A land resource database for the Republic of Niger to estimate topsoil losses through wind erosion at the regional scale

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1 Abstract

In the last decades, the decreasing vegetation cover in the semi-arid part of Niger Republic increased the risk of soil erosion. Thus, in order to assess the spatial distribution of wind erosion risk at the regional scale and to identify areas of priority for conservation measures, a Geographical Information System on the relevant surface properties in the Republic of Niger has been generated. First model based estimations show hotspots of high wind erosion risk in the eastern and northern part of Niger. However, there is still a lack of soil information as well as meteorological data particularly in northern Niger, which is a bottleneck to the regional evaluation. In the southern part of Niger, there are landscape units with elevated wind erosion risk even with vegetation cover, which are characterized by topsoils that show sandy texture with low organic matter content or by soils with growth constraints.The results confirm the importance of vegetation cover in semi-arid Niger to prevent soil degradation from wind erosion.

2 Background and Objectives

Arid and semi-arid regions like the Republic of Niger are most prone to soil losses by wind erosion. In the last decades, the decreasing vegetation cover in the semi-arid part of Niger increased the risk of soil erosion. The decline is partly due to decreasing rainfall (Wezel et al. 2000), but more important is the expansion of cropland. The wind erosion potential is variable in space and time, depending on climate, soil cover, land use, soil moisture and soil surface type. Thus, in order to assess the spatial distribution of wind erosion risk at the regional scale and to identify areas of priority for conservation measures, a Geographical Information System (GIS) on the relevant surface properties in Niger has been generated.

3 Material and Methods

3.1 Database

The database covers different parts of Niger (Figure 1) and consists of the following geographic information stored in a relational database management system:

- Detailed soil maps of the intensively used South of Niger (Gavaud 1967, 1970, Scale 1:500.000)
- Soil map of the world covering the entire Republic of Niger (FAO 1977, Scale 1:6.000.000)
- Geological map of Niger (Greigert and Pougnet 1967, Scale 1:2.000.000)
- Digital elevation model (GTOPO 30)
- Meteorological data from 12 metorological stations
- Land cover and soil surface types based on the analysis of remote sensing data (LANDSAT) from transects covering arid to sub-humid areas in Niger.

The soil data structure follows the concept of the SOTER methodology (ISRIC 1993) and the World Reference Base of Soil Resources (FAO/ISRIC 1998). In a first approach, 72 landscape units (terrain units) with 223 soil components where derived from the FAO soil map of the world.

3.2 Model based estimations of wind erosion risk

Through the combination of soil (surface) data with climatic data, realistic modeling of the soil loss rates in space and time can be performed. The wind erosion risk for each soil component was estimated with the EPIC (Erosion Productivity Impact Calculator, USDA 1990) model (Version 0941) which has been connected to the soil and climate database of Niger. EPIC uses a modification of the Wind Erosion Equation (Woodruff and Siddoway 1965) according to Cole et al. (1982). For the comparison of two scenarios (with and without vegetation), the vegetation parameter set for range vegetation (grass/shrub vegetation) as provided by EPIC was used. The development of vegetation, and hence soil cover, was driven by soil and climatic conditions in the respective landscape units.

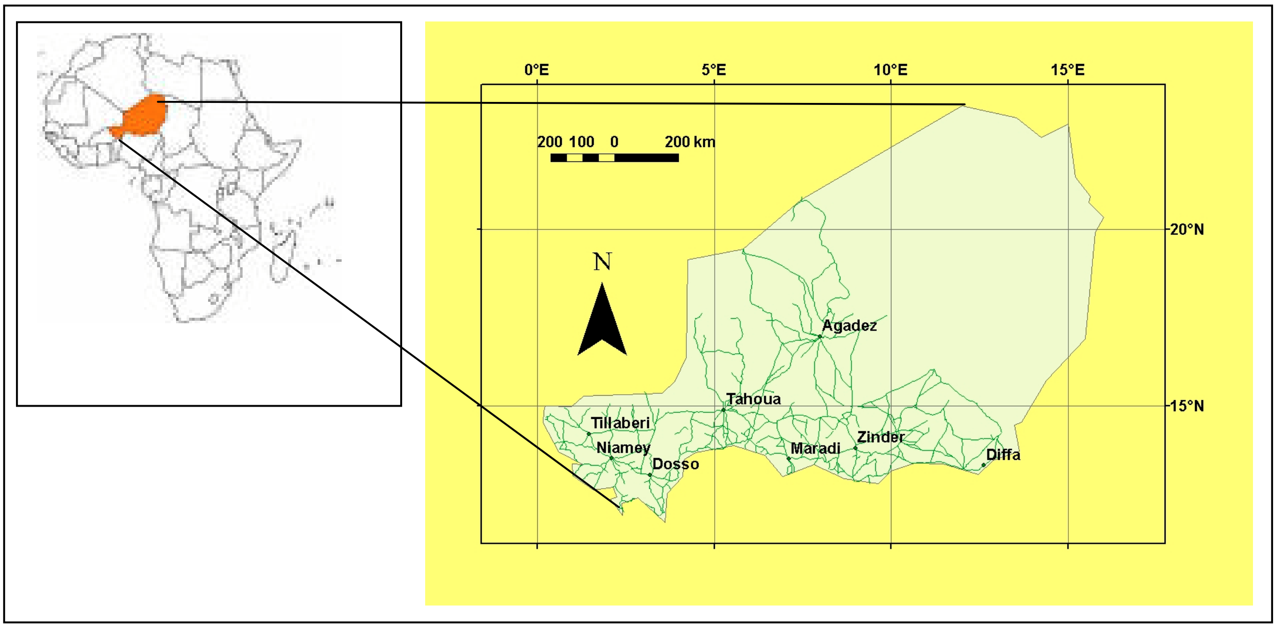

Figure 1: Location of the Republic of Niger

4 Results and Discussion

Although the soil database covers the entire Niger, figure 2 shows the problem of insufficient soil information to carry out simulation runs with the EPIC model in the northern part. EPIC requires a complete soil input parameter set including texture, bulk density, pH and total organic carbon, which is not yet available in 20 out of the 72 landscape units. In addition, there is a lack of wind observation stations in general and a problem of data availability at high temporal resolution in particular. The simulation results in the other landscape units give evidence of some „hotspots“ of wind erosion in the East and North of Niger with topsoil losses above 15 t per ha and year without vegetation cover (Figure 2). The hotspots are characterized by topsoils with sandy texture (loamy sand and coarser) and low organic carbon content (below 3.5 mg kg^{-1}). In the southern part of Niger the wind ersoion risk is moderate (< 15 t per ha and year) when the soil surface is without cover. With grass/shrub vegetation the wind erosion is considerably reduced, however there are still some hotspots which may require specfic conservation measures. These hotspots are characterized either by topsoils with sandy texture and low organic matter content or by soils with growth limitations (Vertisols, stony soils etc.).

Over all landscape units, a vegetation cover reduces the risk of wind erosion considerably (Figure 2b). Mean reduction through the vegetation cover over all landscape units is in the order of 90% (Figure 3)

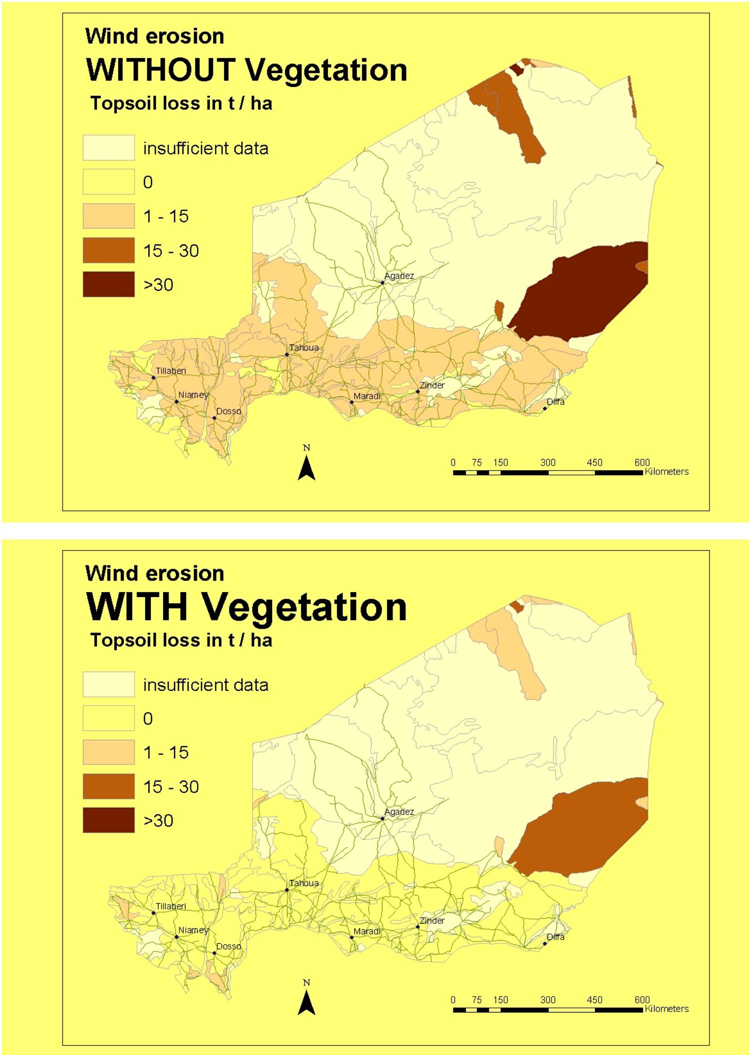

Figure 2: Estimated mean soil loss per year (a) without and (b) with vegetation cover

5 Conclusions and perspectives

The results confirm the importance of vegetation cover in semi-arid Niger to prevent soil degradation from wind erosion. However the general assumptions of the EPIC model for vegetation cover have to be adjusted for some specific vegetation forms like tiger bush in savannah and contracted vegetation in semi-desert environments. Hotspots of wind erosion can be identified with the land resource database, although there is still a lack of soil information as well as meteorological data particularly in northern Niger. In the future, data gaps in the respective regions will be filled with data from secondary literature, own observations and global climate data sets. In addition, the wind erosion model will be tested and calibrated against ongoing wind erosion measurements in the field with a mobile wind tunnel (Maurer et al. 2003).

6 Acknowledgement

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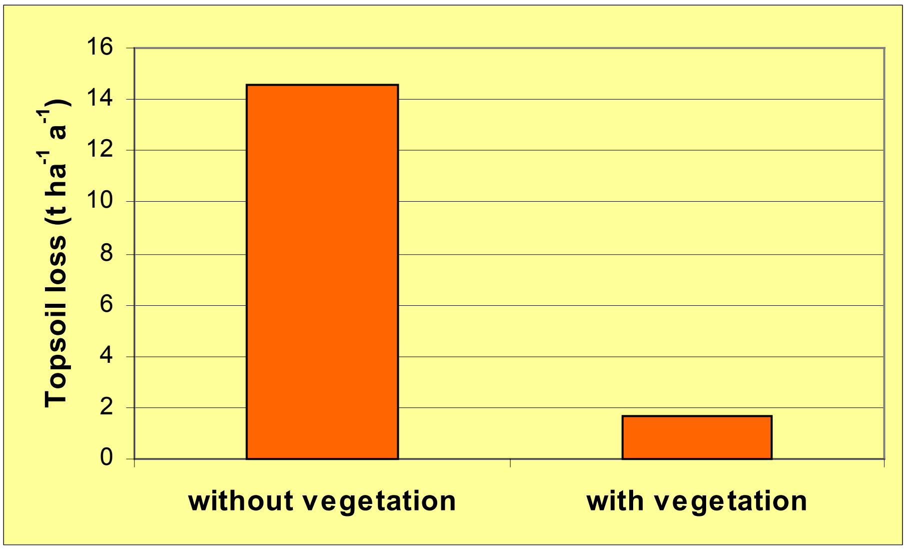

Figure 3: Comparison of mean topsoil loss in Niger with and without grass/shrub vegetation estimated on the basis of EPIC simulations

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