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A GIS-Based Analysis of Residents' Displacement in Khartoum Due to the War (April 2023–June 2025)

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ABSTRACT :

This study uses Geographic Information Systems (GIS)-based analysis to look at the war-related displacement of Khartoum people from April 2023 to June 2025. The paper examines internal displacement flows within Sudan and cross-border refugee movements. ArcGIS 10.8 was used for data processing and analysis. From internal displacement data for the White Nile, Gezira, River Nile, Northern, Kassala, and Blue Nile states to external displacement data for Chad, South Sudan, Egypt, Ethiopia, and the Central African Republic (IOM, 2025; UNHCR, 2025; OCHA, 2024), internal and external displacement flow charts were obtained from Khartoum. The study concluded that the highest internal flow was to White Nile State, and the lowest flow was to Northern State; the highest external flow was to Chad, and the lowest flow was to Libya.

Keywords: Khartoum conflict, geographic information system, internal displacement flow lines, external displacement flow lines.

Abbreviations:

ACLED	Armed Conflict Location & Event Data Project	IOM	International Organization for Migration
DTM	Displacement Tracking Matrix	OCHA	United Nations Office for the Coordination of Humanitarian Affairs
GIS	Geographic Information System	CBS	Central Bureau of Statistics
IDP	Internally Displaced Person	WFP	World Food Program

1. Introduction

One of the worst humanitarian catastrophes in Sudan's recent history is the war that broke out in Khartoum in April 2023. Millions of people were forced to leave their homes as a result of widespread violence that centered on the capital, which serves as the political, cultural, and economic hub (OCHA, 2024). The conflict damaged livelihoods, disrupted vital services, and demolished urban infrastructure. In addition to being a humanitarian problem, displacement also became a socioeconomic and environmental problem that altered patterns of settlement in Sudan and elsewhere. A strong foundation for recording and evaluating such crises is provided by GIS (ACLED, 2024; IOM, 2025). By spatially representing displacement flows and refugee movements, this study seeks to provide a picture of the impact of war on human mobility.

1.1 Research Problem

Despite the magnitude of displacement from Khartoum, most available research remains descriptive and humanitarian-focused. There is a lack of spatially explicit, GIS-based studies that integrate humanitarian data with geographic analysis. This gap limits policymakers' ability to design location-based interventions.

1.2 Research Objectives

Based on the lack of research examining the displacement of Khartoum State residents due to the conflict that broke out in April 2023, based on descriptive and spatial data, this paper was prepared to:

1. Study the internal displacement flows from Khartoum to other Sudanese states.
2. Analyze refugee movements from Khartoum to neighboring countries.

1.3 Previous Studies

Several studies have examined forced displacement in Sudan due to the conflict. This section reviews selected works from the most recent to the older contributions:

The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (2024) addressed humanitarian responses to Sudan's displacement crisis using rapid assessments. The study identified urgent needs but lacked spatial analysis.

The International Organization for Migration (IOM) Displacement Tracking Matrix (DTM) (2023–2025) produced detailed statistical tracking of displaced populations. The methodology focused on surveys and mobility tracking but did not apply GIS.

The United Nations High Commissioner for Refugees (UNHCR) (2023) documented cross-border refugee flows. While strong in data coverage, it provided limited geospatial representation.

The Armed Conflict Location & Event Data Project (ACLED) (2023) analyzed conflict event data across Sudan. It mapped violence events, but it didn't directly connect to the flows of people who had to leave their homes.

Pantuliano's (2005) earlier work on Darfur displacement offered qualitative insights into causes and impacts but lacked quantitative spatial analysis.

What is unique about this study is its reliance not only on the literature but also on descriptive and spatial data and the spatial analysis achieved using geographic information systems technology, which yielded clear results that can be understood even by non-specialists.

2. Methodology

The methodology of this study adopted the analysis of spatial and descriptive data together related to displacement from Khartoum State, internally and externally, due to the conflict, relying on the technology of geographic information systems using the ArcGIS 10.8 program, where the flow lines of internally and externally displaced persons were obtained.

2.1 Study Area

Situated at the intersection of Sub-Saharan Africa and the Middle East, the Republic of Sudan is the third-biggest country in Africa, with an area of 1,886,068 km² and extending as far east as the Red Sea. Its neighbors include Ethiopia, Eritrea, South Sudan, Egypt, Chad, the Central African Republic, and Libya. The White and Blue Niles converge in Khartoum, the capital of Sudan (Abd Elrahman and Ataalmanan, 2023).

One of Sudan's eighteen states is Khartoum State (Figure 1). It is the most populous state while having the lowest area (22,142 km²). It is home to Khartoum, the state capital and national capital of Sudan, as well as Omdurman, the country's second-largest city by population. State offices, governmental and non-governmental organizations, cultural institutions, and the main airport are all located in the capital city. The city is situated at the meeting point of the White and Blue Niles, where they merge to become the River Nile, in the center of Sudan (Abd Elrahman and Ataalmanan, 2022). The state lies between the latitudes 15° to 16°N and longitudes 31.5° to 34°E. It is surrounded by River Nile State in the north-east, in the north-west by the Northern State, in the east and southeast by the states of Kassala, Qadarif, Gezira and White Nile State, and in the west by North Kurdufan. Khartoum State is Sudan's most urbanized and politically significant region. With a pre-war population exceeding seven million, it has been the most affected by the conflict (Sudan CBS, 2023).

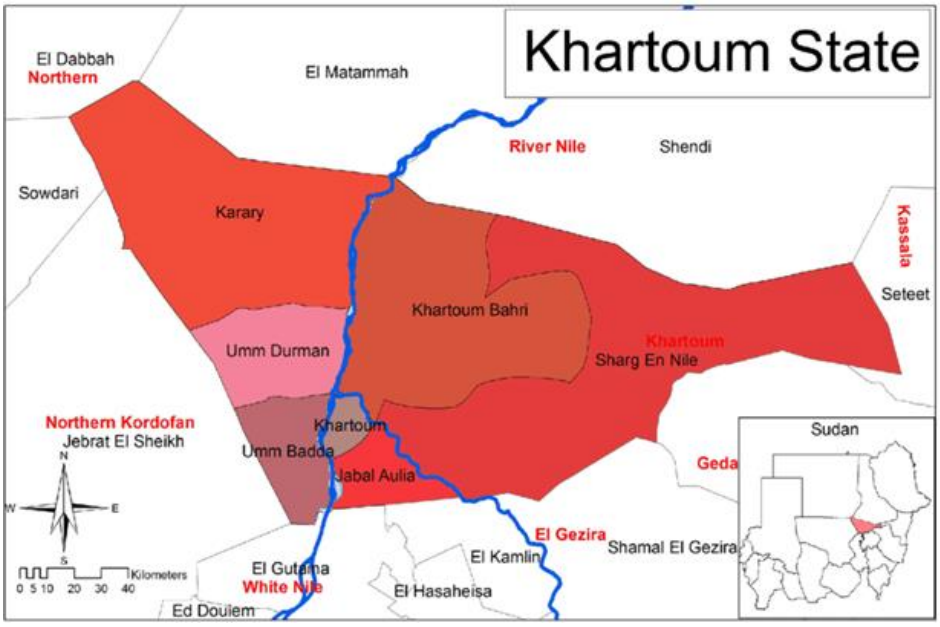

Figure 1: Study Area (Abd Elrahman and Ataalmanan, 2022)

2.2 Data and Software

This study relied on multiple secondary datasets, collected between April 2023 and June 2025 from International Organization for Migration, 2025; Displacement Tracking Matrix, 2025; United Nations Office for the Coordination of Humanitarian Affairs, 2024 and United Nations High Commissioner for Refugees Refugee Data Portal, 2025.

Table 1 shows the internal displacement data of Khartoum residents derived from the above sites, and Table 2 shows the external displacement data.

Table 1: Internal Displacement within Sudan (until June 2025)

State	Estimated IDPs	Source
White Nile	620000	IOM DTM 2025
Gezira	580000	IOM DTM 2025
River Nile	400000	OCHA 2024
Kassala	210000	OCHA 2024
Blue Nile	170000	IOM DTM 2025
Northern	150000	IOM / OCHA 2024

Table 2: Cross-Border Refugee Movements (until June 2025)

Destination Country	Estimated Refugees	Source
Chad	1200000	UNHCR 2025
South Sudan	950000	UNHCR 2025
Egypt	720000	UNHCR 2025
Ethiopia	210000	UNHCR 2025
Central African Republic	95000	UNHCR 2025
Libya	50000	UNHCR / OCHA 2024

2.3 Procedures

GIS-based spatial descriptive analysis was used to create the flow lines of internal and external displacement patterns. Data were imported into ArcGIS 10.8 for analysis.

Within the ArcGIS 10.8 program environment, the geographic coordinate system GCS_WGS_1984 was chosen because the analysis includes external countries.

In the program, a point shapefile of Khartoum state was created, which was used as a source point in internal and external displacement flow lines.

The Sudan states shapefile was created and was used as a basemap for analyzing internal displacement. From it, a point layer was obtained for the states to which people were displaced from Khartoum. Attributes data was added to this layer, and from it, a descriptive spatial analysis was conducted, from which flow lines for the displaced people were obtained.

The countries' shapefile was obtained from the Natural Earth site (Natural Earth, 2025), and from it, a polygon shapefile of the countries to which external displacement occurred was exported in the program. This was used as a basemap for external displacement. From the external displacement shapefile, a point layer was created for the countries of displacement, and displacement estimates data were then added to it. Based on this point layer, an external displacement analysis was conducted, and lines representing the flow of displaced persons were obtained.

3. Results, Analysis and Discussion

Within the ArcGIS 10.8 program environment, the GCS_WGS_1984 geographic coordinate system was configured, and three point shapefiles were created for Khartoum state, the states to which internal displacement occurred, and the countries to which external displacement occurred.

The attribute data obtained on war-related displacement, shown in Tables 1 and 2, were linked to the spatial data in the shapefiles mentioned above, thus creating geographic databases for both internal and external displacement.

A polygon shapefile was created for the states of Sudan and used as a basemap for the states in which internal displacement occurred, while a polygon shapefile was created for the countries to which external displacement occurred as a basemap.

The flow analysis was performed for internal and external displacement from Khartoum state, where flow lines were obtained with thickness proportional to the flow density, giving clear and understandable results even for non-experts. Internal displacement concentrated in White Nile and Gezira states (Figure 2), while international refugee flows were highest to Chad and South Sudan (Figure 3).

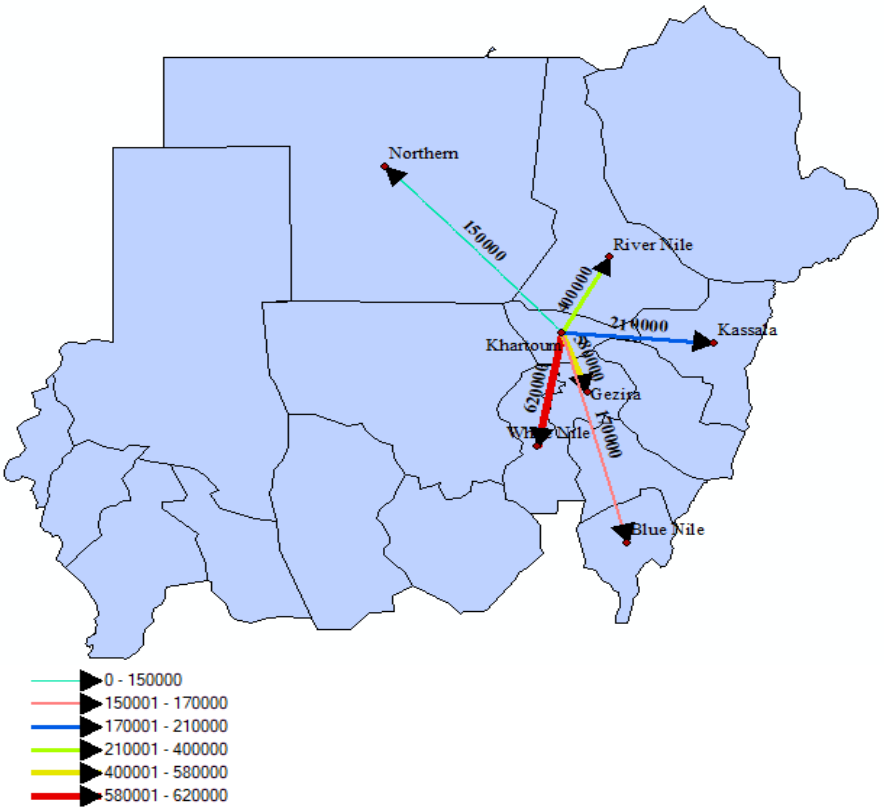

Figure 2: Internal Displacement Flows

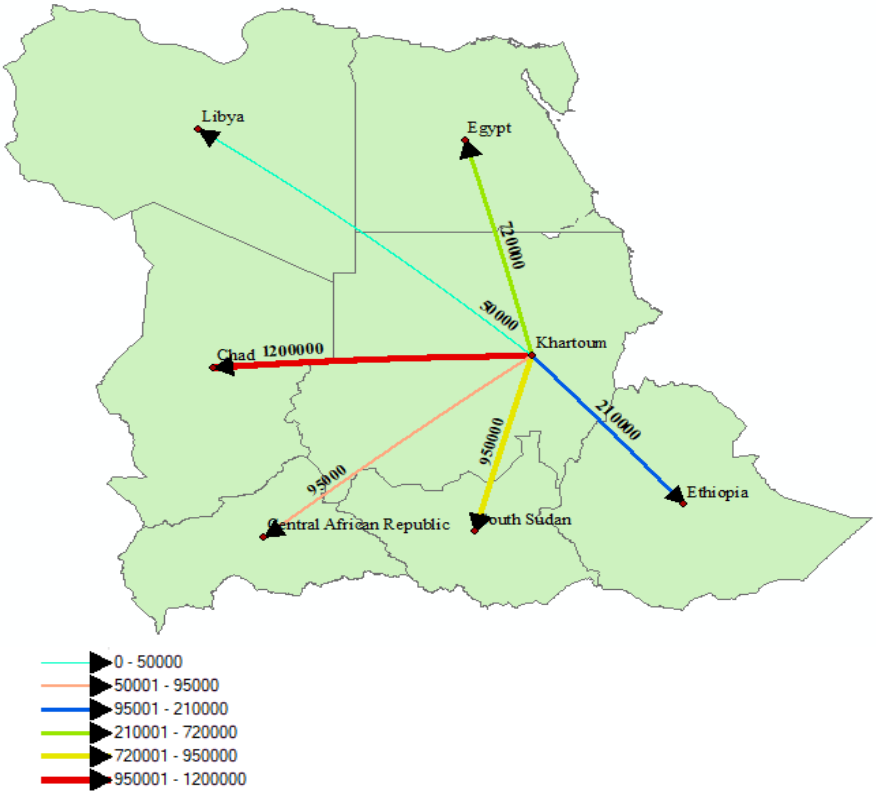

Figure 3: Refugee Cross-Border Flows

The displacement crisis in Khartoum demonstrates how conflict reshapes human geography. Internal flows followed patterns of accessibility and proximity to safer states, while cross-border movements reflected cultural ties and existing migration routes. GIS flows revealed spatial clusters of displacement that humanitarian agencies should prioritize (UNDP, 2024). Limitations of the study include reliance on secondary datasets and a lack of high-resolution temporal data.

4. Conclusion

This study demonstrates the utility of GIS in analyzing forced displacement resulting from war. Khartoum's war displaced millions internally and across borders. The highest rates of internal displacement were reported in the states of White Nile and Gazeera, while the highest rates of external displacement were observed in Chad and South Sudan. Therefore, we conclude that:

1. Strengthening support for host states (White Nile, Gezira).
2. Enhancing refugee assistance in Chad and South Sudan (which is consistent with reports of WFP, 2025; UNICEF, 2025).
3. Incorporating geographic information systems into humanitarian response planning.

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