

Data Collection, Fusion, and Visualization for Decision Making in Stability Operations

David Beskow, David Blum, Nathan Gustafson, Emily Kern, and Jessica Waggoner
Department of Systems Engineering
United States Military Academy
West Point, New York

Abstract

Stability is the measure of regional resistance to political, economic, social and structural degradation or deterioration. Stabilizing mechanisms seek to create an environment for a populace that is legitimate, acceptable, and predictable. In today's strategic context, local, national and regional stability is extremely dynamic; constantly influenced by state and non-state actors, media, financial organizations and behaviors, natural events, and various types of human conflict. While stability is of vital U.S. interest, diminishing resources require innovative and creative solutions that start with a full understanding of any given stability situation. Our research developed a tool that drives data collection methodology by U.S. Army Civil Affairs Teams and Security Force Assistance Teams, fuses this with open source data, and conducts initial analysis and data visualization for consumption by military commanders up to and including Combatant Commands. This tool uses a Risk Framework developed by U.S. Pacific Command's Socio-cultural Analysis Team. This framework views regional, national, and sub-national stability environments through analysis of Humanitarian Crisis, Outlier and Recalcitrant States, Regional Power Balancing, Economic Insecurity, and Violent Extremism.

Keywords

stability, conflict, data analysis, data visualization, data collection

1. Introduction

1.1 Background

The 95th CA BDE utilizes a number of approaches for measuring key statistics and qualitative success within a locality or region, which include CAFE (Civil Affairs Framework for Engagement) and CAOS (Civil Affairs Operating System). Last year (academic year 2013) student research developed an analysis tool that assists in assessing sub-national stability, focusing primarily on agriculture. This tool received positive feedback from both the 95th Civil Affairs Brigade as well as other organizations. The 95th Civil Affairs Brigade, Pacific Command and Special Operations Command South are now interested in a similar tool with a more general focus. Parallel to these efforts, Pacific Command is developing a methodology to help commanders "understand risk, develop targeted military operations, and inform interagency and international engagement" [1]. The PACOM Risk Framework is structured around five primary pillars outlined below. This year's research will seek to use PACOM's risk model as the framework for an analytical tool that measures stability indicators at sub-national level and is able to apply analysis to national and regional levels.

1.2 Stakeholders

This endeavor is unique in that it has many diverse organizations that are interested in the research. Below are the primary stakeholders. In addition to these, British Agricultural Teams expressed interest and are currently actively testing the tool.

1.2.1 US Army Civil Affairs

The mission of Civil Affairs (CA) forces is to support commanders by engaging the civil component of the operational environment. The U.S. Army organizes CA units to support operations at all levels of war—strategic, operational, and

tactical. Mission guidance and priorities from Geographic Combatant Commanders (GCC) provide regional focus. Civil Affairs Operations (CAO) 1) enhance the relationship between military forces and civil authorities, 2) require coordination with other organizations, and 3) involve the application of functional speciality skills that normally are the responsibility of the civil government. Civil-military operations are defined as the activities of a commander that establish, maintain, influence or exploit relations between military forces, governmental and non-governmental civilian organizations and authorities, and the civilian populace in a friendly, neutral, or hostile operational area in order to facilitate military operations, to consolidated and achieve operational U.S. objectives [10].

Civil Affairs Teams (CATs) are also the military's primary means of civil reconnaissance (CR). Civil reconnaissance involves gathering civil information in support of military operations. This collection is not a covert collection effort, but rather involves overt interaction with a host nation population as well as use of open source information and academic research [2]. Our research contributes to this endeavor by highlighting rich and underused sources of civil information while identifying information gaps to drive civil reconnaissance by CATs.

1.2.2 Pacific Command

PACOM is one of nine Unified Combatant Commands. The mission of Combatant Commands is to act as a link between those who form national security policy and strategy with the military forces that conduct operations within the Combatant Command's Area of Responsibility (AOR). PACOM's area of responsibility in the Asia-Pacific consists of 36 nations containing over half of the world's population and multiple sources of instability. PACOM explicitly states that its intent is to "...work closely with partners across the U.S. government and in the region to address shared challenges and prevent conflict, we will ensure we are ready to respond rapidly and effectively across the full range of military operations" (PACOM website). To meet this intent, it must understand the operational environment, the challenges to stability contained in that environment, as well as current and historic US action in the region. Our research will assist in this understanding. PACOM has specifically expressed interest in a sub-national stability assessment of Bangladesh.

1.2.3 Special Operations Command-South

Special Operations Command-South (SOCSOUTH) is a sub-unified command assigned to Commander, U.S. Southern Command. It is a joint (military members from all four services) Special Operations headquarters that plans and executes special operations in Central and South America and the Caribbean, principally employing Special Operations Forces provided by U.S. Special Operations Command (USSOCOM) and the Special Operations Forces (SOF) component commands. Its vision is to enhance security and stability in the Americas with interagency partners and partner nations by establishing an in-depth networked defense that will detect, deter, disrupt, and defeat illicit transnational elements. SOCSOUTH's area of focus includes 31 countries and 10 territories (primarily the land mass of Latin America south of Mexico). SOCSOUTH expressed interest in using Paraguay as a case study and focusing initial data collection there given the ongoing insurgency there.

1.2.4 US Army Communications-Electronics Research, Development and Engineering Center (CERDEC)

The US Army Communications-Electronics Research, Development and Engineering Center (CERDEC) is currently funding the student design project. CERDEC develops and integrates technologies that "enable information dominance and decisive lethality for the networked Warfighter" (CERDEC website). CERDEC is interested in the technology to design and field data collection devices. Parallel to student modeling efforts CERDEC is developing software to facilitate Android tablet questionnaire development by Soldiers in the field. The cadet questionnaire serves as a test case for relatively quick and flexible Android application development.

1.3 Problem Definition

Our research developed a tool that drives data collection methodology by U.S. Army Civil Affairs Teams and Security Force Assistance Teams, fuses this with open source data, and conducts initial analysis and data visualization for consumption by military commanders up to and including Combatant Commands. This tool uses a Risk Framework developed by U.S. Pacific Command's Socio-cultural Analysis Team. This framework views regional, national, and

sub-national stability environments through five primary “pillars.” Our research will focus on the *Violent Extremism* Pillar of this framework.

2. Literature Review

2.1 Stability

Army doctrine states that successful stability operations “aim to create a condition so the local populace regards a situation as legitimate, acceptable, and predictable.” [11]. Stability is a vital US interest and a core pillar of American foreign policy because it determines whether a nation is experiencing or vulnerable to conflict. Conflict, which breeds instability, can degenerate into large scale hostilities. This instability affects the world economy, diplomatic relationships, and societies in general. Overall, stability is crucial in avoiding large scale conflicts and in maintaining mutually profitable and reliable international relationships.

2.2 PACOM Risk Framework

The United States Pacific Command (PACOM) Socio-Cultural Analysis (SCA) program was established for the purpose of building a framework to enable planners and analysts to explore complex security problems in-depth. This framework is divided into categories of risk which elaborate the conditions and factors that account for and influence instability. The framework development process included identifying indicators to facilitate understanding by policy-makers and analysts. More specifically, the framework brings light to specific elements capable of stimulating tensions such as violent extremism due to its heightened potential for sparking a resurgence of violence. It breaks down large-scale security problems into categories of risk with elaboration of the conditions and factors accounting for such risk. It develops a structured method to guide campaign planning priorities through a holistic analysis of areas that pose risk to the accomplishment of national security end-states in the Asia Pacific region. It also identifies whether specific risk factors are pervasive in nations or constrained to certain regions or urban centers.

The PACOM Socio-cultural Analysis team presents a risk framework which can be used to assess an area’s stability. The five foundations of the framework are:

1. Humanitarian Crisis
2. Outlier and Recalcitrant States
3. Regional Power Balancing
4. Economic Insecurity
5. Violent Extremism

Our efforts will focus on *violent extremism*. According to SCA, violent extremism “encompasses state and non-state actors (groups and individuals) who support, facilitate, organize radicalization efforts, or attempt to commit violent acts in order to achieve ideological, political, social, or economic change. The broad violent extremism enterprise impacts individuals, communities, nations and regions and create risk to stability and security at every level” [1]

The framework aims to provide efficient, systematic, and transparent planning support to Special Operations Command, Pacific (SOCPAC) and other PACOM entities. Its purpose is to provide the analyst and planner with guiding questions and insight into how to think through and identify the major sources of risk, identify “hot spot” locations and assess the seriousness of the risk on three planes: varying degrees of generality-specificity, degrees of certainty-uncertainty and levels-of-analysis [1].

Each framework foundation is divided into more specific subcategories. In order from general to detailed, the levels of categories are foundation, component, and indicator (some with an accompanying geospatial observable). The breakdown of the *Violent Extremism* pillar is given in Table 1.

2.3 Event Data and its use in measuring stability

A significant portion of our model relies on event data. Since the middle of the Cold War various models have used event data to assist decision makers in understanding their operational context. Early on the Conflict and Peace Data-bank (COPDAD) and World Event Interaction Survey (WEIS) used various analytic methods and relied on “human-coders” to analyze and catalog news reports. These early efforts were severely constrained by the level of effort required to generate event data. Philip Shrodt developed a suite of automated tools to generate the data which was

Table 1: The Violent Extremism Framework

	Conditions	Factors
Socio-Cultural Vulnerability	Economic Dysfunction and Subsistence	Poverty and Relative Deprivation
	Social Exclusion and Immobility	Societal Discrimination
	Community Insecurity and Anti-Democratic Conditions	State Violence and Repression
Community Grievance and Susceptibility to Influence	Cultural Narratives and Public Sentiment	Hostile Public Sentiment Discontent
	Civil Disobedience	Mass Demonstrations
	Support for Extremist Ideology	Popular Perception of VEO Objectives and Violence
Governance and Public Services	Political Legislative and Judicial Competency	Political Effectiveness and Corruption
	Emergency, Health, and Sanitation Services	Public Service and Health
	Social Welfare Services	Inadequate Social Safety Net
Extremist Violence and Facilitation	Financing and Sustainment	Arms and Illicit Activity
	Organization, Recruitment, and Training	Ideology and International Connections
	Violent Extremist Operations	VE / Insurgent Attacks
Security and Counter-Terrorism Capacity	Border, Transportation, and Trade Security	Border Patrol and Infrastructure
	Internal Security and Police	Civil Law Enforcement Capacity and Effectiveness
	Military and Counter Terrorism Response	Military and Counter-Terrorism Capacity

eventually called the Kansas Event Data System (KEDS). These efforts later developed into the TABARI/CAMEO taxonomy for creating event data [12].

Following the genocide in Rwanda in 1994, Vice President Al Gore requested intelligence leadership to create an analytic tool that would assist in predicting failed states. The CIA designated the Political Instability Task Force (PITF) to accomplish this, with state failure characterized by 1) genocides and politicides, 2) ethnic wars 3) abrupt regime transitions and 4) revolutions. This task force primarily used time series data with logistic regression in order to predict state failure [8].

Recently the Defense Advanced Research Projects Agency (DARPA) began a search for the Integrated Crisis Early Warning System, which to date is the largest of these efforts. This goal of ICEWS combines all past methods and analytics with intuitive software to provide near real time predictions of a variety of events. A large portion of ICEWS predictive models uses TABARI coded event data. Of note is that ICEWS final stage of development attempts to develop analysis designed to measure the international impacts of Diplomatic, Information, Military, and Economic initiatives and activities [4].

The ICEWS projects have motivated several similar research among academia. Many of these models are using the recently established open source dataset known as GDELT (Global Database of Events, Language, and Tone). In particular Arva et al. [6] compares predictive models using GDELT with ICEWS.

2.4 Proliferation of Stability Indices

Recently there has been a proliferation of stability, risk, and governance indices which use a variety of indicators to measure and compare stability across nations. These indices provide information to various organizations and individuals, ranging from investors to Non-Governmental Organizations (NGOs). Each of these uses different (though sometimes overlapping) indicators, some of which are quite subjective. They are all influenced both by the choice of indicators as well as the quantitative methodology by which the indices is created. A detailed table of these indices is provided in Table 2. Many of these indices are used to create various geospatial visualizations and are often intended to draw the observer to certain stability “hotspots.” Note that none of these indices are at the sub-national level.

Table 2: Stability Indices

Index	Indicators
Failed States Index Fund for Peace	Demographic Pressures, Refugees and IDPs, Group Grievance, Human Flight and Brain Drain, Uneven Economic Development, Poverty and Economic Decline, State Legitimacy, Public Services, Human Rights and Rule of Law, Security Apparatus, Factionalized Elites, External Intervention http://global.fundforpeace.org/
Political Instability Task Force George Mason University, commissioned by CIA	Infant mortality rate, extreme cases of economic or political discrimination against minorities, “a bad neighborhood”, and regime type [9]
Peace and Conflict Instability Ledger University of Maryland	Economic Openness, Infant Mortality Rates, Militarization, Neighborhood Security, Institutional Consistency http://www.cidcm.umd.edu/
Political Instability Index The Economist Intelligence Unit	Level of Development as Measured by Infant Mortality Rate, Extreme Cases of Economic or Political Discrimination Against Minorities, “A Bad Neighborhood”, Regime Type, Inequality, State history, Corruption, ethnic fragmentation, trust in institutions, status of minorities, history of political instability, proclivity to labour unrest, Level of social provision, Growth in incomes, Unemployment, Level of income per head http://viewswire.eiu.com/index.asp?layout=VWArticleVW3&article_id=874361472
State Fragility Index George Mason University	Effectiveness Score, Legitimacy Score, Security Effectiveness, Armed Conflict Indicator, Political Effectiveness, Political Legitimacy, Regime Type Economic Effectiveness, Net Oil Production or Consumption, Social Effectiveness, Social Legitimacy, Regional Effects http://www.systemicpeace.org/
Failed and Fragile States Country Indicators for Foreign Policy	Governance, Economics, Security and Crime, Human Development, Demography, Environment http://www4.carleton.ca/cifp/app/serve.php/1407.pdf
International Country Risk Guide Political Risk Services	Political: Government stability, Socio-economic conditions, Investment profile, internal conflict, external conflict, Corruption, Military in politics, Religious tensions, law and order, ethnic tensions, democratic accountability, bureaucracy quality. Financial: Total foreign debt as % of GDP, debt service as % of exports of goods and services, Current account as % of exports of goods and services, International liquidity as months of import cover, Exchange rate stability as % change. Economic: GDP per capita, Real annual GDP growth, Annual inflation rate, Budget balance as % of GDP, Current account as % of GDP http://www.prsgroup.com/icrg.aspx
Global Peace Index Institute of Economics and Peace	Number of total conflicts fought, number of deaths from external organized conflict, number of deaths from internal organized conflict, level of internal organized conflict, relations with neighboring countries, level of perceived criminality in society, number of refugees and displaced persons as a percentage of population, political instability, terrorist activity, political terror scale, number of homicides per 100,000 people, level of violent crime, likelihood of violent demonstrations, number of jailed persons per 100,000 people, number of internal security officers and police per 100,000 people, military expenditure as percentage of GDP, number of armed-services personnel, volume of transfers of major conventional weapons as imports per 100,000 people, volume of transfers of major conventional weapons as exports per 100,000 people, financial contribution to UN peacekeeping missions, nuclear and heavy weapons capability, ease of access to small arms and light weapons http://www.visionofhumanity.org/#/page/indexes/global-peace-index

2.5 Data Visualization

While aggregating data and calculating descriptive statistics, our model creates more data than decision makers can intake and process quickly. Data visualization assists decision makers in understanding the data with better clarity and precision. Edward Tufte, one of the foremost experts of data visualization states “excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency” [7]. Our research involved exploring geospatial and time-series visualizations that will assist commanders and planners.

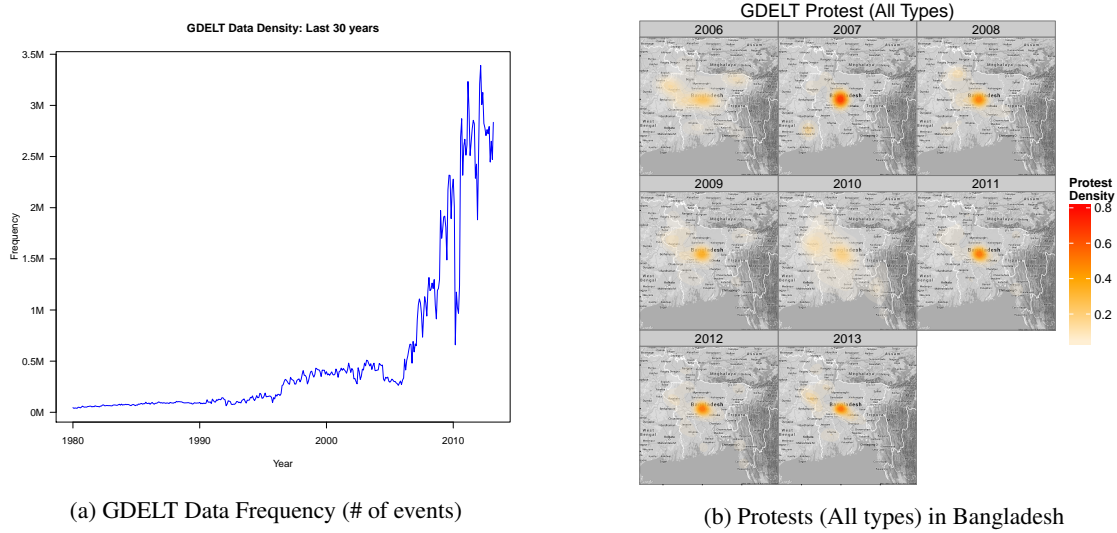



Figure 1: Exploratory analysis of GDELT Data

3. Data

In addition to well known sources of time series indices data (such as World Bank), we included two important event based data sets: GDELT and KIVA. These datasets are explained below.

3.1 Global Database of Events, Language, and Tone (GDELT)

The Global Database of Events, Language, and Tone (GDELT) is an initiative to construct a catalog of human societal-scale behavior and beliefs across all countries from 1979 to present. The data is created using enhanced TABARI [12] coding of numerous English language news and report sources. GDELT is geo-referenced and distinguishes between ethnic and religious affiliations of various state and non-state actors. Additionally, GDELT examines and classifies emotion-based indicators. This dataset is relatively large ($\approx 350GB$ in a MySQL database), and therefore requires appropriate analytic tools to query and analyze. Our use of GDELT is one of the first times that a DoD entity has used this new and large data set for a practical application [3].

GDELT, although containing latitude and longitude, does not classify events by the province/district that they occurred in. Since it was our intention to facilitate sub-national analysis, we created this field (defined as one boundaries one level below national) by “cutting” the data with province/district level shapefiles, as illustrated here . Using geospatial packages in R, we computationally assigned every event the district/province name where it occurred. This process allowed us to aggregate a large dataset at both national and sub-national levels.

As seen in Figure 1a, the events recorded in GDELT have grown over time due to an increase digital news media. This growth has not been even across the world. In order to use event counts in models, we created two normalized tables that became the foundation for our analysis. The first was normalized by year and by country, facilitating regional analysis and comparison. The second table was normalized by year and by province/district, facilitating national level analysis.

3.2 KIVA

KIVA is a non-profit organization whose stated goal is to help alleviate poverty through lending. They facilitate micro-finance across the world in 73 countries by linking lenders with borrowers. KIVA data contains information about every loan that they’ve facilitated, to include the amount, the sector (retail, agriculture, etc.), and whether or not the loan was repaid. This data can give rich insight into the stability of a country as well as the business interest and viability of various sectors of the economy. We explored and used KIVA in a limited capacity.

4. Modeling

Our technical approach primarily employed the Systems Design Process developed by and taught at the Department of Systems Engineering at the United States Military Academy. The SDP is a four phase process developed for complex decision environments. The four phases are *Problem Definition*, *Solution Design*, *Decision Making*, and *Solution Implementation*. During the *Problem Definition* Phase, we interviewed stakeholders, explored relevant literature, existing models, and conducted exploratory data analysis of possible data sets. This phase ended with the development of our problem definition as well as completed functional analysis. During *Solution Design* we refined our data structures, and developed the prototype user interface and data fusion algorithms. During the *Decision Making* phase we solicited feedback from the stakeholders as well as data collection teams. Following refinement, the *Solution Implementation* phase involved launching the tool to Combatant and Sub-unified commands, civil affairs teams, Security Force Assistance Teams (SFAT), and British Agricultural Development Teams.

4.1 Functional Analysis

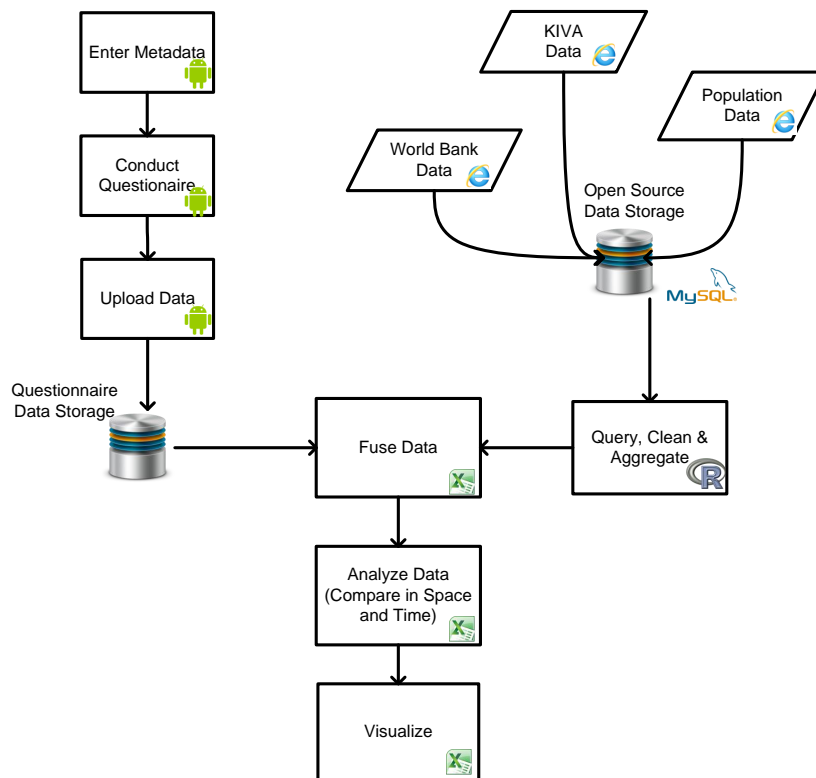


Figure 2: Functional Flow Diagram

The functional flow of the tool, given in Figure 2, is like that of a computer-aided puzzle, with the final picture adding up to quantitative and visual results for decision makers at all levels. On the right hand side of the functional flow, the project team is the main user. This involved collecting, cleaning, conducting any necessary geospatial analysis, aggregating, and storing data for future use. The left side of the functional flow highlights the steps conducted by data collection teams (CATs, SFATs, etc.). Using the CERDEC-developed Android application, teams would enter necessary Metadata (Country, Province/District, Data, Latitude/Longitude), conduct the questionnaire, and later upload it to a server. The tool provides these teams with quantitative and visual representation of relevant open source data to assist them as they answer questions (discussed below).

4.2 Question Selection and Presentation

Our modeling efforts went to great lengths to consider the feasibility of data collection. CATs, SFATs, Agricultural Development Teams, and conventional military forces must be able to feasibly collect the data from multiple locations over multiple time periods. This means that the total number of questions must be reasonable, and that a small team must be able to collect reliable data for each question. All data requirements were filtered based on feasibility of data collection. This screening criteria meant that some indices common in regional and global models were eliminated because collection efforts at the sub-national level are problematic.

To assist in collecting sub-national data, our team developed a methodology that facilitates “extrapolation” by data collection teams. When collecting data at a village, municipality, or district, the questionnaire provides national level data as a benchmark from which the team can extrapolate. For example, national electrical usage is provided to assist the team in verifying their estimate of a municipality’s electrical usage.

4.3 Analysis

Our analysis focused on facilitating relative comparison as much as possible. For this reason, all indicator requirements answered with open source data were converted to a percentile rank for the district or country. Leaders intuitively measure stability by comparison. Percentile ranking mirrors this intuitive evaluation and facilitates relative comparison of a district within a country or nation within a region. Data requirements that were met through CATs and SFATs were answered on a 1-5 scale (data met through human data collection may not facilitate percentile comparison if the area of interest lacks requisite data).

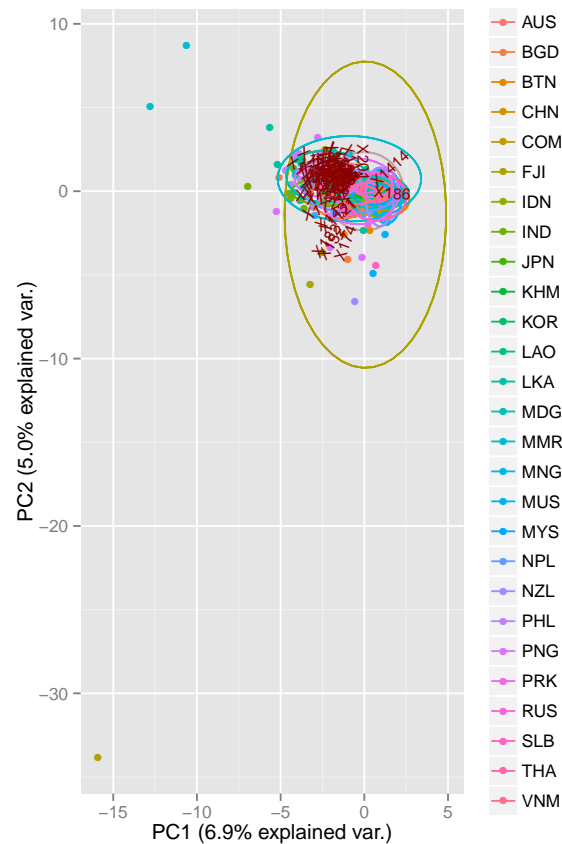


Figure 3: Principal Component Analysis

We propose two methods for creating a single index to measure *violent extremism*. The first and simplest method involves normalizing both types of numerics (percentile rank and 1–5 answers) and then summing them with a weighted additive value model. This additive model is a primary component of several of the indices listed in Table 2. The

second proposed method is to use Principal Component Analysis (PCA) to generate a single index. PCA transforms the original set of all indicators into an orthogonal set of variables (the principal components). Using only the first principal component, which accounts for the greatest portion of the variance, we created a single index from multiple indicators. This method is illustrated in Figure 3. The concern with this method is that, given the high variance observed in societal data, first principal component may not explain enough of the variance. Note in Figure 3 that the first principal component only explains for 6.9% of the variance. We visually compare both results in Figure 4. This graphic plots the respective index (additive value model or principal component analysis) against stability (measured by *fighting* events recorded in GDELT) for 2012. The size of the bubbles in both of these plots represents the number of *protests*.

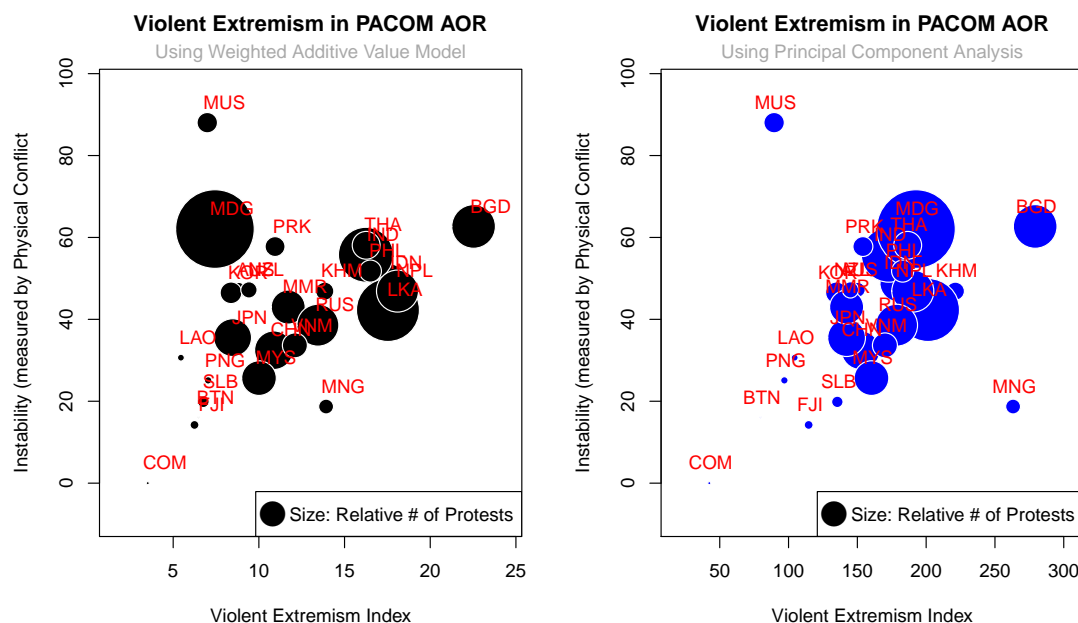


Figure 4: Comparison of Principal Component and Additive Value generated indices with 2012 Data

5. Conclusion

In this paper we proposed a method using human data collection and open source data to assist leaders in understanding stability in a designated operational environment. This method attempts to exploit open source big data, especially with the use of GDELT, in order to meet information requirements. Our method attempts to limit the information requirements of data collection teams, while at the same time providing them with relevant national and regional data to assist in “extrapolating” to the sub-national level where necessary. Our research assisted in validating the overall structure of the Risk Framework proposed by PACOM’s socio-cultural team, while at the same time recommending new indicators that measure their factors of interest. We do recommend that the scale of the Risk Framework needs evaluation to ensure that load placed on CATS/SFATS is reasonable and feasible. To be effective, this data collection must be simple enough that leaders can distribute the data collection effort broadly across geography and time.

Several organizations will begin testing this methodology and tool in the near future. After CERDEC converts the questionnaires to an Android application, Civil Affairs Teams associated with the PACOM AOR will use it as they gather information in Bangladesh. National Guard Civil Affairs Teams associated with SOCSOUTH will use it this summer as they gather data in Paraguay (which currently has an active insurgency). British agricultural teams, already using the agricultural tool developed last year, have expressed interest in using the new generalized tool in Africa.

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