500 000 and 1:200 000; interpretations regarding stratigraphy, lithology, type of rock, geochemistry, resistance to weathering
- Soil data - aggregated to two layers: Point data from 211 soil profiles (depth, skeleton content, texture, $CaCO_3$, organic carbon, nitrogen, pH)

Fig. 3*: Examples for relief and geology data base*



Quality of regionalisation

- All regionalisation rules are significant at the 95 % - level
- Depending on the parameter, between 22 and 89 % of the variance can be explained (tab. 1)
- Confidence intervals are acceptable in relation to the populations mean (tab. 1)
- The 'artificial' aggregation of soil horizons limits prediction quality of layer depth
- The lack of information on the distribution of aeolian dust input limits prediction quality of $CaCO_3$ content
- The very low variance of the measured pH values influences MSE_{norm}

Tab. 1*: Quality of the regionalisation procedure (smallest confidence interval at the populations mean, highest at its minimum and maximum)*

		mean	r^2_F	$RMSE_{norm}$	MSE_{norm}	Confidence Interval 95 %	evaluation
	Soil Depth [cm]	85.95	0.466	0.38	0.54	± 4.5 – 28.2	moderate
Upper Layer	Depth [cm]	31.66	0.223	0.54	0.81	± 2.4 – 14.4	poor
	Skeleton [%]	43.56	0.756	0.15	0.24	± 1.4 – 3.2	very good
	Sand {%]	44.91	0.536	0.19	0.48	± 1.6 – 4.0	satisfactory
	Silt [%]	37.94	0.507	0.21	0.50	± 1.2 – 3.8	satisfactory
	Clay [%]	17.07	0.634	0.23	0.37	± 0.7 – 2.6	good
	Carbonate [%]	11.82	0.566	0.43	0.45	± 0.9 – 4.2	satisfactory
	Organic Carbon [%]	0.67	0.629	0.38	0.38	± 0.05 – 0.03	good
	Nitrogen [%]	0.06	0.623	0.32	0.39	± 0.004 – 0.03	good
Lower Layer	Depth [cm]	61.96	0.520	0.39	0.50	± 4 0 – 30.3	satisfactory
	Skeleton [%]	48.89	0.540	0.25	0.46	± 1.9 – 4.1	satisfactory
	Sand {%]	42.48	0.742	0.17	0.26	± 1.3 – 3.4	very good
	Silt [%]	36.87	0.728	0.15	0.27	± 1.2 – 3.1	very good
	Clay [%]	20.61	0.668	0.21	0.33	± 0.7 – 2.4	good
	Carbonate [%]	17.16	0.352	0.56	0.72	± 1.3 – 4.7	poor
	Organic Carbon [%]	0.52	0.841	0.18	0.16	± 0.03 – 0.2	very good
	Nitrogen [%]	0.06	0.891	0.31	0.11	± 0.005 – 0.04	very good
	pH	11.86	0.640	0.02	2.72	± 0.03 – 0.1	good

Conclusions

- Continuous maps of soil properties are regionalised
- Reasonable relationships between soil properties and CORPT - factors are identified
- The relations are formalised via MLR incl. dummy variables, the method is applicable for (semi-)arid, macro-scale basins
- With the applied method one map for each soil property listed in table 1 is derived (example see fig. 5). The advantage of these "property maps" compared to traditional maps of soil types are:
  - The results can be used as input for pedotransfer functions to derive further soil properties, such as available water capacity or soil erodibility
  - For the application in ecological models the maps can be aggregated based on sensitive model parameters incl. a quantification of uncertainty

Relationship between soil properties & CORPT factors

Most soil properties vary on two spatial scales, the catchment scale and the hillslope scale (fig. 4).

Catchment scale:

- Climatic & vegetation gradients determine organic matter input and thus soil nutrient state and pH
- Parent material & climate dominate soil depth, skeleton content and texture via weathering intensity and properties of parent material
- $CaCO_3$ content depends on parent material & dust input; no information on the distribution of aeolian input

Hillslope scale:

- erosion processes dominate soil physical properties via selective removal of fine material

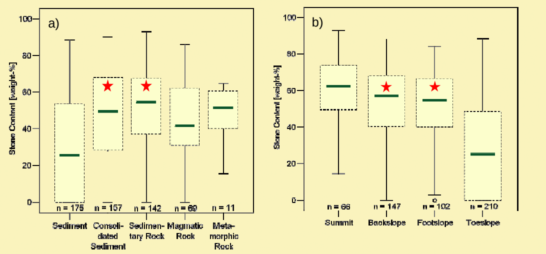
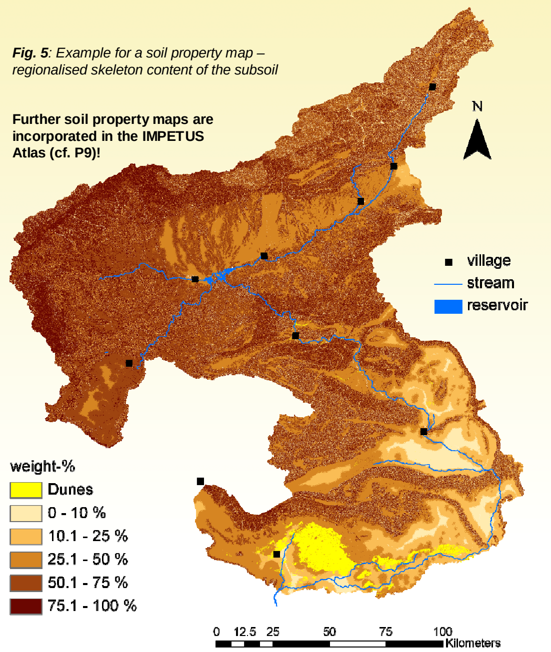


Fig. 4: Influence of a) parent material and b) hillslope position on soil skeleton content (n = number of samples, bars = minima & maxima, box = interquartile, line = median, red star = **no** significant (95 % - level) difference according to the t-test)

Fig. 5*: Example for a soil property map – regionalised skeleton content of the subsoil*

Further soil property maps are incorporated in the IMPETUS Atlas (cf. P9)!



Universität zu Köln
GLOWA
Ministry of Innovation, Science, Research and Technology of the German State of North Rhine-Westphalia
Federal Ministry of Education and Research
universitätbonn