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Stefan Kienberger, Marion Borderon, Christina Bollin, Britta Jell

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Corresponding Author:
stefan.kienberger@sbg.ac.at
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Climate Change Vulnerability Assessment in Mauritania: Reflections on Data Quality, Spatial Scales, Aggregation and Visualizations

Stefan Kienberger[1], Marion Borderon[1], Christina Bollin[2] and Britta Jell[3]

[1] University of Salzburg, Austria
[2] Adelphi GmbH, Berlin, Germany
[3] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Abstract

Mauritania is vulnerable to climate change due to its location along the Sahel, the desert climate of the Sahara, and its socio-economic characteristics. To support the identification of climate change adaptation measures in Brakna and Assaba in Mauritania, a spatial assessment of vulnerability to climate change targeting the livelihood sectors of agriculture and pastoralism was carried out. Based on the identification of relevant drivers of climate change vulnerability in a broad consultation process among national and local stakeholders, a variety of geospatial indicators were identified and integrated in the assessments based on a standardized vulnerability assessment approach. In this paper, we provide a reflection on the methodology applied and identify lessons to be learnt on data quality, spatial scales, aggregation and visualizations. The primary conclusion is that users of the assessment results and stakeholders need to be engaged in the entire assessment process in order to reflect local characteristics more fully, and to ensure that the results are reflected in informed decision-making.

Keywords:

composite indicators, spatial analysis, visualization, integrative assessments

1 Introduction

Mauritania – located in north-western Africa, and covering parts of the Sahel and the Sahara – is particularly vulnerable to climate change (IPCC, 2014). While 75% of the country is part of the Sahara and largely uninhabited, 25% lies within the semi-arid Sahel. The Sahel is impacted by climate change through increased temperatures and related heat waves, and higher variability of precipitation (Niang et al., 2014). In addition, competing interests for land in a region with very high dependency of livelihoods on natural resources, population growth, poverty, complex governance structures and related conflicts add to the vulnerability of the region and its population.

To address these challenges and to identify appropriate climate change adaptation measures, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, on behalf of the German Federal Ministry for Economic Cooperation and Development and the European Union, requested a climate change vulnerability assessment, which aims to assess how the capacities to adapt to climate change in rural areas can be improved. The assessment targeted key national actors in order to better identify and design adaptation measures.

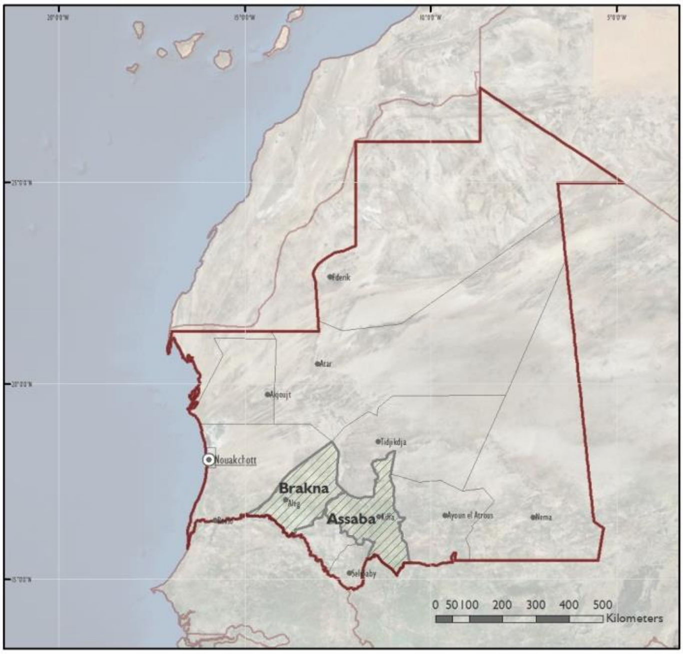

Figure 1: Location of the case study areas, the wilayas of Brakna and Assaba

The specific aim of this study was therefore to spatially assess the vulnerability of rural livelihood systems, especially agriculture and pastoralism, to climate change for the two wilayas (provinces) of Assaba and Brakna in southern Mauritania (Figure 1). This was achieved by adapting a standardized assessment for vulnerability to climate change (Fritzsche et al., 2014). A range of relevant indicators for agriculture and pastoralism were identified, together with stakeholders. A variety of geospatial datasets were also collected and integrated in the assessments based on standard composite indicator approaches, and mapped for the commune (village) level. Modelling results were visualized and made available in a compilation of maps accompanying the report on the results of the assessment. Below, we provide a reflection on the methodology applied and identify lessons to be learnt on data quality, spatial scales, aggregation and visualizations.

2 Method and Results

The method applied in the study is based on the Vulnerability Sourcebook, a standardized vulnerability assessment commissioned by GIZ (Fritzsche et al., 2014) and recently used in Burundi (Becker et al., 2014). The definition and conceptualization of vulnerability and risk appear to be in the process of being consolidated among the scientific communities (see e.g. IPCC, 2014). Nevertheless, there is still often confusion among users on the meaning and practicability of the concepts. Based on the Vulnerability Sourcebook, we followed a pragmatic definition of the IPCC AR4 concept. Vulnerability is defined as the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change. According to this definition, vulnerability is a function of three sub-domains: the exposure of a system to climate change, the system's sensitivity, and its adaptive capacity (IPCC, 2014; see also Fritzsche et al., 2014 and Becker et al., 2014).

This conceptual understanding of vulnerability was applied to structure the assessment and identify the relevant factors characterizing climate change vulnerability of (i) agriculture and (ii) pastoralism, the major livelihoods in the wilayas of Brakna and Assaba. We followed the generic steps outlined in the Vulnerability Sourcebook (Fritzsche et al., 2014):

(1) In order to ensure the relevance of factors identified for the selected case study areas, impact chains were developed for the target sectors of agriculture and pastoralism through workshops and active stakeholder engagement. The conceptual vulnerability framework served as a guide to identify the factors for the three vulnerability sub-domains. The impact chains reflect the broad range of interrelated socio-economic, political, environmental and climatic factors creating the specific vulnerability profile of the region. On this basis, a set of possible indicators to measure relevant factors was established in various consultation processes.

(2) Datasets were identified and collected from different regional, national and international sources. The assessment for agriculture comprised 11 indicators; the assessment for pastoralism comprised 10 indicators (Figure 2). Availability of data was a key challenge within this assessment, especially access to detailed, accurate socio-economic data as well as high-resolution climate model projections. Other datasets, such as the climatic suitability of the three main crops used in agriculture, were modelled using the EcoCrop model (Hijmans et al., 2001) and the related EcoCrop database (FAO, 2000). Recent climate scenarios were used as inputs to the EcoCrop model (CORDEX-Africa data for the climate scenarios RCP4.5 and RCP8.5, for the present day and end-of-century conditions). Due to the limited availability of socio-economic census data at the level of the communes, a number of distance proxies were calculated to capture socio-economic variations within the wilayas (e.g. 'distance to roads' as an accessibility indicator, or 'distance to water points' to evaluate the availability of water resources for humans as well as livestock). Future projections were available only for climatic parameters; socio-economic conditions were kept constant for the future and are based on the present-day conditions.

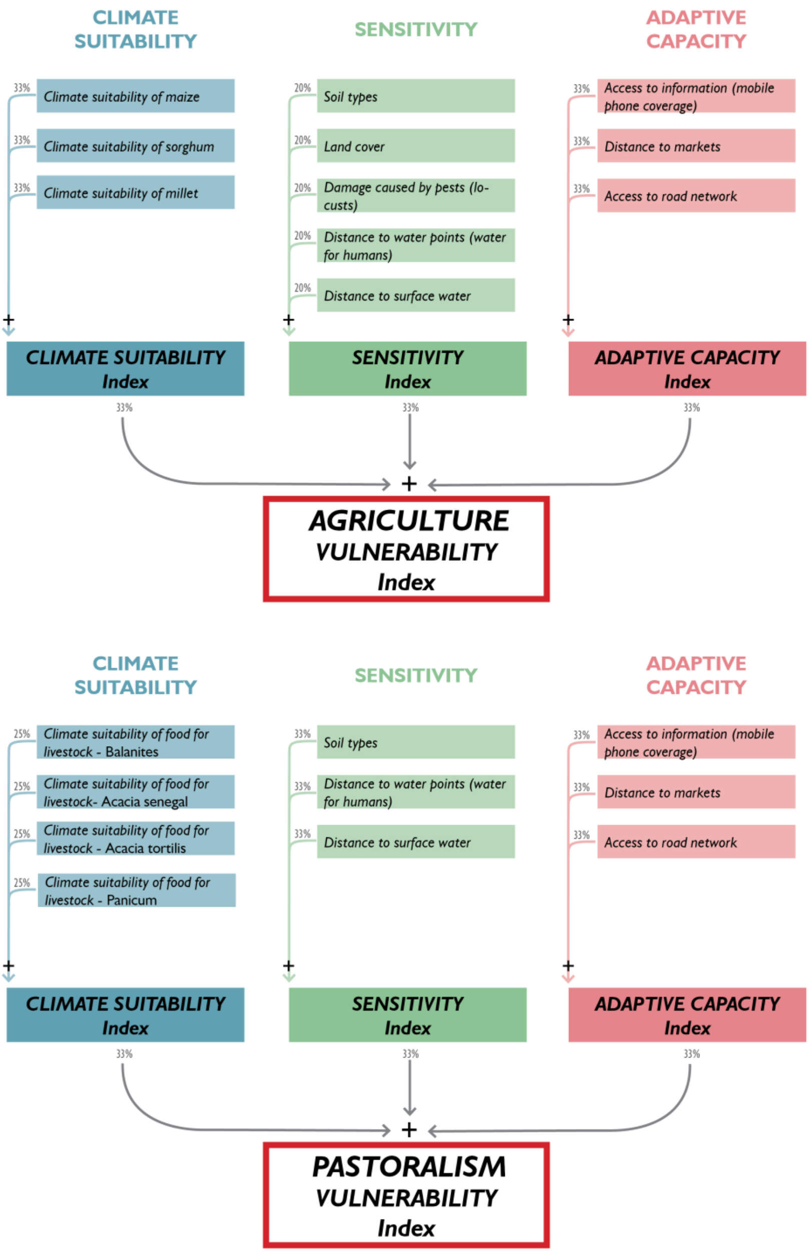

Figure 2: Overview of the framework, indicators used and aggregation scheme applied

(3) Normalization procedures were applied to standardize the datasets within a common value range, in order to allow comparison and aggregation of the individual indicators. Value functions were used (see e.g. Beinat, 1997), which were defined in a discussion at a workshop with local representatives and experts.

(4) Weighting approaches are helpful to value indicators according to their significance and importance. In our case study, it was decided that weights should be assigned equally to all indicators. This was decided jointly with the stakeholders as all factors have equal importance and a differentiation would not have been possible to identify and agree on.

(5) Indicators were then aggregated, using a (weighted) sum aggregation: (i) a climate suitability index of crops (which reflects an instance of climate exposure), (ii) sensitivity, and (iii) adaptive capacity. These three sub-domains were then further aggregated, using the same approach, in order to create the final vulnerability maps of agriculture and pastoralism (Figure 3).

(6) The individual indicators, the integrated vulnerability index maps, as well as the climate projections were visualized, validated with regional and national stakeholders, and made available in a series of maps, together with a report on the results of the vulnerability assessment. The vulnerability indices are mapped for each commune and are therefore defined by administrative boundaries. For visualization purposes, an approximate ecumene was derived from population data and buffered locations of village point data, as large areas of the two wilayas are uninhabited. This provides a quasi-spatial-explicit approach which aims to support the user in interpreting the maps. The result maps include the vulnerability index maps, as well as maps for the three sub-domains of the vulnerability framework (Figure 3).

The results show (as in Figure 3) that climate change vulnerability differs within the two wilayas and according to the two sectors. A general north–south trend can be observed which is linked to the climatic conditions, including changed precipitation patterns as well as differences in temperatures. The southern part of the two wilayas is generally more influenced by the Sahel conditions, whereas the northern areas are part of the Sahara desert. Additionally, socio-economic conditions are reflected in the sensitivity and adaptive capacity of the two areas: the two wilayas show increased or altered vulnerability, and certain vulnerability ‘hotspots’ emerged. Those areas with relatively high vulnerability to climate change served as the starting point to identify priority locations for climate change adaptation measures.

Reflections

During the implementation of the climate change vulnerability assessment, we encountered a number of challenges. These challenges included the availability and quality of data, implications concerning the spatial scale, questions regarding the most representative aggregation sequence, and others concerning how best to communicate the results to users and decision-makers. These key aspects are discussed below.

- **Data availability and quality**: During the consultative meetings and the development of the impact chains, a number of key factors to be considered in the assessment were noted. Some drivers are difficult to quantify and reflect by quantitative geodata, e.g. factors in the context of legal issues. However, the most critical aspect was to obtain access to relevant datasets, although some of the desired factors needed to be dropped due to limited data. Specifically, there were difficulties gaining access to recent population data at *commune* level. This data included a variety of socio-demographic variables as well as the locations of settlement areas. As an integrative vulnerability assessment relies on a variety of inter-sectoral data sources, access to these datasets is a pre-requisite, and policies for data-sharing embedded in a Spatial Data Infrastructure (SDI) are required to provide more meaningful results. In this case, we had to use proxy indicators (e.g. distance proxies), which limit the quality of the results. These shortcomings, caveats and the related uncertainty of model outputs need to be communicated to the users adequately.

- **Scale implications**: Scale implications were observed in two ways. Firstly, the 'downscaling' and the appropriate resolution of climate change model outputs for sub-national and local assessment scales; secondly, the spatial coverage of required data. The first point is limited by the current state-of-the-art of downscaling, and even more by the lack of availability of long-term climatological observation data, of proven quality, in the region. Given this lack of data, especially at the required density for the current observational network, the size of the grid cells for the climate scenario is limited to 50x50km². As can be seen in Figure 3 (lower left-hand corner), only a few grid cells cover the *wilayas*. Therefore, for the 'grid-cell' view, the cell size needs to be reduced to provide results at the administrative level of the *communes*. Again, related uncertainties need to be considered when interpreting the results. Assessments carried out at larger-scale levels may also increase the complexity of the analysis to be carried out because additional and context-specific factors need to be considered (see e.g. Kienberger et al., 2013). Therefore, the general issue of getting access to data is exacerbated by the need for more detailed data, with regard to its spatial resolution as well as to its attributional range.

- **Aggregation:** The issue of aggregation methods and schemes is discussed in detail in Fritzsche et al. (2014) and OECD (2008). In the present case, the question of method has been less important than the sequence for integrating the indictors and sub-domains, and therefore the links to the conceptual framework being defined in the initial stage of an assessment. In our case, the climate-driven sub-index (climate suitability index, reflecting climate exposure) was given the same weighting as the sensitivity and adaptive capacity (which are independent of climatic conditions). When following e.g. a stricter definition of the IPCC AR4 conceptualization, sensitivity and climatic exposure would constitute another sub-domain of the potential impact. These different possibilities impact the final vulnerability value. In our case, the climate signal – and therefore the potential change in vulnerability between two time periods – is relatively high compared to other options.

- **Implications for visualization**: Results of the assessment are provided at the level of the administrative boundaries for *communes*. The challenge is that such administrative boundaries do not reflect realities, for instance exactly where the population vulnerable to climate change is living. Additionally, some *communes* are not populated regularly at all, due to the adverse environmental conditions in the

Sahara. In general, the area is also sparsely populated with settlements along certain favoured topographical features. We used a combined approach, with saturated colours for the index value for ecumene areas, whereas each *commune* is also represented by hatched and coloured lines to provide a complete picture (see Figure 3). This should give the user an understanding of the spatial heterogeneity of the populated places, and illustrates that the index is calculated at *commune* level. A similar approach is used to visualize socio-economic data in Austria (see Wonka, 2008).

Conclusions and Outlook

As a basis for the identification of vulnerable areas and the development of effective adaptation strategies, our study demonstrates how a vulnerability assessment in the context of climate change adaptation can be implemented. However, it is critical (1) to involve the key actors at national and sub-national level at all stages of the assessment, which allows the consideration of local circumstances and legitimizes the results; (2) to follow robust methods, integrating suitable and valid data, and to communicate limitations, such as methodological and data uncertainties, to users/stakeholders in a transparent manner.

However, to be able to deal with these uncertainties adequately, users need to be able to understand the underlying vulnerability concepts, as well as the process and methods applied. Hence it is very important that users follow the assessment process and be aware of the limitations and constraints through their active participation. Finally, the results of the assessment need to be presented in a comprehensive report, which presents methodological aspects as well as qualitative information not captured in a spatial and quantitative assessment (e.g. information on the vulnerability factors identified in the impact chains but not reflected in the final indicator set).

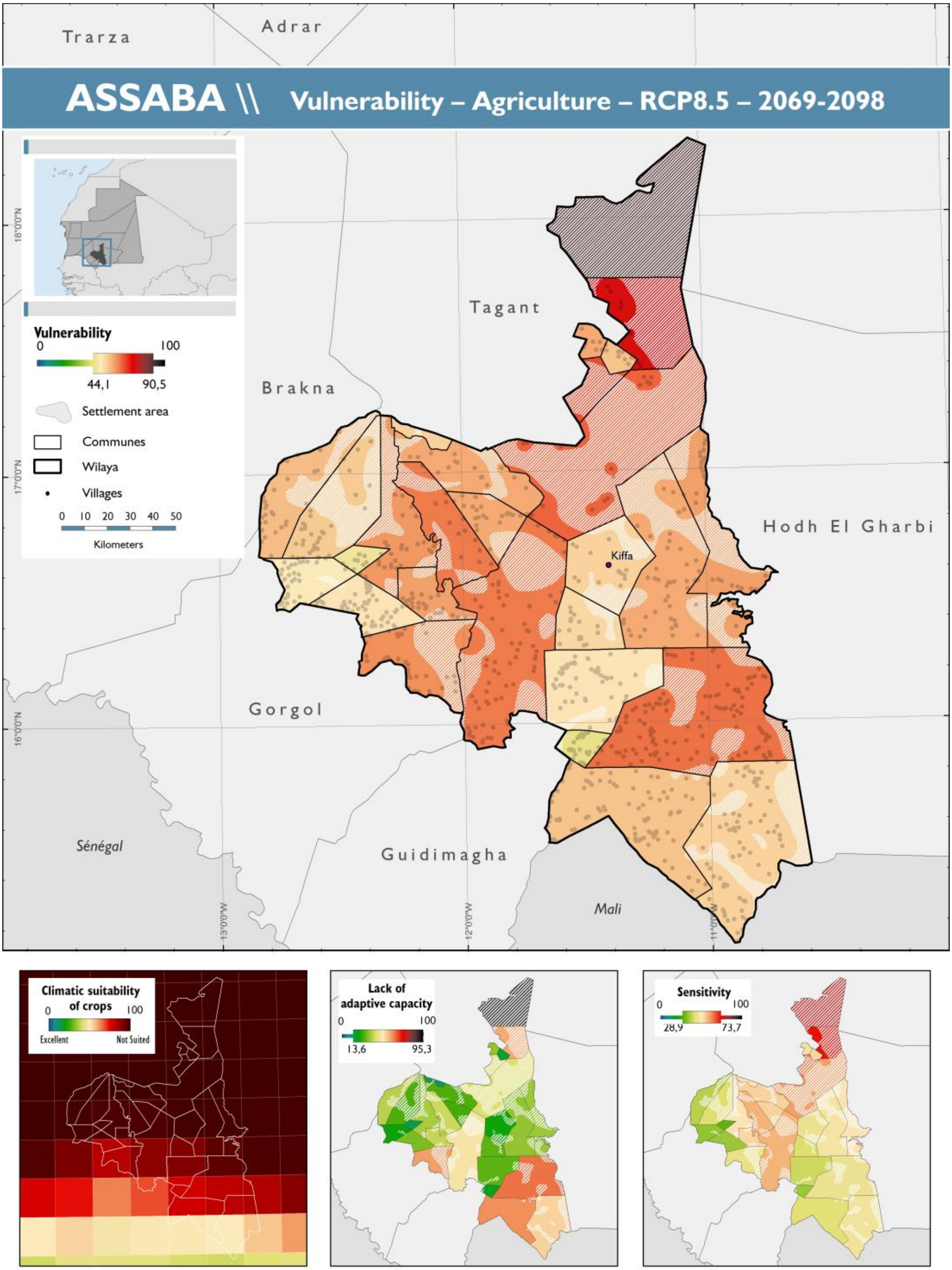

Figure 3: Result of the vulnerability mapping for the wilaya of Assaba, agricultural sector, the worst case scenario (RCP8.5), and at the end of the century

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