

DEFINING A METHODOLOGY FOR INTEGRATING SEMANTIC, GEOSPATIAL, AND TEMPORAL TECHNIQUES FOR CONFLICT ANALYSIS

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ABSTRACT:

Globally, the absolute number of war deaths has been declining since 1946. And yet, conflict and violence are currently on the rise, with many conflicts today waged between non-state actors such as political militias, criminal, and international terrorist groups. Unresolved regional tensions, a breakdown in the rule of law, absent or co-opted state institutions, illicit economic gain, and the scarcity of resources exacerbated by climate change, have become dominant drivers of conflict (UN. A new era of conflicts, 2022). In the era of modern technology, data science, machine learning, and AI, the available shall be used to analyze, understand and possibly predict the possibility of conflicts outbreaks in various parts of the world. Moreover, it should provide tools for political scientists to a deeper understanding of political processes and enhance their decision-making processes. This paper focuses on applying data science techniques to process and analyze data in three various data analysis domains: Semantic, Geospatial, and Temporal Analysis. It provides the possible sources of the conflict and other datasets used for the analytics mentioned above. The data is used for research and experimental purposes only. These analytical processes provide the mechanisms to discover the historical data and identify the potential causes of the conflicts.

1. INTRODUCTION

According to the United Nations, the number of battle-related deaths has been on a significant decline since the end of the second world war (UN. A new era of conflicts, 2022). However, the number of armed or violent conflicts today remains to be on the rise. In 2016, more countries experienced violent conflict than at any time in nearly 30 years. Recent types of conflicts are happening less between states. Instead, many armed conflicts are happening between state and non-state armed actors or between non-state armed actors (Koldor, M., 2013). There are various types of violent conflicts that have taken place in different parts of the world.

In the current technological era, where the availability of big data and machine learning technology has made enormous progress in various fields, the application of data science for conflict analysis and political geography science has been used to a much lesser extent.

This research is not focusing on the political aspect of the conflicts and their classifications. Instead, it focuses on applying data science techniques to process and analyze data in three various data analysis domains: Semantic, Geospatial, and Temporal Analysis.

The semantical domain where natural language processing tools can provide an additional understanding of textual components of big conflict-related datasets. Thus, the abstract defines a methodology for integrating natural language processing technology and its application to structured and unstructured textual data classification and extraction.

The geospatial domain where conflicts data can be further analyzed using geospatial functions and further understood through overlaying other geospatial data such as socio-economic, population, land use, environment, and others.

The temporal analysis would lead to understanding where the conflicts have taken place and how the conflicts evolved during the time, whether the conflicts intensified over time or moved to another location. The process provides the mechanisms to discover the historical data and identify the potential causes of the conflicts.

The use case for this research is the selected Somalia dataset. In 1991 the functioning government in Somalia [government of Siyad Barre] was overthrown and civil war broke out, dividing the country into fiefdoms controlled by rival warlords (Basic Fact about the United Nations, 42nd edition, 2017). Followed by the international community intervention to monitor the ceasefire and assist in the delivery of humanitarian aid.

The Somalia dataset provides the deep temporal composition for the conflict dataset accounting for the records starting from January 1997 and provides the highest count of the conflict records in the ACLED (Armed Conflict Location and Event Data) database. ACLED is a conflict database that collects reported information on internal political conflicts disaggregated by date, location, and actor (Raleigh et al., 2010). Another dataset used in the process is GHSL. The GHSL (Global Human Settlement Layer) is a georeferenced layer that provides global coverage information on human settlements and populations. It is produced by elaborating on historical satellite images and data from open sources.

2. CASE STUDY CONTEXT

From the beginning of the Somali Civil war in 1978 to the present, hundreds of thousands of Somalis have lost their lives either directly or indirectly to the conflict. Millions have been displaced internally and externally, thus making the majority of the Somalis aid-dependent. After Siyad Barre [government] was

overthrown in 1991, most of the country's institutions, as well as law and order, were destroyed (Afyare Abdil Elmi, 2010).



Figure 1. Map of Somalia (UN Geospatial, 2020)

The civil war in Somalia severely affected the diversity of Somalis' cities. Having once been inclusive, they become dominated by certain clans, causing some groups to feel excluded from rights, resources, power, and political life. Continued impunity hampers state-building, especially efforts to build a functioning justice system or to tackle corruption. Impunity fosters grievances, including by benefiting dominant clans, which causes weaker clans to turn to Al-Shabab¹ and other armed groups. (Keating M. and Wildman M., 2018).

In 2004 the Somali leaders agreed on the establishment of a Transitional Federal Government (TFG). During the year of 2006, the Islamic Courts Union (ICU) took over much of the south. The TGF with the assistance of Ethiopian troops and the African Union² peacekeepers manage to drive ICU out. Radical elements, including Al-Shabab, regrouped to resume the insurgency against the TFG and oppose the Ethiopian military presence. By 2008 Al-Shabab gained control of key areas, including Baidoa [city].

A major military offensive against Al-Shabab began in February 2011 and TGF forces, supported by AMISOM³, made significant territorial gains in Mogadishu. Somalia's eight-year transitional plan ended successfully with the establishment of new Federal Parliament in 2012. Nevertheless, the security situation in Mogadishu, though improved, remained unpredictable. Somalis National Security Forces and AMISOM maintained their hold on the city, but Al-Shabab attacks

¹ The United Nations Security Council included armed group Al-Shabaab on its 1844 Sanctions List in 2008. <https://www.un.org/securitycouncil/sanctions/751/materials/s-ummaries/entity/al-shabaab>

² The African Union (AU) is a continental body consisting of the 55 member states that make up the countries of the African Continent. <https://au.int/en/overview>

³ The African Union Mission in Somalia (AMISOM) is an active, regional peacekeeping mission operated by the African Union with the approval of the United Nations. <https://amisom-au.org/amisom-background/>

occurred frequently. (Basic Fact about the United Nations, 42nd edition, 2017).

Somalia's prolonged humanitarian crisis is characterized by ongoing conflicts, climate-related shocks, communicable disease outbreaks and weak social protection mechanisms.

Communities living in conflict areas were severely impacted by armed violence. The ongoing conflict continues to reduce the resilience of communities, trigger displacement and impede civilians' access to basic services and humanitarians' access to those in need. Exclusion and discrimination of socially marginalized groups are contributing to high levels of acute humanitarian need and lack of protection among some of the most vulnerable. Civilians bore the brunt of the conflict through death and injury, property destruction, taxation of communities (including through forced child recruitment), land grabbing, destruction of livelihoods, limited freedom of movement, and limited access to services and humanitarian assistance (Humanitarian Needs Overview. Somalia. OCHA 2021).

In such a complex conflict environment, data science tools and analytical processes are critical with multiple actors and various types of conflicts. Political scientists and analysts may use these tools and processes for better conflict understanding and informed decision-making processes.

3. CONFLICT DATASETS

The Armed Conflict Location & Event Data Project (ACLED) is a disaggregated data collection, analysis, and crisis mapping project. ACLED collects the dates, actors, locations, fatalities, and types of all reported political violence and protest events around the world. The ACLED team conducts analysis to describe, explore, and test conflict scenarios, and makes both data and analysis open for free use by the public (ACLED, 2022).

The temporal resolution of the dataset is varied between continents. See Table 1 for details. For Africa, data starts from January 1997.

Continent	Temporal resolution
Africa	1/1997 - present
East Asia	1/2018 - present
Central Asia & the Caucasus	1/2017, 1/2018 - present
Europe	1/2018, 1/2020 - present
Middle East	1/2015, 1/2016 - present
South & Southeast Asia	1/2010, 1/2015, 1/2016, 1/2018 - present
Latin America & the Caribbean	1/2018 - present

Table 1. Temporal resolution of ACLED (ACLED, 2021)

Each data record is referred to as an individual event of a conflict classified as event type and subtype. See table 2 for details.

ACLED data contains geographical information in the form of the location represented in longitude and latitude and the administrative location.

The data are collected from various sources: traditional media – national and international media outlets, reports from national and international non-government organizations, local partner data – collected by local social organizations through primary and secondary means, and new media such as social media platforms. Conflict data researchers consider that an individual process of sourcing data for each conflict is the most reliable (Salehyan, 2015). Therefore, ACLED applies data quality verification processes individually to each conflict, location, or country.

Event Type	Even Subtype
Battles	Armed clash
	Government regains territory
	Non-state actor overtakes territory
Explosions/Remote violence	Air/drone strike
	Grenade
	Remote explosive/landmine/IED
	Shelling/artillery/missile attack
	Suicide bomb
Protests	Excessive force against protesters
	Peaceful protest
	Protest with intervention
Riots	Mob violence
	Violent demonstration
Strategic developments	Abduction/forced disappearance
	Agreement
	Arrests
	Change to group/activity
	Disrupted weapons use
	Headquarters or base established
	Looting/property destruction
	Non-violent transfer of territory
	Other
Violence against civilians	Abduction/forced disappearance
	Attack
	Sexual violence

Table 2. Taxonomy of event types and subtypes in ACLED (ACLED. 2021)

Various scholars and academic institutions use the ACLED database, International Organizations such as United Nations and its Agencies Funds and Programmes, ICRC, European Union Agencies, and other government and inter-government institutions, think tanks as well as media news agencies.

The ACLED datasets are used in all three analytical components. Description of the conflict events are used for Semantic and NLP analysis to classify the events and provide a better understanding of the cause of the events. It is used for Geospatial analysis and correlations with the population data and temporal analysis to analyze the events over time.

Somalia data is extracted and filtered from the ACLED dataset. From January 1997 to December 2021 over thirty-five thousand Somalia-related records were allocated, for here it is referred to as the Somalia-conflict database.

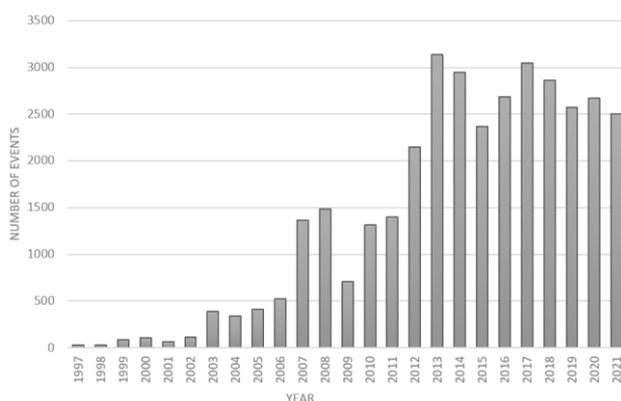


Figure 2. A number of events in the Somalia conflict database from 1997 to 2021.

4. POPULATION DATASETS

The GHSL (Global Human Settlement Layer) is a georeferenced layer that provides global coverage information on human settlements and populations. It is produced by elaborating on historical satellite images and data from open sources.

The primary datasets consist of gridded layers of built-up area and the number of inhabitants at a high resolution for four dates: 1975, 1990, 2000, and 2015. In addition, the GHSL allows measuring the growth of cities and towns over time, including information on population, urbanization rate, and land consumption.

GHS population grid (GHS-POP), derived from GPW4.1, multi-temporal (1975-1990-2000-2015), R2019A [GHS_POP_MT_GLOBE_R2019A]. This product was distributed as part of the Community pre-Release of the GHSL Data Package 2018 (GHS CR2018) (Florczyk et al. 2018); however, an updated version of the datasets is available (v2.0).

The GHSL layer is used in two analytical components. It is used for Geospatial analysis and correlations with the conflict data and for temporal analysis to provide an understanding of how the population change affected the composition and frequency of the conflicts over time.

5. CONCEPT OF METHODOLOGY

The methodology consists of three main components: First, semantic analysis of the structured and unstructured textual data describing the conflict events in various places. Second is the correlation of conflict data and population data—the world population GHSL (Global Human Settlement Layer) dataset for the research experiment. Third, to understand the direct and indirect causes of the conflict, it is essential to conduct a temporal analysis.

6. SEMANTIC ANALYSIS

The semantic analysis procedure begins with defining keywords for the Somalia-conflict database in the event description field. In addition to text categorizations, the relevance of individual issues can be measured by the number of unique words in the database. For example, figure 3 shows that the word “Shababaab” or Al-Shabab was used the most times (14,696 times).

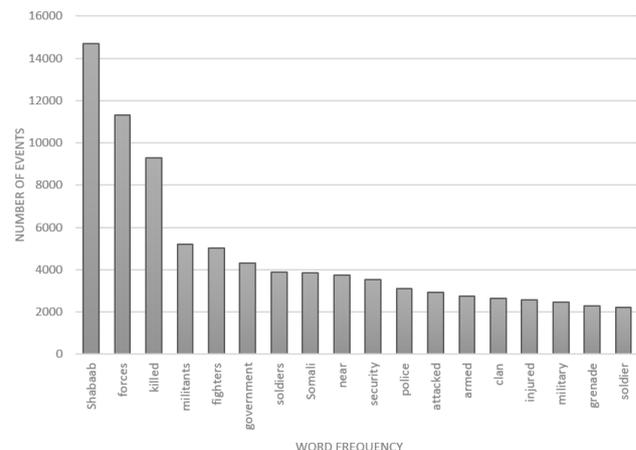


Figure 3. Relevance and frequency of identifies conflict issues

The temporal resolution of using the word “Al-Shabab” is presented in Figure 4. It should be noted that the use of the word

“Al-Shabab” began in 2006, and it was used only in 2 instances in 2006. The situation has drastically changed from 2006 to 2021, and the number of uses of the “Al-Shabab” word grew from 2 in 2006 to 1927 in 2021.

Figure 4 shows the relative change of word frequency “Al-Shabab” and in percentage.

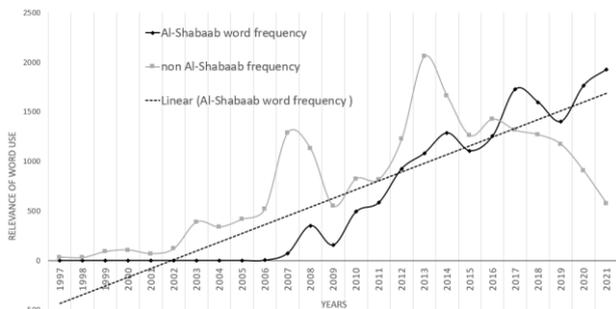


Figure 4. The absolute number of use of “Al-Shabab” word by years.

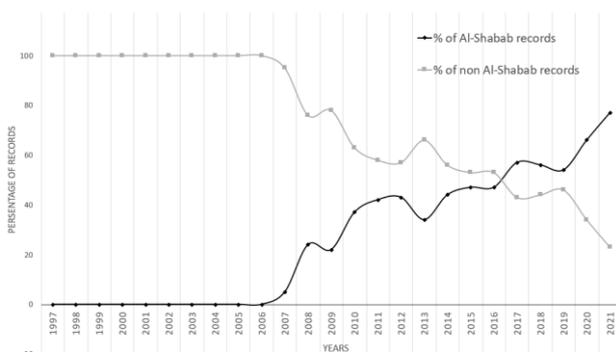


Figure 5. Percentage number of use of “Al-Shabab” word by years.

Al-Shabaab is an armed group that demonstrates violence against various actors, such as civilians, other armed groups, government, clans, and different actors. Classified actors and their indications have been analyzed by year during this research.

Classification of different actors was identified as Government forces is classified as Actors 1; Rebel forces, including Al-Shabaab as Actor 2; Various politely affiliated militias identified as Actor 3; Ethnic Militia, including clan militias as Actor 4; Rioters as Actor 5; Protesters as Actor 6; Civilians as Actor 7; and finally, outside external forces, including AMISOM forces as Actor 8.

Table 3 presents interactions between the government and other actors (from 11 to 18) and rebels and other conflict actors (from 22 to 28) only. Other exchanges are excluded from the table. Finally, a combination of actors 12 presents the heist number of conflict events, and it presents the actions of Actor 1 (Government forces) against Actor 2 (Rebel forces including Al-Shabaab).

Analyzing this table, we can say that the highest number of violent conflicts between government forces and rebels (combination 12), government forces, and political militia (combination 13). In terms of rebel attacks on various actors, the predominant combination is rebel attacks on civilians (combination 27) and rebel attacks on eternal actors, including the AMISOM.

ACTORS INTERACTIONS																												
YEAR	11	12	13	14	15	16	17	18	22	23	24	25	26	27	28													
1997								1			6				3	2												
1998											6					2												
1999			4							1	20	1			4	2												
2000	2	1	4					1		3	4				2													
2001	2	1	16					2			6				1	1												
2002		14	16								31				1	4												
2003			175												5	2												
2004		11	110	1				2					1			10												
2005	5	1	5	1	2			3			1	10				3												
2006	1	32	15	10	3	3	8	1		66	4	5	5	6	15													
2007	29	80	300	18	5	1	39	4		3	2			19	70													
2008	23	148	293	9	8	1	54	2	15	43	10			38	147													
2009	15	26	128	2	6	1	9	1	7	63	6	1	1	13	17													
2010	38	215	224	4	1	4	62	3	1	128	3			24	88													
2011	32	237	121	17	4	2	32	2		129	15			41	75													
2012	41	412	316	25	9	7	79	2		79	15			114	252													
2013	87	404	701	44	15	23	89	5	30	107	11	1	1	166	317													
2014	121	579	411	53	24	32	84	3	7	40	22	1		184	432													
2015	93	570	244	47	41	24	63	3	12	12	16		1	162	316													
2016	113	580	267	65	31	31	67	7	5	14	44			202	411													
2017	92	796	139	24	38	18	118	7	7	21	33			337	545													
2018	149	909	183	25	24	24	128	10	10	12	25	1		268	379													
2019	94	706	310	17	10	7	105	11	17	29	20			310	318													
2020	94	1,068	154	28	9	20	107	5	9	9	13			287	368													
2021	43	1,291	87	25	6	8	65	6	2		14			242	387													
Total	1,074	8,086	4,223	415	236	206	1,118	72	127	838	255	9	8	2,432	4,160													

Table 3. A number of Actors Interactions by year.

The result of semantic analysis provides an additional understanding of the dataset. First, we identified the relevance and frequency of a specific issue appearing in the dataset. For example, in Somalia's case, the word "Al-Shabaab" is prevalent. Second, we identified a specific period when "Al-Shabaab"-related issues have started to accrue. Thus, the increase of the "Al-Shabaab"-associated events occurred steadily over the period from 2006 to 2021. Furthermore, using the classification of various actors interacting with each other, we were able to identify the combination of actors with the highest number of violent events.

This knowledge is used in geospatial analysis of the same database.

7. GEOSPATIAL ANALYSIS

The geospatial analysis procedure begins with identifying a specific area of interest in Somalia. A density analysis was performed using QGIS software. The results provide locations of areas of interest with the highest density of the conflict locations.

Visual interpretation of the density analysis provides that the highest number of conflict events is concentrated in or around the Mogadishu Area, which accounts for 21,224 records in the Mogadishu area out of a total of 35,301 conflict events in Somalia. Thus, the number of conflicts in Mogadishu constitutes 60% of Somalia's total number of conflicts.

The number of conflict event rebel-related conflicts, including Al-Shabaab-related, amounted to 10,817 out of Mogadishu records (21,224) or 51% of conflicts in the Mogadishu area. Thus, we can say that over half of the records related to the conflict records are related to Rebels i.e., Al-Shabaab.

Next is to correlate the locations of the conflict incidents with the population dataset to estimate how certain conflict incidents affect the number of people living in the area.

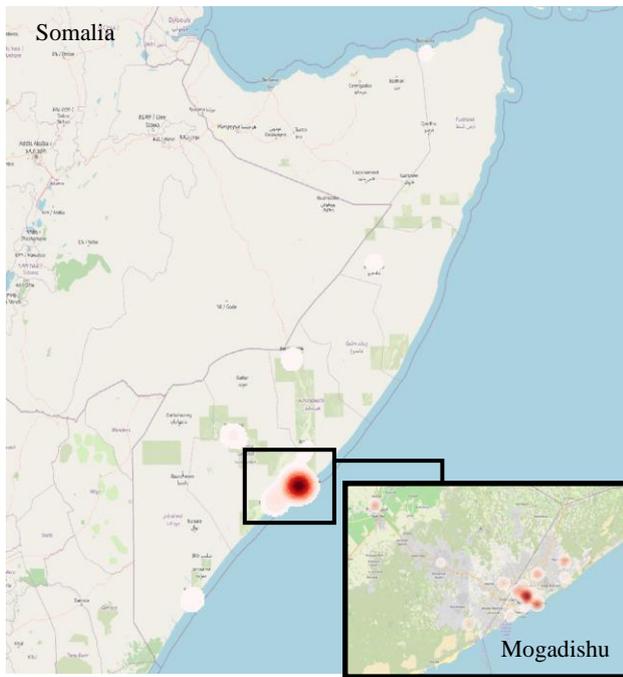


Figure 6. Somalia and Mogadishu. Density analysis of conflict events in Somalia and Mogadishu. (background map OpenStreet map, 2015)

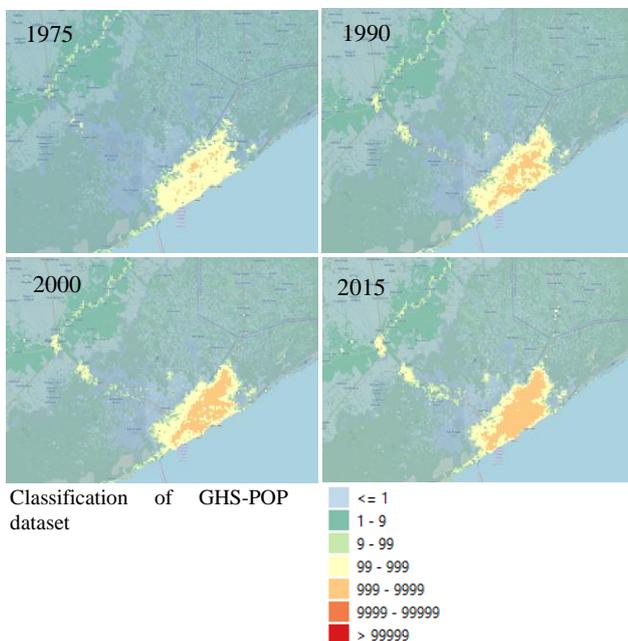


Figure 7. GHS-POP Population data (Schiavina, 2019) for 1975, 1990, 2000 and 2015.

The process of correlation of population and conflict data is performed, which helps understand how conflict events affect the communities and the people in Somalia. In this experiment, the GHS-POP 2015 population dataset is used. However, any other available population dataset can be used for analysis and correlation purposes. The population layer is correlated with the cluster data values of a number of conflicts with a specific distance rendering and is presented in the figure below.

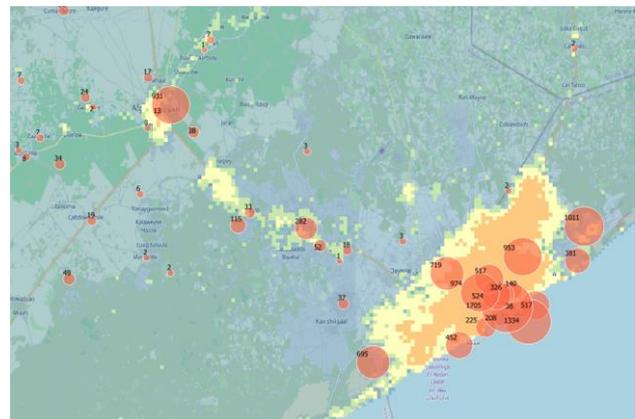


Figure 8. GHS-POP 2015 correlated with conflict locations clusters in Mogadishu.

Figure 8 shows a phenomenon where the highest number of conflicts occur in the most populated areas of Mogadishu and in greater Mogadishu. Thus, the conflicts affect the most people. On the other hand, in a rural areas, the amount of conflicts events is considerably low.

The geospatial analysis results provide an additional understanding of the location of the conflict events in the Mogadishu area.

Additionally, using the classified population data provides an understanding of the location of conflicts in relation to the most populated areas of Mogadishu and Afgoye.

Thus, this analysis can also be used with other additional layers, such as infrastructure, etc., and provide a deeper understanding to the political scientist of the conflict situation in Mogadishu and Afgoye.

8. TEMPORAL ANALYSIS

Spatio-temporal analysis refers to the analysis of data with time attributes and absolute and relative positions in three-dimensional space, as well as the process and methodology of analyzing these data.

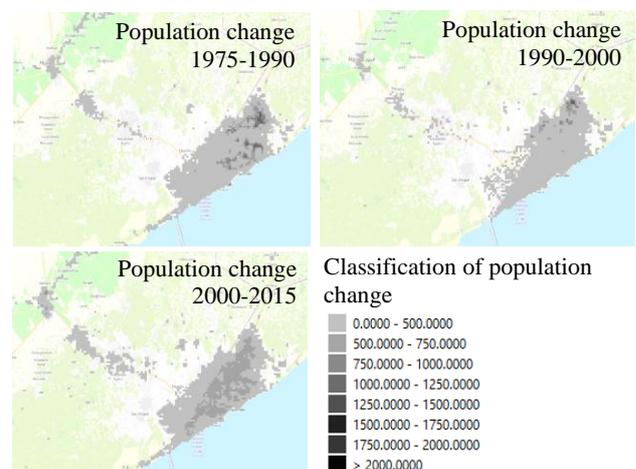


Figure 9. Classification of population change in Mogadishu for the period 1975-1990, 1990-2000, and 2000-2015.

The ubiquitous spatial correlation in spatial data, coupled with the randomness and complexity of the time dimension, spatio-temporal data presents the characteristics of multi-dimensional, semantic, and spatio-temporal dynamic correlation (Dong, Guo, 2021).

A classified population change within the period 1975 to 1990, 1990-2000, and 2000-2015 has been identified, as shown in Figure 9. It is noticed that despite the increase in violence during the mentioned periods, the population of Mogadishu has continued to increase. Therefore, political analysts may want to conduct further investigation on whether the Somali society is becoming more urban and what socio-economic factors may drive this process.

To define a methodology for temporal analysis, we conducted the correlation of time series of population change 1990-2000 and 2000-2015 and conflict events.

Figure 10 presents the classification of population change and location/number of conflict events for the period 1990-2000. It is noticed that during this period, a number of conflicts have taken place in the areas with significant population change in both Mogadishu and Afoye and no conflicts in rural areas. The 1999-2000 period represents the situation with conflicts before the formation of Al-Shabaab in 2006.

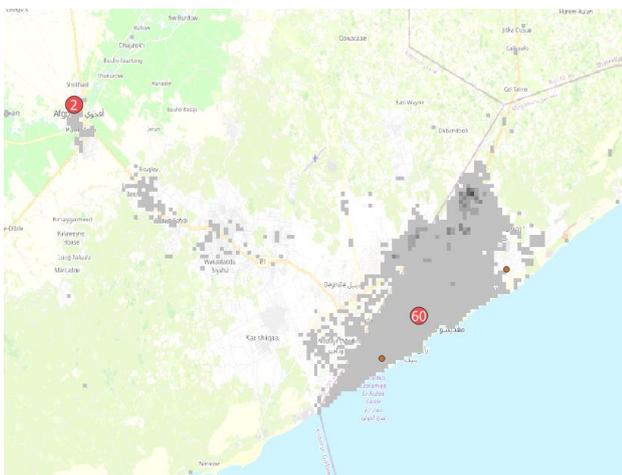


Figure 10. Classification of population change in Mogadishu for the period 1990-2000, and locations and number of conflict incidents for the same period.

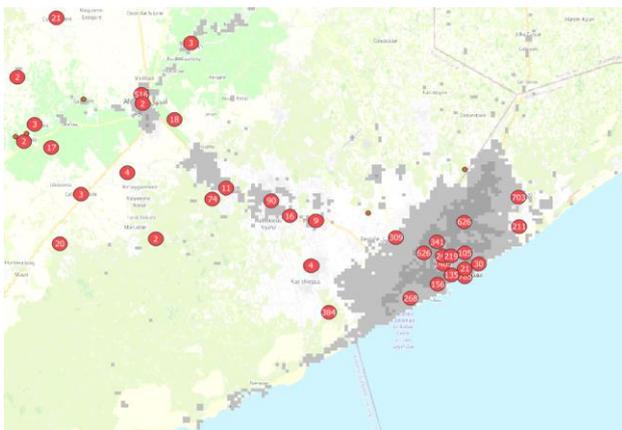


Figure 11. Classification of population change in Mogadishu for the period 2000-2015, and locations and number of conflicts

Figure 11 shows the population change and conflicts locations from 2000 to 2015. There is a significant increase in population change in this period. The number of conflicts is also on the substantial rise. In this period, the conflicts already spread out not only to the areas with significant population growth but also to the rural areas. Such an increase in conflict may be related to the rise of Al-Shabaab activities in 2006.

The result of temporal analysis provides deep knowledge of the historical components of the conflict situation. For example, the situation with conflicts has looked like before the formation of Al-Shabaab. In this example, we can see that the number of conflicts was significantly less, and there were predominantly located in urban areas with high population growth.

9. CONCLUSION

This paper describes various datasets and the processes and defines the methodology to apply semantic, geospatial, and temporal analysis to study and investigate conflicts. In addition, it provided the process of working with conflict data and segregating the issue related to the conflict situation. In the use case of Somalia, it has been identified that "Al-Shabaab" played a significant proportion of all conflict events in Somalia. Also, we identified that the first mention of "Al-Shabaab" was in 2006, and since then, the number of conflicts has increased exponentially. Using Geospatial and spatio-temporal analysis, we investigated the conflict situation even further, identified the location with a high number of conflicts, correlated the population change, and how the number of conflicts increased over time.

The correlation of population data and other geospatial data to identify the geographical processes of the conflict's other variables provides an understanding of the dependencies of population growth and a specific type of conflict.

It is believed that applying a combination of semantic, geospatial, and temporal analysis enhances understanding of the causes of the conflicts. In such a process, the analysis of various datasets can be applied that help to understand the evolution of the conflicts, their dynamics, narratives, and severity. It is hoped that the research and proposed methodology would enhance the understanding of conflicts and contribute to policymaking processes by providing additional insight on the conflicts and suggesting actions to prevent and mitigate them. Thus, this research could also contribute to meeting the targets of Sustainable Development Goals 16 – Peace and Justice.

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