Findings Report

DSVI Burkina Faso

Digital Social Vulnerability Index 2023, Burkina Faso

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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

This report presents the findings of the Digital Social Vulnerability Index (DSVI) Burkina Faso study, a collaborative effort between the Istanbul Centre for Private Sector in Development (ICPSD) SDG AI Lab and the UNDP Burkina Faso Accelerator Lab, aimed at assessing social vulnerability across the country using advanced technologies such as geographic information systems, artificial intelligence and machine learning. The study's primary objectives were to identify the most and least vulnerable communities, understand the drivers of vulnerability, and compare DSVI results with other vulnerability indicators to support policymaking. 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 DSVI project used a rigorous methodology to calculate high-resolution social vulnerability scores. The process involved:

- Collection and preprocessing of high-quality survey and geographical data
- Long- and shortlisting of relevant vulnerability indicators with expert feedback
- Principal component analysis to derive core components influencing vulnerability
- Creation of high-resolution maps showing social vulnerability intensity across 504 locations, representing about 8,000 villages in Burkina Faso

The analysis revealed several insights:

- **Urban versus rural:** Urban areas, particularly Ouagadougou and Bobo-Dioulasso, are less vulnerable compared to rural areas. Vulnerability increases with distance from these urban centres.
- **Key drivers:** The main drivers of vulnerability were identified as lack of critical infrastructure (clean water and electricity) and low socioeconomic factors (night light intensity, an indicator of economic activity).
- **High-risk areas:** Regions such as Sahel, Est and Nord exhibit high to very high vulnerability levels. These areas may benefit from targeted interventions for vulnerability reduction.

The DSVI Burkina Faso 2023 successfully demonstrated the utility of combining advanced technological tools for detailed vulnerability mapping. The insights gained can significantly aid national stakeholders in making informed decisions and effectively targeting resources to the most vulnerable populations, ultimately contributing to increased resilience and better socioeconomic outcomes for Burkina Faso.

Introduction

The Digital Social Vulnerability Index (DSVI) Burkina Faso is a collaboration between the Istanbul Centre for Private Sector in Development (ICPSD) SDG AI Lab and the UNDP Burkina Faso Accelerator Lab. This report summarizes the key takeaways from the DSVI study conducted for Burkina Faso 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 Burkina Faso. 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 Burkina Faso.

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.

Figure 1: Map of Burkina Faso

[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 Burkina Faso

The objectives of the DSVI Burkina Faso 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 Burkina Faso tried to answer:

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

Overview of Burkina Faso

Burkina Faso has recently ranked among the countries with the lowest Human Development Index, reflecting significant challenges in areas such as education, healthcare and income levels.[3] More than 3.5 million people, or roughly 20 percent of the population, are food insecure, and the World Bank estimates that 40.1 percent of the population remain below the poverty line.[4] In the last two years Burkina Faso has faced multiple challenges, including the COVID-19 pandemic and political instability. This has worsened the already challenging context of growing climate crises, malaria outbreaks, forced displacement and ongoing armed conflicts. Thus, with reducing donor aid, it is crucial to target the most vulnerable and allocate resources in an effective manner. However, worsening conflict, pandemics and millions of displaced people make it almost impossible to collect and analyse the data. Therefore, identifying (the needs of) the vulnerable population is of critical importance for resource allocation and informed decision-making processes. However, the data collection, processing and analysis require a significant budget and fieldwork. Considering the challenges mentioned, time restrictions and budget limitations, an alternative approach to vulnerability assessment and mapping is required.

[3] UNDP, "Human Development Index", *Human Development Reports*. Available at: https://hdr.undp.org/data-center/human-development-index.
[4] USAID, "Burkina Faso: Agriculture and Food Security", *USAID*. Available at: https://usaid.gov/burkina-faso/agriculture-and-food-security.

Data and methodology

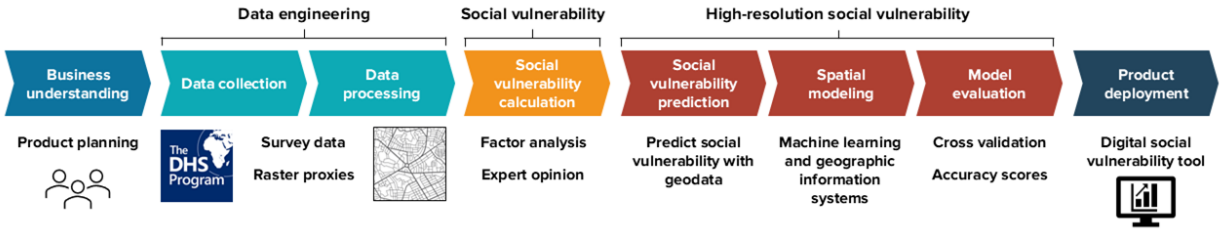


Figure 2: Flowchart of Digital Social Vulnerability Index workflow[1]

[1] DHS = Demographic Household Survey

The DSVI uses three different types of data:

1) **Survey data**, high-quality data with socioeconomic dimensions of vulnerability.[5] Additional survey/census data from other sources can be used if it contains geolocations.[6]
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 Burkina Faso's specific circumstances.

Survey data

Social vulnerability was calculated using Demographic and Household Survey (DHS) data.[7] 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 nationwide 2012 Standard, 2017 Malaria Indicator Survey and the newest 2021 Standard DHS survey data sets to calculate social vulnerability for Burkina Faso. Table 1 summarizes the commonly found and used indicators derived from DHS surveys for social vulnerability calculations.

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
Migration	Vaccinations	Child labour	Building materials	Diagnostic blood tests
Household size	Disability	Access to banking	Transportation	Awareness of malaria and methods to reduce risk
Literacy	Malaria		Urban/rural	
	Sexually transmitted diseases		Cooking fuel	

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

Spatial data

Figures 3 and 4 show examples of geodata used for social vulnerability prediction. 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 Burkina Faso. 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	2023
Socioeconomic	Proximity to healthcare	Derived	2023
Socioeconomic	Proximity to education	Derived	2023
Socioeconomic	Proximity to main road	Derived	2023
Socioeconomic	Population density	Raw data	2020
Socioeconomic	Relative wealth	Raw data	2021
Socioeconomic	Cell tower density	Derived	2023
Biophysical	Temperature	Raw data	2023
Biophysical	Precipitation	Raw data	2023
Biophysical	Vegetation indices	Raw data	2023
Biophysical	Elevation	Raw data	-

Figure 3: Geodata on night light intensity in Burkina Faso

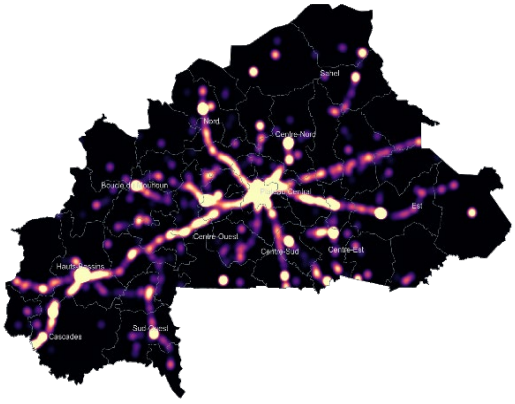


Figure 4: Geodata on cell tower density in Burkina Faso

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 Burkina Faso.

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.[8] SDG AI Lab adapted and further developed the scientific methods applied in social vulnerability analysis for the purpose of the DSVI.[9] For this study, the lab calculated scores for a total of 504 locations in Burkina Faso (see Figure 5). These locations are a representative sample for the situation in approximately 8,000 villages scattered across 351 municipalities, 45 provinces and 13 regions.

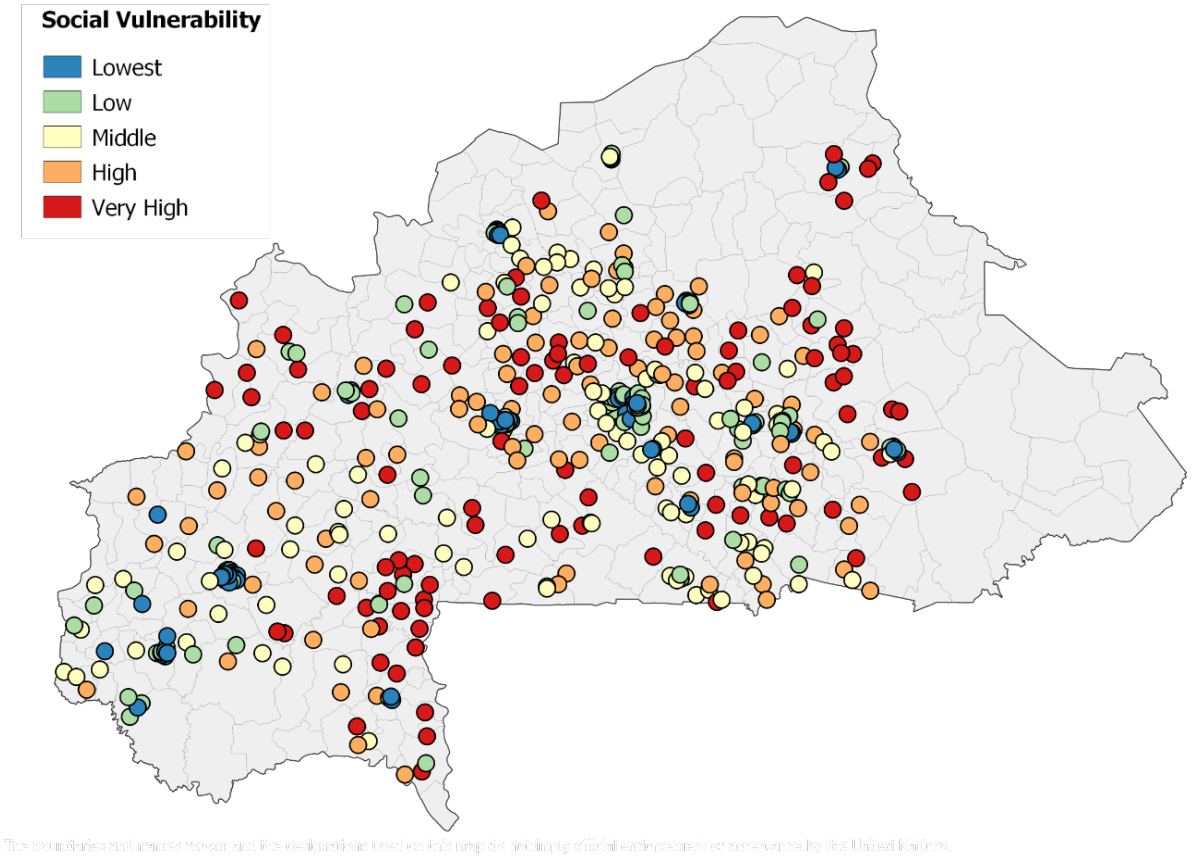


Figure 5: Social vulnerability per interview cluster, 2021

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

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

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

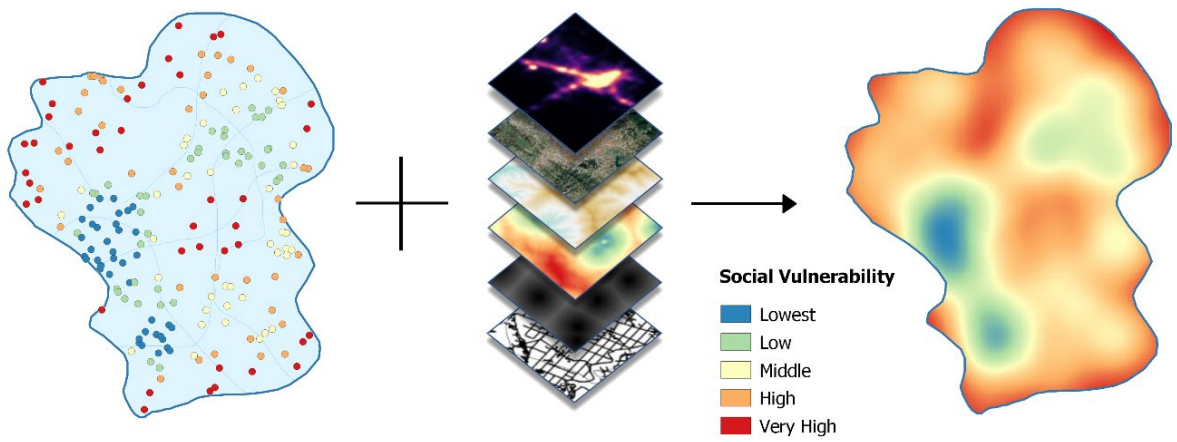


Figure 6: Social vulnerability prediction with gridded geodata (country outlines illustrative)

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 Burkina Faso, 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 Burkina Faso. The resulting point clouds are visible in Figure 5; they show the number, distribution and also the vulnerability class of each survey cluster.

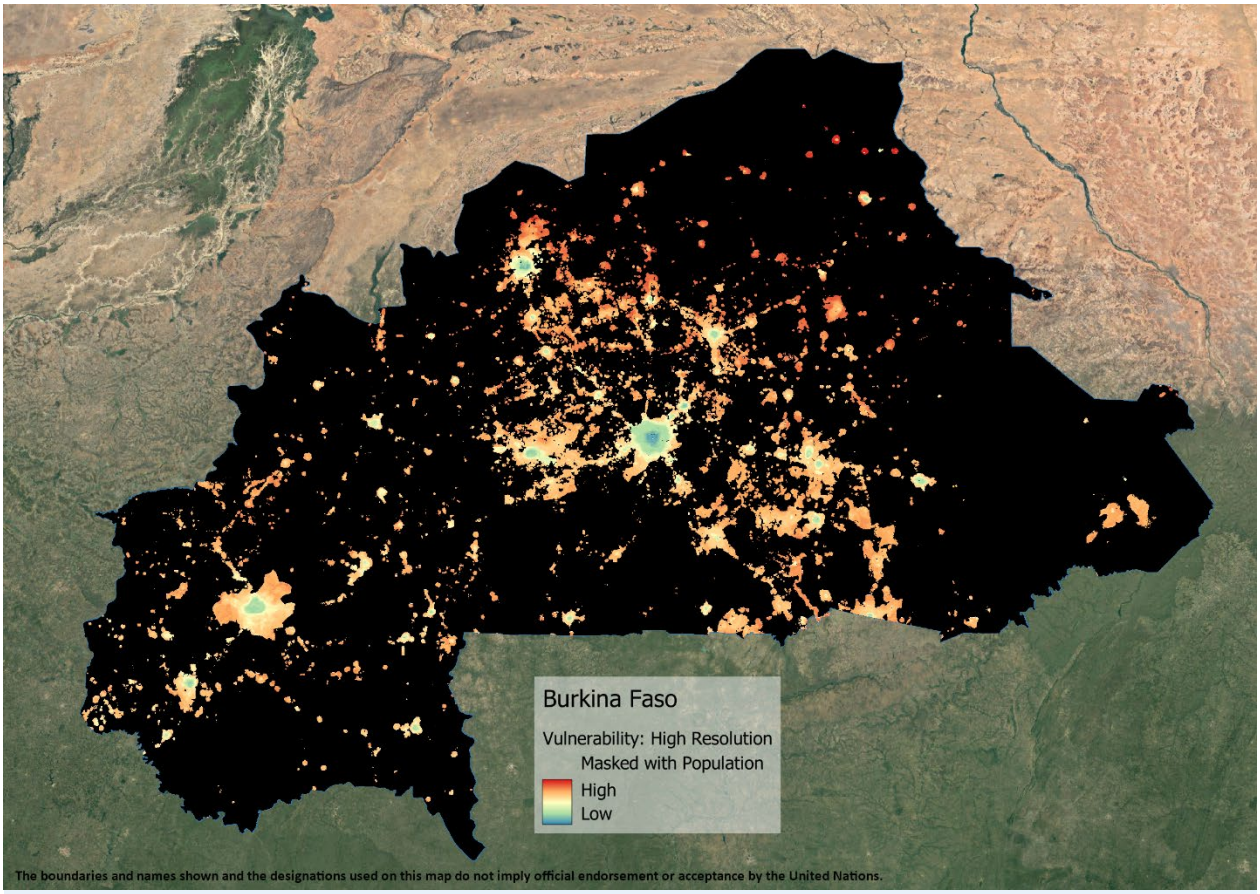


Figure 7: Social vulnerability prediction with only populated areas

Figure 7 shows social vulnerability as a heatmap for the whole country of Burkina Faso. Large portions 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 Sahel, Est and Nord regions experience high to very high levels of vulnerability. It is noticeable that with growing distance from urban centres, vulnerability also grows. Also, drier and hotter climate seems to strongly influence the well-being of certain population groups in a negative way. The least vulnerable areas are the nation's capital, Ouagadougou, and the large urban centres of Bobo-Dioulasso and Ouahigouya.

Where are the most and the least vulnerable communities in Burkina Faso?

The map in Figure 8 shows an aggregated view of social vulnerability for all 45 provinces in Burkina Faso. Vulnerability follows a general southwest-to-northeast gradient in the country. The capital Ouagadougou scores lowest on the vulnerability benchmark, while the provinces in the north score highest. The seven provinces next to the capital experience lower vulnerability compared to other provinces surrounding them.

Table 3 summarizes the 10 least vulnerable provinces in Burkina Faso and reports their corresponding population numbers.

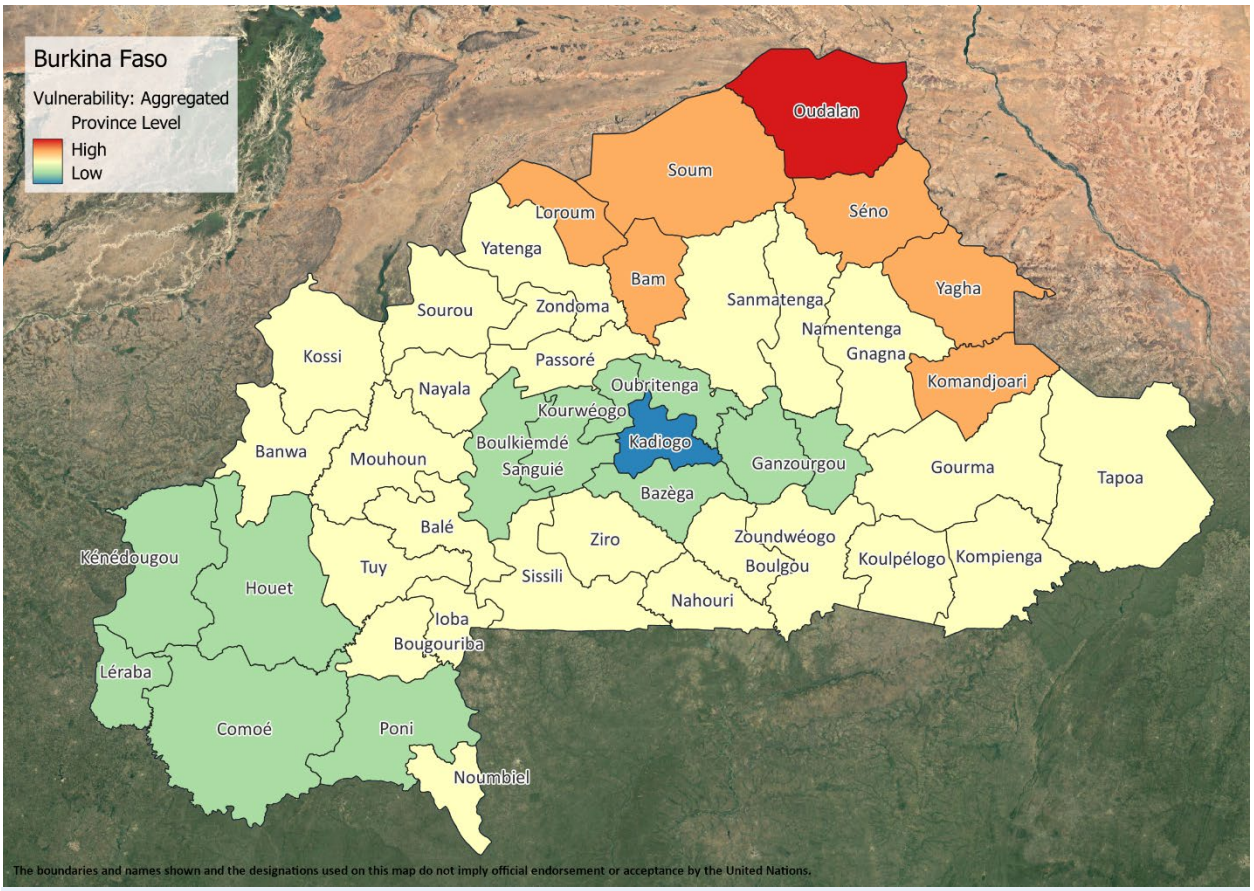


Figure 8: Social vulnerability aggregated to province level

Table 3: The least vulnerable provinces in Burkina Faso

Rank	Province	Region	UN population estimate	Vulnerability score	Vulnerability class
1	Kadiogo	Centre	4,219,252	0.555	Medium
2	Boulkiemde	Centre-Ouest	679,672	0.716	High
3	Passore	Nord	413,196	0.727	High
4	Leraba	Cascades	189,622	0.727	High
5	Houet	Haut-Bassins	1,615,893	0.732	High
6	Poni	Sud-Ouest	401,440	0.735	High

7	Kouritenga	Centre-Est	492,784	0.736	High
8	Comoe	Cascades	949,725	0.737	High
9	Bazega	Centre-Sud	281,279	0.740	High
10	Ioba	Sud-Ouest	201,942	0.743	High

According to Table 3, over 4.2 million people in Burkina Faso appear to live under conditions of medium vulnerability. This is approximately 20 percent of the total population of 22 million. However, vulnerability scores grow quickly once the single province of Kadiogo (Ouagadougou) is discounted from the analysis. The other provinces listed in Table 3 are already in the high vulnerability class. The largest population numbers affected by this level of vulnerability are in the regions of Centre-Ouest, Haut-Bassins and Cascades. Over 3 million people are affected by medium to high levels of vulnerability in those regions.

Table 4 shows all 13 regions of Burkina Faso and their average social vulnerability scores, based on the calculations carried out by SDG AI Lab using 2022 DHS survey data. Most of the regions experience high or very high vulnerability, with the only exception being Centre with the capital city Ouagadougou. The most vulnerable regions are Centre-Nord, Est and Sahel.

Table 4: The 13 regions of Burkina Faso and their average vulnerability scores

Region	Vulnerability score	Vulnerability class
Boucle du Mouhoun	0.794	High
Cascades	0.736	High
Centre	0.561	Medium
Centre-Est	0.773	High
Centre-Nord	0.801	Very high
Centre-Ouest	0.753	High
Centre-Sud	0.755	High
Est	0.818	Very high
Hauts-Bassins	0.743	High
Nord	0.770	High
Plateau Central	0.761	High
Sahel	0.862	Very high
Sud-Ouest	0.741	High

Photo: A person walks on a dirt road in a rural area of Burkina Faso (UNDP asset image library)

Table 5: The most vulnerable provinces in Burkina Faso

Rank	Province	Region	UN population estimate	Vulnerability score	Vulnerability class
1	Oudalan	Sahel	326,806	0.868	Highest
2	Soum	Sahel	523,294	0.859	Very high
3	Seno	Sahel	391,681	0.857	Very high
4	Yagha	Sahel	251,271	0.858	Very high
5	Komandjoari	Est	150,098	0.838	Very high
6	Loroum	Nord	197,811	0.829	Very high
7	Kompienga	Est	195,148	0.826	Very high
8	Tapoa	Est	581,741	0.814	Very high
9	Bazega	Centre-Sud	281,279	0.740	High
10	Ioba	Sud-Ouest	201,942	0.743	High

Table 5 offers a focused view on the most vulnerable provinces in Burkina Faso. These provinces are home to more than 3 million people. The vulnerability values for each province were summed up and averaged across the total number of available pixels. Most of the most vulnerable provinces in Burkina Faso are rural and located in the north of the country, near the border with Mali in the north, or near the borders with Benin and Togo in the east and southeast.

What are the drivers of vulnerability in Burkina Faso?

Table 6 shows the drivers of vulnerability in Burkina Faso according to our available methods. First, we looked at what PCA 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.

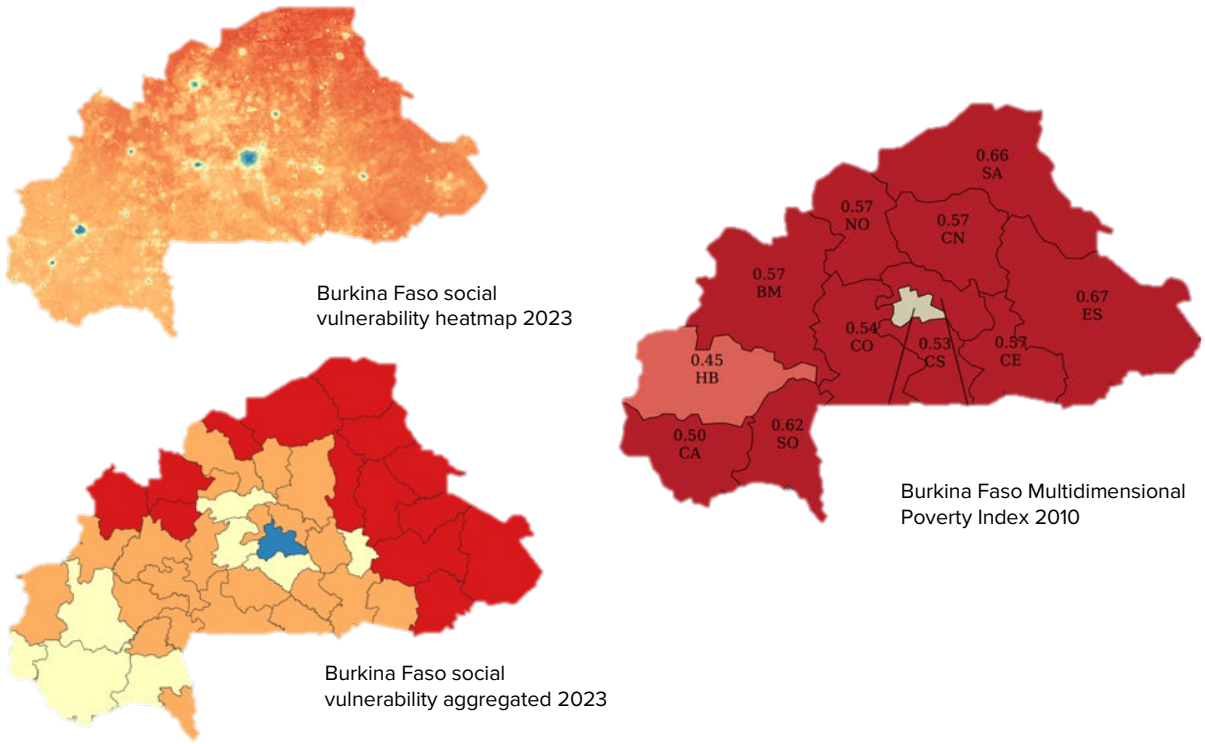
Table 6: Indicator influence on vulnerability

Source of insight	Component used	Rank	Strong variables
Principal component analysis and domain knowledge	Component 1 with high loading	No rank	Type of cooking fuel
		No rank	Source of drinking water
		No rank	Owns land usable for agriculture
		No rank	Has electricity
		No rank	Has a computer
Extra trees regressor Impact ranked from high to low		1	Night light intensity
		2	Road network
		3	Relative wealth
		4	Population density
		5	Cell tower density
		6	Distance to education
		7	Temperature
		8	Plant health

Table 6 first shows the PCA ranked variables of the strongest component 1. This component explains more than 40 percent of the total variance of the data included. Both the PCA and the modelling results show that similar variables were considered important for the social vulnerability analysis. The results show that indicators related to 'Access to basic goods and services' were of high importance in the explanation of total variance in the data. Next, 'Ownership' and 'Infrastructure', but also 'Education level', seem to influence the score significantly. Based on the geodata used, this suggests that the influence of economic indicators is strongest, followed to a lesser degree by biophysical ones.

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 Burkina Faso.

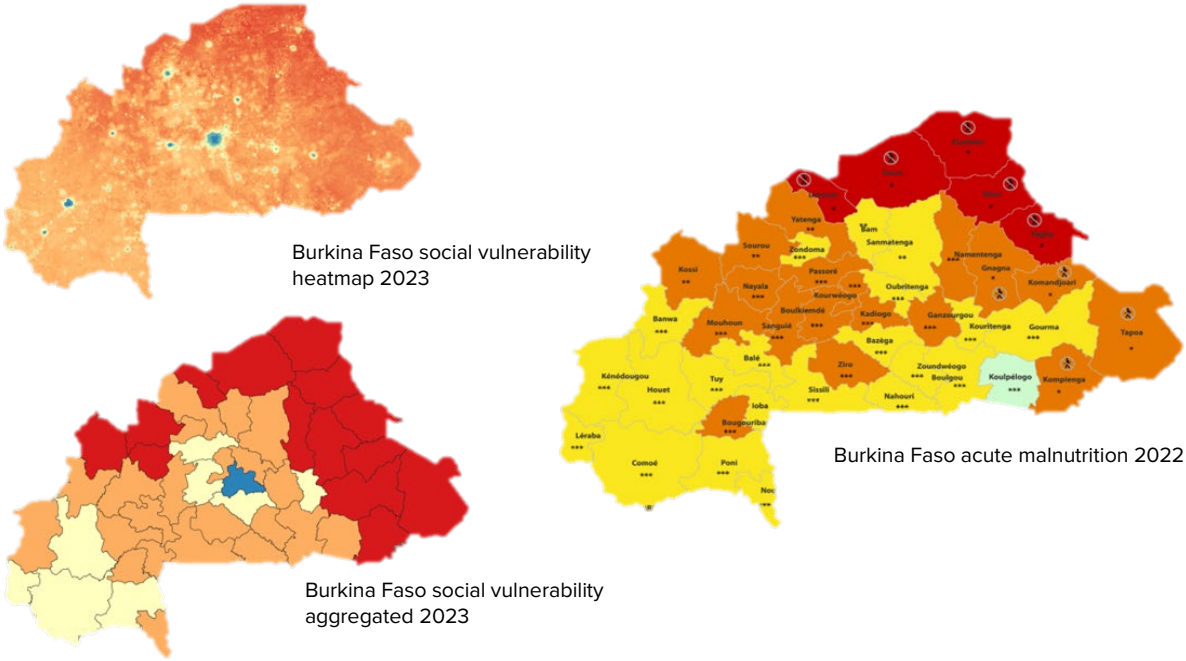


The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 9: Comparison of Digital Social Vulnerability Index maps (left) and Multidimensional Poverty Index map (right)

Figure 9 shows a side-by-side comparison of DSVI vulnerability scores for values in 2021 (heatmaps are based on geodata from 2023) and the Multidimensional Poverty Index[10] scores resulting from a 2010 DHS study. The global Multidimensional Poverty Index[11] was created using the multidimensional measurement method of Alkire and Foster.[12] 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.[13] Based on all three maps in Figure 9, the most vulnerable and poorest regions of Burkina Faso are Sahel, Est, Nord, Central-Nord, Central-Est and Sud-Ouest. Comparing different development indicators helps validate and strengthen the suggested trends in those indicators.

[10] UNDP, *2023 Global Multidimensional Poverty Index (MPI)* (UNDP, 2023).
[11] Oxford Poverty and Human Development Initiative, "What is the global MPI?", *OPHI*. Available at: https://ophi.org.uk/what-global-mpi.
[12] 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).
[13] 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.

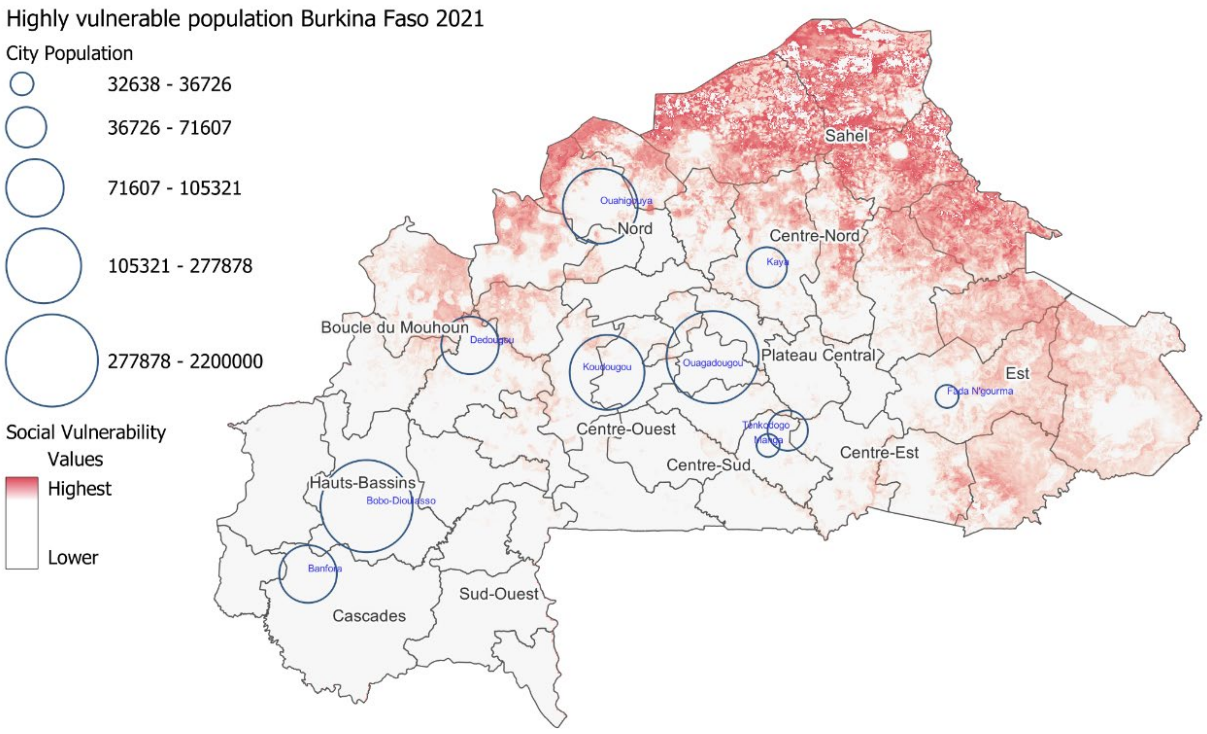


The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 10: Comparison of Digital Social Vulnerability Index maps (left) and acute malnutrition map (right)

Figure 10 compares the high-resolution and aggregated DSVI maps for values in 2021 (heatmaps are based on geodata from 2023) with a malnutrition map created by the Integrated Food Security Phase Classification (IPC) in January 2023. In this IPC acute malnutrition analysis of the country, of the 45 provinces of Burkina Faso, 31 provinces were analysed, with the rest not analysed due to lack of recent data because of limited or no humanitarian access in these areas. In total, it was estimated that nearly 400,000 children under the age of five would likely suffer from acute malnutrition between August 2022 and July 2023. Of these, nearly a quarter were expected to experience severe acute malnutrition. [14] The DSVI high-resolution and aggregated maps align well with the malnutrition map produced by the IPC. Both maps agree on vulnerabilities concentrated on the border regions of the north and east.

[14] Integrated Food Security Phase Classification (IPC), *Burkina Faso: Acute malnutrition analysis August 2022–July 2023* (IPC, 17 January 2023). Available at: https://reliefweb.int/report/burkina-faso/burkina-faso-acute-malnutrition-analysis-august-2022-july-2023-published-january-17-2023.



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 11: Country-wide overview of vulnerable regions in Burkina Faso

Figure 11 shows the most vulnerable populations in Burkina Faso. The DSVI Burkina Faso study identified these as the highest priority areas for vulnerability reduction and intervention.

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 Burkina Faso. 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. 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 models' 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 Burkina Faso, 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