Findings Report

DSVI Niger

Digital Social Vulnerability Index 2023, Niger

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Their thoughtful comments and suggestions have significantly contributed to the rigour and relevance of the report.

Acronyms and abbreviations

DHS: Demographic and Household Survey
DSVI: Digital Social Vulnerability Index
ICPSD: Istanbul Centre for Private Sector in Development
IPC: Integrated Food Security Phase Classification
PCA: Principal component analysis

Summary

The Digital Social Vulnerability Index (DSVI) Niger report, a collaboration between the UNDP Niger Accelerator Lab and the Istanbul Centre for Private Sector in Development (ICPSD) SDG AI Lab, presents a comprehensive assessment of social vulnerability in Niger using high-resolution maps and advanced technologies such as geographic information systems, artificial intelligence and machine learning. This initiative aims to support national stakeholders in informed decision-making and policy development by identifying and analysing the most vulnerable communities and the key drivers of vulnerability across the country. This report is part of a series designed to showcase the results of the DSVI in various regions and countries. The main technical whitepaper can be accessed here: https://undp.org/publications/digital-social-vulnerability-index-technical-whitepaper.

The primary objectives of the DSVI Niger project were to calculate nationwide socioeconomic vulnerability estimates using high-quality data sets, and to provide insights to stakeholders to enhance policymaking. The research addressed three main questions: identifying the most and least vulnerable communities, understanding the drivers of vulnerability, and comparing DSVI results with other vulnerability indicators to inform policy.

The methodology involved rigorous data collection, preprocessing and the use of multiple machine learning models to predict social vulnerability. Key data sets included socioeconomic and biophysical variables such as night light intensity, proximity to healthcare and education, population density, conflicts and climate-related data.

The analysis revealed several insights:

- High levels of vulnerability were observed in regions such as Diffa, Maradi, Zinder, Tahoua and Tillabéri.
- The capital, Niamey, along with other major cities, exhibited lower vulnerability scores.
- A notable north-to-south gradient in vulnerability was identified, with urban areas generally less vulnerable compared to rural areas.
- Lack of critical infrastructure, such as access to clean drinking water and electricity, emerged as significant contributors to vulnerability.
- Socioeconomic indicators, particularly night light intensity, were strongly correlated with vulnerability levels.
- Urban centres and mining cities, particularly in the Agadez region, showed lower vulnerability due to better infrastructure and economic opportunities.

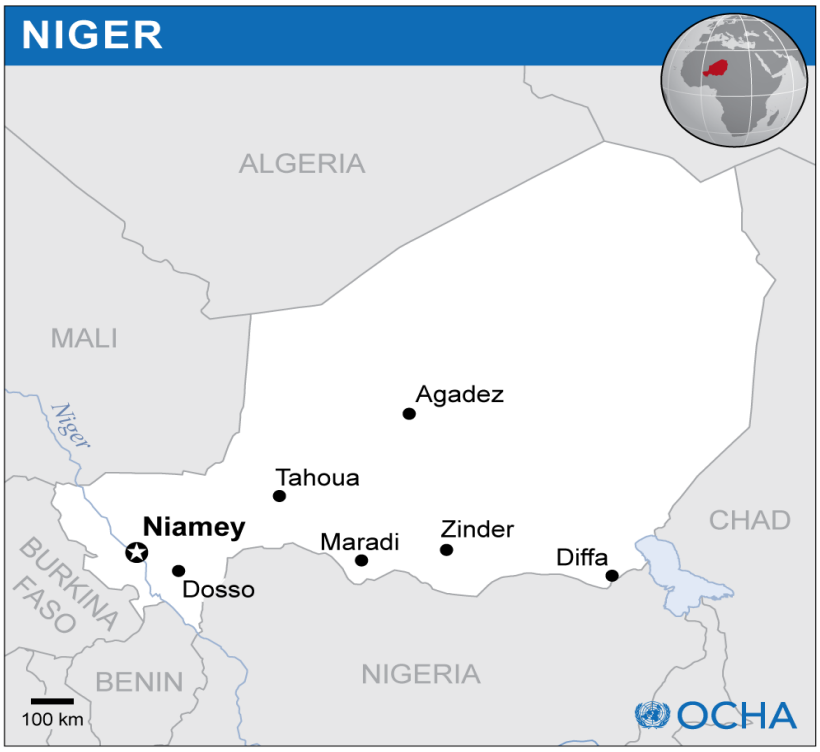
Overall, the DSVI Niger report provides a detailed and scientifically robust framework for understanding and addressing social vulnerability in Niger, contributing valuable insights for the development of effective and targeted policies aimed at reducing vulnerability and enhancing resilience in the country.

Introduction

The Digital Social Vulnerability Index (DSVI) Niger is a collaboration between the Istanbul Centre for Private Sector in Development (ICPSD) SDG AI Lab and the UNDP Niger Accelerator Lab. This report summarizes the key takeaways from the DSVI study conducted for Niger in 2023. It first introduces the core concepts of social vulnerability analysis and the approach invented by SDG AI Lab. It then outlines the main vulnerability challenges and overall humanitarian situation in Niger. Next, the data and methods used to calculate and predict high-resolution vulnerability are explained. Lastly, all relevant results are presented, and research questions discussed to better understand the outcomes of the DSVI Niger.

Social vulnerability

Social vulnerability is the multifactor capacity of groups and individuals to cope with shocks and stresses based on their positions within the physical and social worlds.[1] Social vulnerability helps assess and quantify the relationship between the shock- or disaster-related fragilities of vulnerable populations and their ability to cope with the associated risks.[2] Insights derived from social vulnerability analyses will increase the capacities of a society to build long-term resilience. Social vulnerability analysis must consider the potential causes of vulnerability and the abilities of individuals and communities to anticipate, respond to and recover from crises.



Map Sources: ESRI, UNCS.
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Map created in Nov 2011.

Figure 1: Map of Niger

[1] Kirstin Dow, "Exploring differences in our common future(s): The meaning of vulnerability to global environmental change", *Geoforum*, vol. 23, No. 3 (1992), pp. 417–436.
[2] Susan L. Cutter, Bryan J. Boruff and W. Lynn Shirley, "Social vulnerability to environmental hazards", *Social Science Quarterly*, vol. 84, No. 2 (2003), pp. 242–261.

Background to the DSVI

The DSVI is a vulnerability assessment product consisting of high-resolution vulnerability maps, technical data and knowledge products. The DSVI combines geographic information systems, artificial intelligence and machine learning technologies to build interactive high-resolution maps visualizing vulnerabilities. The DSVI can calculate and visualize populations' vulnerability to different stressors such as famines or droughts, socioeconomic shocks, natural disasters and climate change–related effects.

Objectives of the DSVI Niger

The objectives of the DSVI Niger were to use high-quality socioeconomic and geographic data sets to calculate nationwide social vulnerability estimates. These scores are then used to inform national stakeholders and partners to support policymaking decisions and be aware of the most vulnerable communities in the country.

Research questions

There were three core research questions that the DSVI Niger tried to answer:

1. What are the most and the least vulnerable communities in Niger?
2. What are the drivers of vulnerability in Niger?
3. How does the DSVI compare with other vulnerability indicators?

Overview of Niger

Niger has ranked among the countries with the lowest Human Development Index for the last decade, reflecting significant challenges in areas such as education, healthcare and income levels.[3] The country suffers from high poverty rates, limited access to basic services, and food insecurity. The United Nations Office for the Coordination of Humanitarian Affairs' 2023 Humanitarian Response Plan is targeting 2.7 million people with life-saving humanitarian assistance,[4] and according to the World Bank, more than 48 percent of the population were living in extreme poverty in 2023.[5] The country has highly vulnerable populations to different kinds of shocks, and the country's risk portfolio includes diverse elements: natural hazards and climate change impacts like droughts, floods and landslides; public health concerns; and security-related issues.[6] Therefore, identifying (the needs of) the vulnerable population is of critical importance for resource allocation and informed decision-making processes.

[3] UNDP, "Human Development Index", *Human Development Reports*. Available at: https://hdr.undp.org/data-center/human-development-index.
[4] Office for the Coordination of Humanitarian Affairs (OCHA), "Niger Humanitarian Response Plan 2023", *Financial Tracking Service*. Available at: https://fts.unocha.org/plans/1145/summary.
[5] World Bank, "The World Bank in Niger: Overview", *World Bank Group*. Available at: https://worldbank.org/en/country/niger/overview.
[6] Global Facility for Disaster Reduction and Recovery (GFDRR), *Disaster risk profile: Niger* (GFDRR, 2019); United Nations Office for Disaster Risk Reduction (UNISDR) Regional Office for Africa, *Policy coherence between disaster risk reduction and climate change adaptation: Case study—Niger* (UNISDR, 2022); World Food Programme (WFP), *WFP Niger country brief, March 2023* (WFP, 2023).

Data and methodology

The DSVI follows a rigorous workflow to obtain its results. It relies on high-quality surveys, up-to-date geographical data, and a scientific methodology for social vulnerability calculation. Furthermore, DSVI relies on several technologies such as geographic information systems and machine learning to work at a high level of precision and to achieve the best results. The workflow steps are shown in Figure 2.

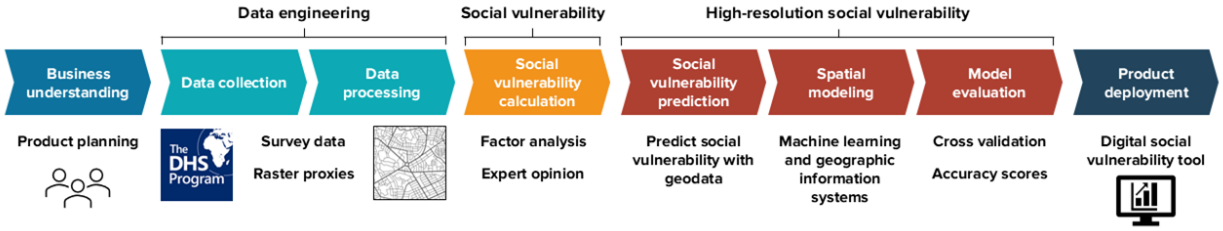


Figure 2: Flowchart of Digital Social Vulnerability Index workflow[1]

[1] DHS = Demographic Household Survey

The DSVI uses three different types of data:

1) **Survey data**, high-quality data with socioeconomic dimensions of vulnerability.[7] Additional survey/census data from other sources can be used if it contains geolocations.[8]
2) **Spatial data**, which can be used to predict social vulnerability for areas without survey coverage.
3) **Domain knowledge** to identify the composition of variables, indicators and other influencing factors relevant to Niger's specific circumstances.

Survey data

Social vulnerability was calculated using Demographic and Household Survey (DHS) data.[9] The data sets contain hundreds of variables covering dimensions of income, employment status, access to infrastructure, health, violence, gender equality, race, age and more. These variables are collected from thousands of individuals and standardized into statistical representative samples. The DHS data used comes with geolocations to individually determine the specific survey locations and thus enable us to explore certain regional dimensions of vulnerabilities. SDG AI Lab obtained national 2021 Malaria Indicator Survey and 2012 Standard DHS survey data sets to calculate social vulnerability for Niger. Table 1 summarizes the commonly found and used indicators derived from DHS surveys for social vulnerability calculations.

[7] This must be geotagged, suitable survey data available for Niger or a region of it.
[8] Geolocations are precisely defined locations of surveys taken, e.g. with latitude and longitude.
[9] Demographic Household Survey Program, https://dhsprogram.com.

Table 1: Overview of indicator groups from DHS surveys

Social	Health	Economy	Infrastructure	Malaria
Age	Health insurance	Working environment	Travel times to water/health	Mosquito nets and their use
Gender	Tuberculosis	Unemployment	Internet access	Treatment against malaria
Ethnicity	Vaccinations	Child labour	Building materials	Diagnostic blood tests
Migration	Disability	Access to banking	Transportation	Awareness of malaria and methods to reduce risk
Household size	Malaria		Urban/rural	
Literacy	Sexually transmitted diseases		Cooking fuel	

Spatial data

We collect and create high-quality spatial data to find spatial connections between them and the already-calculated social vulnerability scores. These variables can be biophysical, such as 'Elevation above sea level', or socioeconomic, such as 'Distance to healthcare' or 'Conflict fatalities'. The latter variable is shown in Figure 3 as an example of geodata used for social vulnerability prediction.

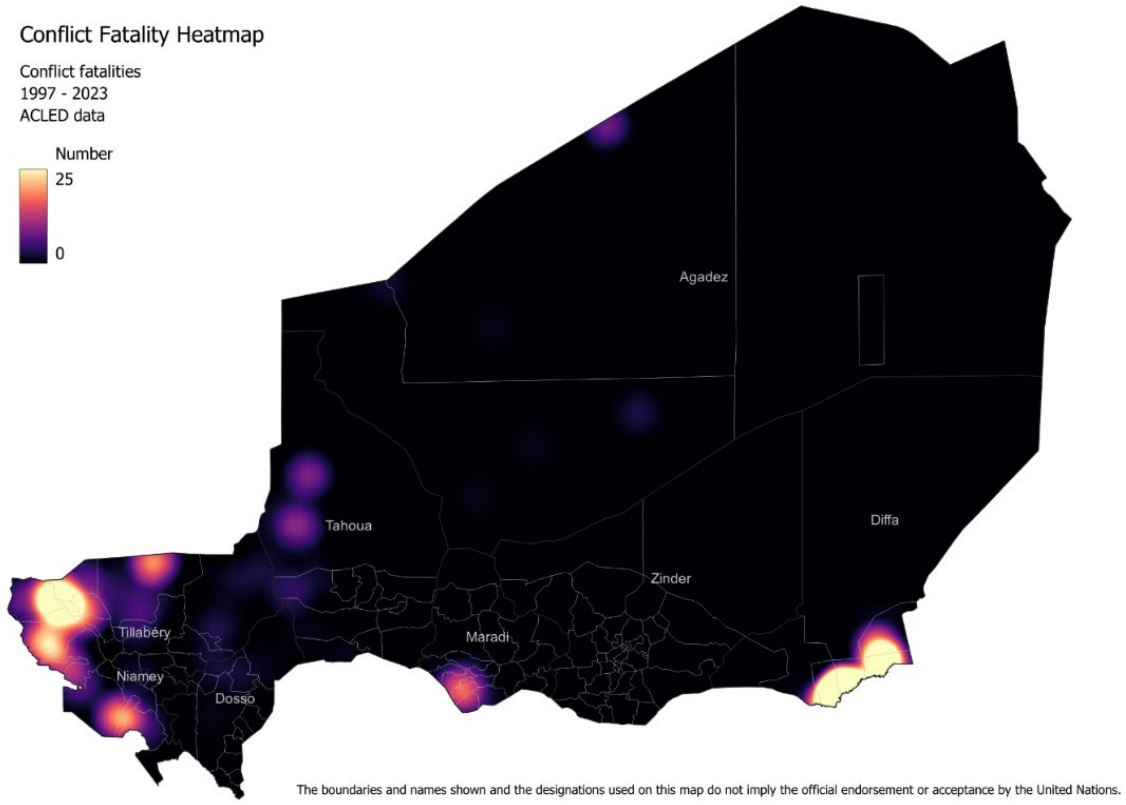


Figure 3: Example of geodata set used, from Armed Conflict Location and Event Data (ACLED), https://acleddata.com

All data sets available to SDG AI Lab were converted into a format that can be used by machine learning algorithms to make predictions of how social vulnerability is distributed in Niger. A full overview of the data sets used is given in Table 2.

Table 2: Overview of geodata sets used

Group	Variable	Calculated	Year
Socioeconomic	Night light Intensity	Raw data	2022
Socioeconomic	Proximity to healthcare	Derived	2022
Socioeconomic	Proximity to education	Derived	2022
Socioeconomic	Proximity to main road	Derived	2022
Socioeconomic	Population density	Raw data	2020
Socioeconomic	Conflicts	Raw data	2000–2023
Socioeconomic	Relative wealth	Derived	2021
Socioeconomic	Cell tower density	Derived	2022
Biophysical	Temperature	Raw data	2018
Biophysical	Precipitation	Raw data	2022
Biophysical	Vegetation indices	Raw data	2022
Biophysical	Elevation	Raw data	-

Domain knowledge

Social vulnerability is a contextual metric that requires expert input for weighting. For every country studied, domain knowledge of the specific circumstances must be considered. For instance, the influence of humanitarian indicators such as the average age of household heads or gender-related indicators can be interpreted in different ways and thus lead to different conclusions for a region or Niger.

Social vulnerability calculation

The calculation of social vulnerability follows a detailed process that involves careful data preprocessing, inspection and principal component analysis (PCA). PCA reduces the number of dimensions in large data sets to principal components that retain most of the original information. It does this by transforming potentially correlated variables into a smaller set of variables, called principal components.[10] SDG AI Lab adapted and further developed the scientific methods applied in social vulnerability analysis for the purpose of the DSVI.[11] For this study, the lab calculated scores for a total of 207 locations in Niger (see Figure 4).

The calculation methods developed by the lab follow this structure:

1) Collection and preprocessing of survey data
2) Longlisting of potentially relevant vulnerability indicators
3) Shortlisting of indicators with feedback from country offices and experts
4) PCA on remaining indicators

[10] IBM, "What is principal component analysis (PCA)?", *IBM*. Available at https://ibm.com/topics/principal-component-analysis.
[11] Sovi-validity, https://github.com/geoss/sovi-validity.

5) Discussions with experts on indicator influences and component meanings
6) Summation of components into single vulnerability score

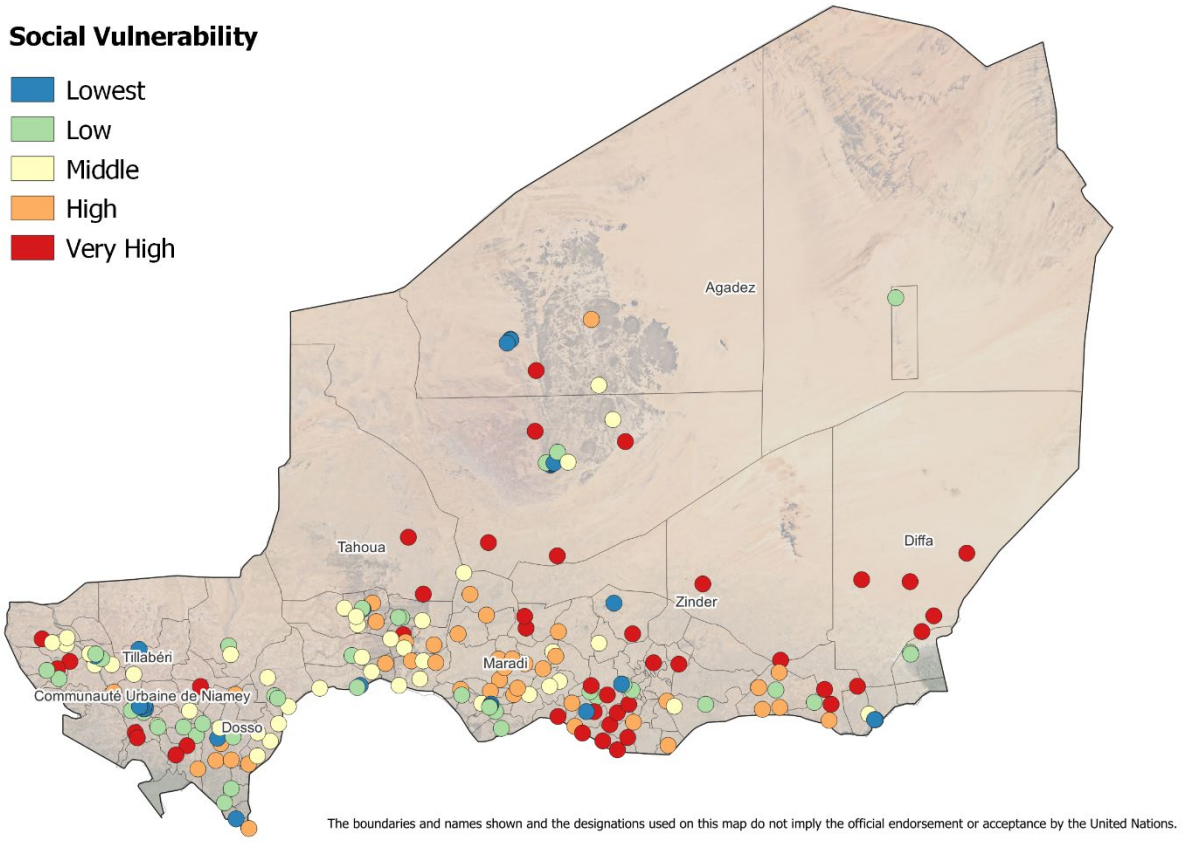


Figure 4: Social vulnerability per interview cluster, 2021

High-resolution social vulnerability maps

A core component of the DSVI is high-resolution mapping to show social vulnerability as intensity maps. The creation process involves the previously calculated social vulnerability scores that exist as points on a map and the geodata sets mentioned in the data section of this report. The data sets are then combined into one and fed into machine learning models to learn the potential linkages between vulnerability and the existing biophysical and socioeconomic realities on the ground.

Figure 5 illustrates the process of combining social vulnerability points (left) with geodata (centre) and the resulting high-resolution map (right) for a given country.

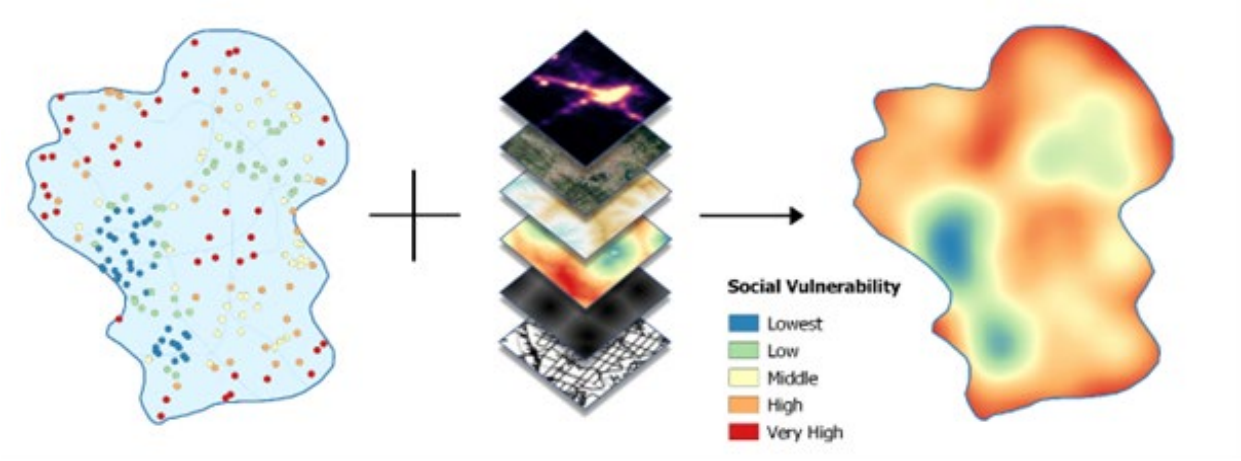


Figure 5: Social vulnerability prediction with gridded geodata (country outlines illustrative)

Modelling

The lab tested several machine learning models to assess their individual performance and the strengths of their predictions. Twelve different geodata sets, each representing biophysical or socioeconomic realities in Niger, have been used to predict social vulnerability.

Results

The main outputs of the DSVI are produced as maps, tables and in text form. The lab first calculated social vulnerability for Niger. The resulting point clouds are visible in Figure 4; they show the number, distribution and also the vulnerability class of each survey cluster.

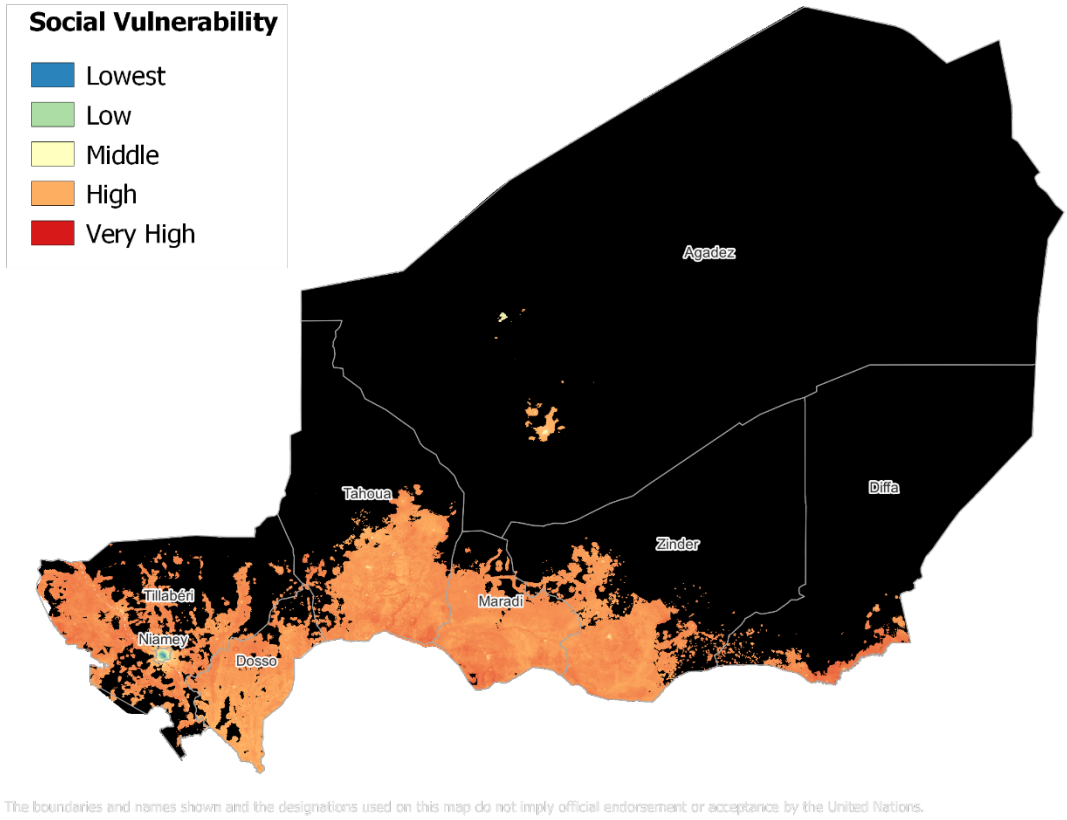


Figure 6: Social vulnerability prediction with only populated areas

Figure 6 shows social vulnerability as a heatmap for the whole country of Niger. Level 1 administrative boundaries were used to delineate the largest political areas of the country. Large proportions of the country have relatively high or very high vulnerability scores. Much of the rest is masked in black because of its low population density. Parts of Diffa, Maradi, Zinder, Tahoua and Tillabéri experience high to very high levels of vulnerability. The least vulnerable areas are in the mining region of Agadez and the capital of Niamey.

Where are the most and the least vulnerable communities in Niger?

The map in Figure 7 shows an aggregated view of social vulnerability in all departments of Niger. The least and most vulnerable communes are summarized in Tables 3 and 4. Vulnerability in Niger follows a general north-to-south gradient. The capital Niamey scores lowest on the vulnerability benchmark. This is also true for most larger cities of the country.

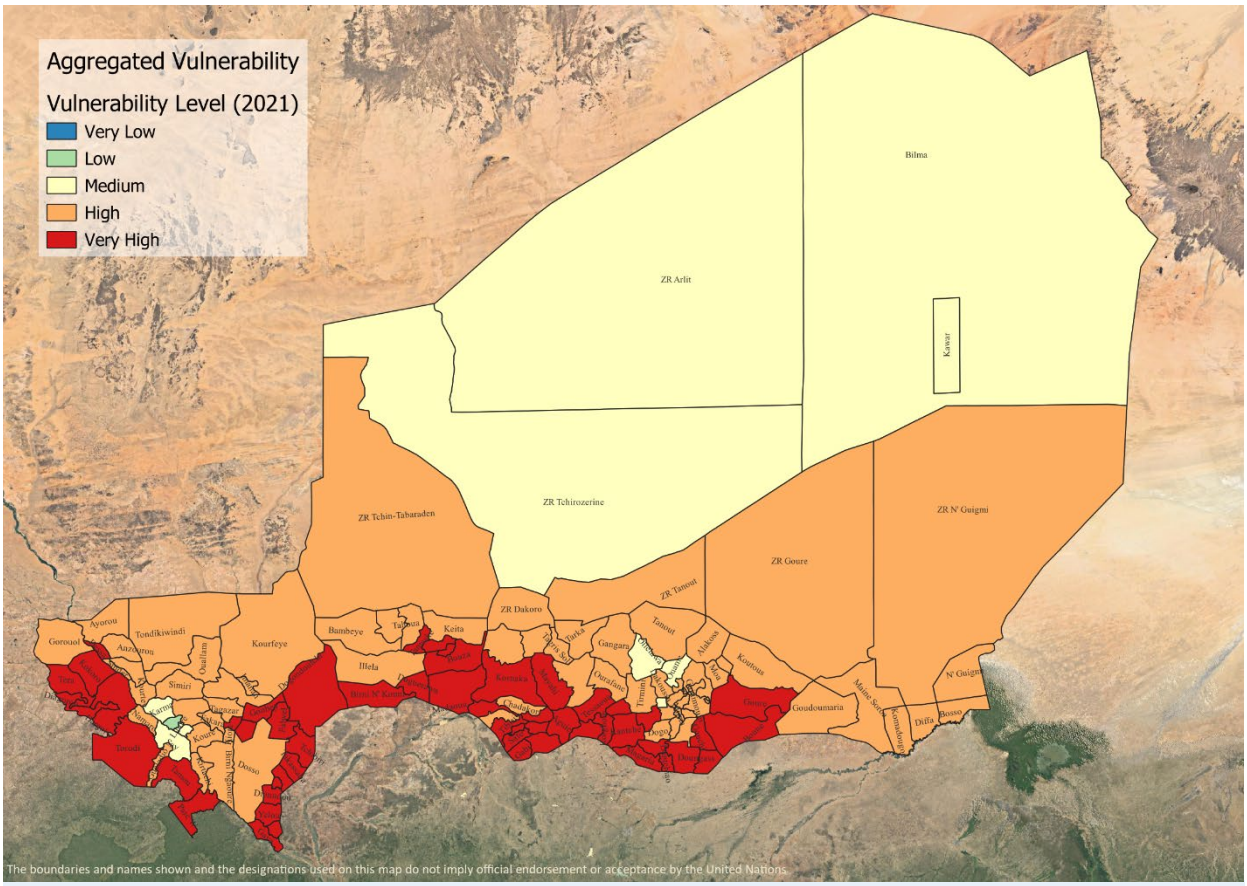


Figure 7: Aggregated social vulnerabilities for departments in Niger (2021)

Table 3: The least vulnerable communes in Niger

Rank	Commune	Department	Region	UN population estimate	Vulnerability score	Vulnerability class
1	Lamorde	Niamey	Niamey	1,194,351	0.288	Low
2	Libre	Kollo	Tillabery	145,194	0.468	Medium
3	N'Dounga	Kollo	Tillabery	48,243	0.539	Medium
4	Zinder	Mirriah	Zinder	412,741	0.559	Medium
5	Karma	Kollo	Tillabery	130,887	0.573	Medium
6	Say	Say	Tillabery	173,001	0.579	Medium
7	ZR Arlit	Arlit	Agadez	177,027	0.58	Medium
8	Bilma	Bilma	Agadez	16,941	0.581	Medium
9	Kawar	Bilma	Agadez	1,808	0.589	Medium
10	ZR Tchirozerine	Tchirozerine	Agadez	482,202	0.593	Medium

According to Table 3, over 2.7 million people in Niger appear to live under conditions of low or medium vulnerability. This is approximately 11 percent of the total population of 25 million. However, vulnerability scores grow quickly once the two least vulnerable communes, Lamorde (Niamey) and Libre (Kollo), are discounted from the analysis.

Table 4: The most vulnerable communes in Niger

Rank	Commune	Department	Region	UN population estimate	Vulnerability score	Vulnerability class
1	Mallaoua	Magaria	Zinder	71,193	0.652	High
2	Korghom	Tessaoua	Maradi	198,429	0.650	High
3	Gangara	Aguie	Maradi	266,808	0.650	High
4	Parc W	Say	Tillabery	56,713	0.647	High
5	Gabi	Madarounfa	Maradi	110,777	0.647	High
6	Dantchiao	Magaria	Zinder	99,821	0.645	High
7	Doguerawa	Bkonni	Tahoua	279,632	0.645	High
8	Safo	Madarounfa	Maradi	80,946	0.643	High
9	Gaya	Gaya	Dosso	203,176	0.641	High
10	Magaria	Magaria	Zinder	603,381	0.641	High

Table 4 offers a focused view on the most vulnerable communes in Niger. These communes are home to almost 2 million people. The vulnerability values for each commune were summed up and averaged across the total number of available pixels. Most of the most vulnerable communes in Niger are rural and located in the south of the country, near the borders with Nigeria and Benin.

What are the drivers of vulnerability in Niger?

Table 5 shows the drivers of vulnerability in Niger according to our available methods. First, we looked at what PCA analysis returned as highly loaded and with high explanatory power. Second, we looked at the results from the machine learning predictions using several geodata sets. The geodata modelling results are ranked according to their specific strength.

Table 5: Indicator influence on vulnerability

Source of insight	Component used	Rank	Strong variables
Principal component analysis and domain knowledge	Component 1 with high loading	No rank	Main floor material
		No rank	Education in single years
		No rank	Has bank account
		No rank	Frequency of watching television
		No rank	Household has refrigerator
Extra trees regressor Impact ranked from high to low		1	Night light intensity
		2	Population density
		3	Relative wealth
		4	Temperature
		5	Road density
		6	Distance to education
		7	Plant bioactivity
		8	Rainfall

The most important PCA ranked variables are of the strongest component 1. This component explains more than 40 percent of the total variance of the data included. Both of the PCAs returned similar insights to which variables were important for the social vulnerability analysis as a whole. The results show that indicators related to 'Ownership' and 'Infrastructure', but also 'Education level', seem to influence the score significantly.

How does the DSVI compare with other development and vulnerability indicators?

DSVI results were developed to show the intensity of vulnerability and the position of vulnerable people in Niger.

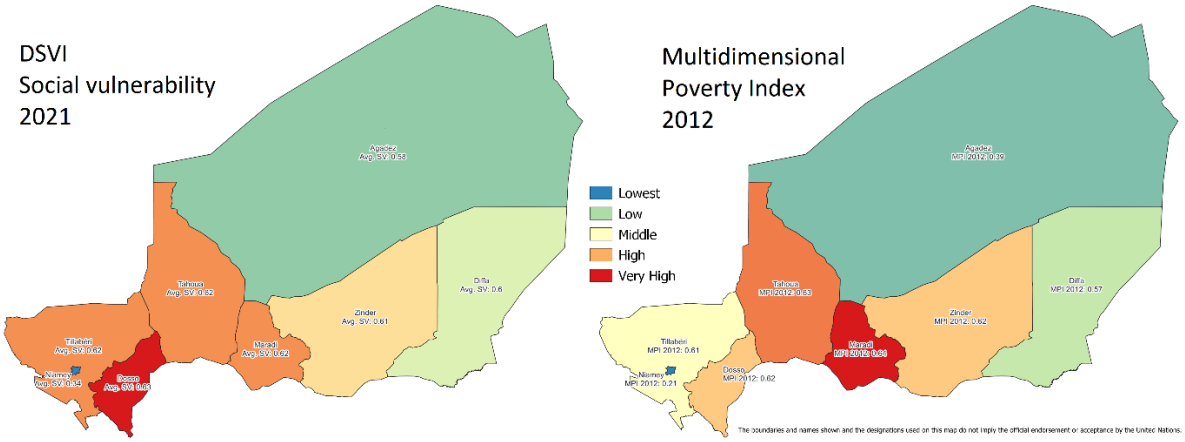


Figure 8: Comparison of Digital Social Vulnerability Index (DSVI) map (left) and Multidimensional Poverty Index map (right)

Figure 8 shows a side-by-side comparison of DSVI vulnerability scores for 2021 and Multidimensional Poverty Index[12] scores resulting from the 2012 DHS data. The global Multidimensional Poverty Index[13] was created using the multidimensional measurement method of Alkire and Foster.[14] Following their methodology, the index is calculated by multiplying the 'incidence' of poverty and the average 'intensity' of poverty. More specifically, incidence is the proportion of the population that is multidimensionally poor, while intensity is the average proportion of dimensions in which poor people are deprived.[15] Based on both maps, the most vulnerable and poor regions of Niger are Tillabéri, Dosso, Tahoua, Maradi and Zinder. Comparing different development indicators helps validate and strengthen the suggested trends in those indicators.

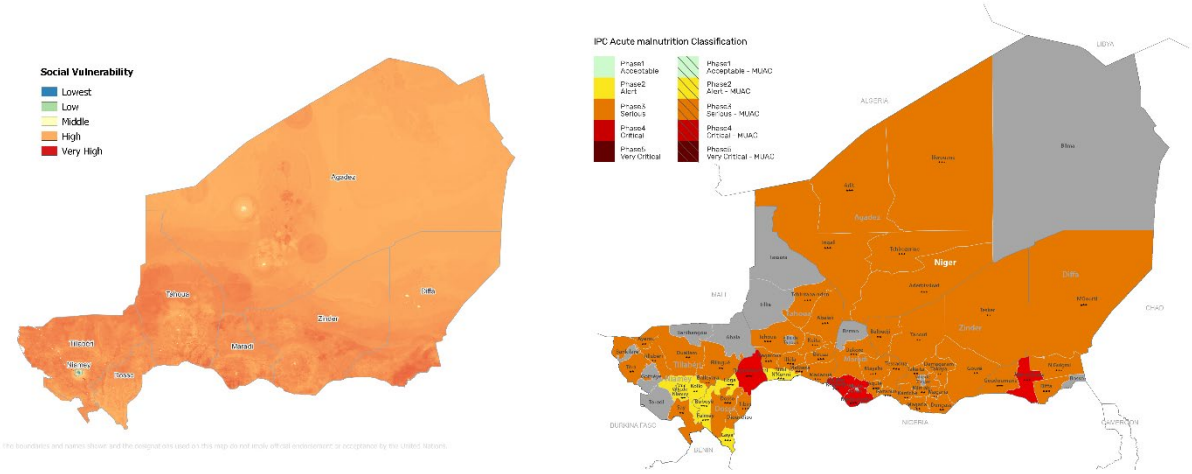


Figure 9: Comparison of Digital Social Vulnerability Index map (left) and Integrated Food Security Phase Classification (IPC) acute malnutrition map (right)

[12] UNDP, *2023 Global Multidimensional Poverty Index (MPI)* (UNDP, 2023).
[13] Oxford Poverty and Human Development Initiative, "What is the global MPI?", *OPHI*. Available at: https://ophi.org.uk/what-global-mpi.
[14] Sabina Alkire et al., "The Alkire-Foster counting methodology", in *Multidimensional Poverty Measurement and Analysis,* Sabina Alkire et al., eds. (Oxford, Oxford University Press, 2015).
[15] Sabina Alkire, Usha Kanagaratnam and Nicolai Suppa, "A methodological note on the global Multidimensional Poverty Index (MPI) 2023 changes over time results for 84 countries", *OPHI MPI Methodological Note*, No. 57 (OPHI, July 2023). Available at: https://ophi.org.uk/sites/default/files/2024-03/OPHI_MPI_MN57_2023.pdf.

Figure 9 compares the high-resolution DSVI map created with 2021 data with a malnutrition map published by the Integrated Food Security Phase Classification (IPC) in March 2023. This IPC acute malnutrition analysis of Niger estimated that throughout 2023, nearly 1.9 million children aged 6–59 months would likely be acutely malnourished.[16] Acute malnutrition can be one dimension of vulnerability. The SDG AI Lab's vulnerability maps mostly agree with the patterns while giving more detail at the sub-district level.

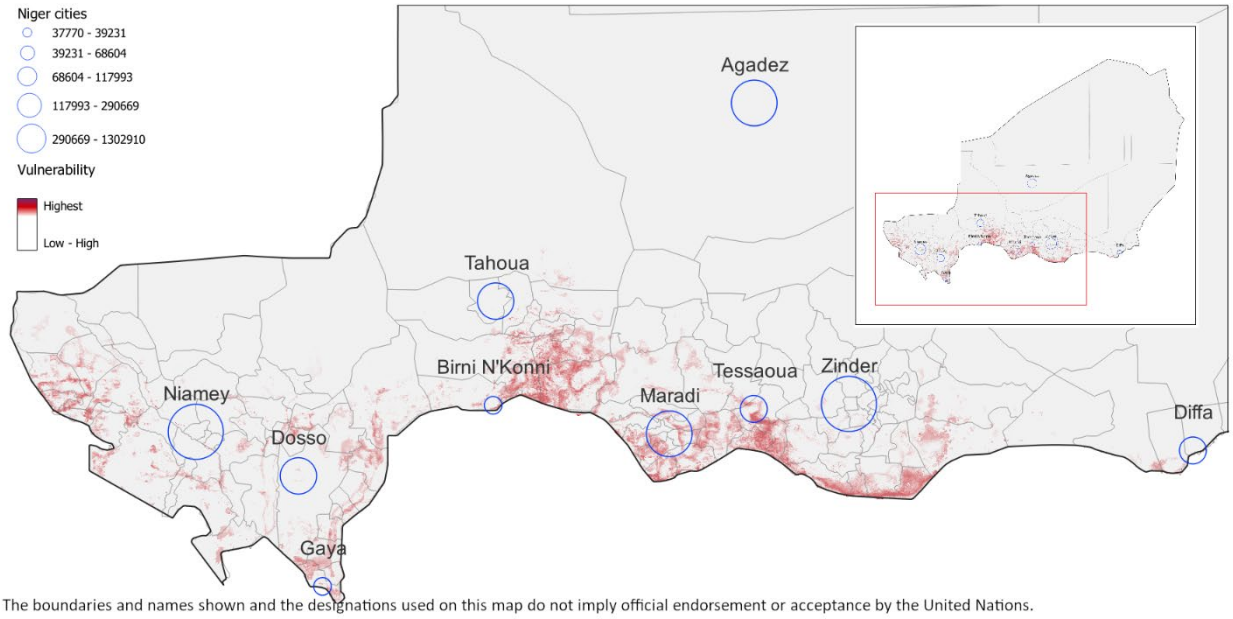


Figure 10: Close-up regional view of the most vulnerable areas in Niger

Figure 10 shows vulnerable populations on a close-up map of the south of Niger. These regions are specifically important because they have both relatively high population numbers and high vulnerability scores. The DSVI Niger study identified these regions as the highest priority areas for vulnerability reduction and intervention.

[16] Integrated Food Security Phase Classification (IPC), *Niger: IPC Acute Malnutrition Snapshot January–December 2023* (IPC, 6 March 2023). Available at: https://reliefweb.int/report/niger/niger-ipc-acute-malnutrition-snapshot-january-december-2023.

Conclusions

This report has summarized the main findings of the DSVI and attempted to answer the research questions. The results indicate that social vulnerability analysis with the methods deployed can complement and strengthen existing knowledge, but also provide new insights into vulnerabilities in Niger. First, the vulnerability scores calculated in this project were based on scientific and accepted methods. The process was also assisted by regional experts to increase the region-specific sensitivity of the scores. The high-resolution maps were then compared and overlaid with data sets depicting various thematic elements regarding the poverty and development dimensions in the country. Our social vulnerability scores were not only able to confirm and reinforce several spatial patterns observed in those maps, but also to point to new areas.

Based on our findings, urban areas are less vulnerable than rural areas. These effects increase in intensity with growing distance to those centres. The mining cities in Agadez are also comparatively better off, which skews the vulnerability for this northern region to be lower than expected. This may be true for the cities, but for the less densely populated areas in the rest of the region, vulnerability may still be a major issue. By studying the indicator results from PCA, the main drivers of vulnerability are the lack of critical assets and infrastructure, such as easy access to clean drinking water and electricity.

As an additional source of information, the regression model's variable importance rankings were examined, with similar results. Rather than demographic drivers, the core impact on vulnerability was achieved by socioeconomic indicators, such as night light intensity. This leads to the notion that households that are better equipped with critical assets and connections to electric grids or water supplies have better chances to cope with shocks.

The results of this report provide a general overview of the social vulnerabilities in the country and offer new insights into them. The quality and scope of the predictions are limited by the data that was available to study them. To enhance the quality of such studies, it is recommended to further invest in primary data collection activities in countries such as Niger, so that future policies can be targeted to the identified vulnerable population groups more effectively. Studies like the DSVI can help to overcome some of those data limitations and help to better understand the potential reasons for vulnerability and the location of vulnerable groups in the country, while keeping the time and resources needed at a minimum.

Annex: Full list of considered vulnerability indicators

Has gas/electric stove	Respondent's **current age**	**Household has car/truck**
Has improved stove	Highest educational level	Main floor material
Has air conditioner	Source of drinking water	Main wall material
Has access to Internet	Type of toilet facility	Main roof material
Has tractor	Household has electricity	Education in single years
Owns a mobile telephone	Household has radio	Educational attainment
Has motorized seeder	Household has television	Sex of household head
Has tricycle motorcycle	Household has refrigerator	Age of household head
Has moped/bike	Household has bicycle	Literacy
Has motor pump	Household has motorcycle/scooter	Frequency of reading newspaper
Have mosquito bednet for sleeping	Has mosquito bednet for sleeping	Owns cows/bulls
Are there ways to avoid getting malaria	Used mobile phone for financial transactions	Owns horses/donkeys/mules
Ever attended school	Has watch	Owns goats
Number of births 2016–2021	Has animal-drawn cart	Owns sheep
Know a child that benefited child protective services (CPS) treatment	Has boat with a motor	Owns chickens/poultry
Number of household members	Has a computer	Owns camels
Number of *de facto* members	Owns land usable for agriculture	Owns ducks
Type of place of residence	Owns livestock, herds or farm animals	Owns rabbits
Native language of respondent	Owns cattle	Has bank account
Number of rooms used for sleeping	Person slept under a long-lasting insecticidal net (LLIN)	Number of mosquito bednets
Sons who have died	Use of Internet	Frequency of listening to radio
Daughters who have died	Frequency of using Internet last month	Frequency of watching television
Births in last five years	Wealth index combined	Type of cooking fuel