A Hybrid Model of Ethnic Conflict, Repression, Insurgency and Social Strife

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ABSTRACT: *Ethnic conflict, Repression, Insurgency, and Social strife (ERIS) is a multi-paradigm model of ethnic conflict at varying levels of analysis and implementation. ERIS attempts to address the complexity of micro and macro-level social interactions among a population and can be used to assess the effects and implications of social unrest and conflict.*

1. Introduction

Ethnic Conflict, Repression, Insurgency and Social Strife (ERIS) is a comprehensive, multi-level model of ethnic conflict that simulates how population dynamics impact state decision making and, in turn, respond to state actions and policies. Population pressures (e.g., relocation, civil unrest) affect and are affected by state actions. The long term goal of ERIS is to support operations development and analyses, enabling military planners to evaluate evolving situations, anticipate the emergence of ethnic conflict and its negative consequences, develop courses of action to defuse ethnic conflict, and mitigate the second and third order effects of U.S. actions on ethnic conflict.

2. Background

The current ERIS system is based on a macro-level model specified by Urdal (2008) and a micro-level model specified by Lim, Metzler and Bar-Yam (2007). Each model addressed a particular aspect of ethnic conflict, repression, insurgency or social strife, and could potentially be suitable for multi-level integration.

The Urdal model predicts conflict within a state based upon demographic inputs. The model by Lim et. al. simulates the movement of individuals desiring to cluster with those in their own ethnic group. Conflict is predicted in this model where islands or peninsulas of one ethnicity are surrounded by a sea of another (Figure 2.1).

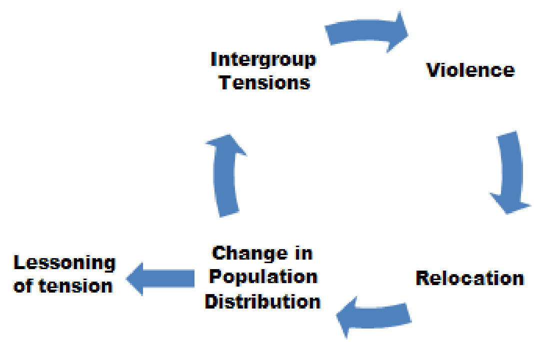

Figure 2.1. The geospatial distribution of the population both affects and is affected by the occurrence of conflict

3. The ERIS Model

The ERIS system integrates Urdal's state-level model as a systems dynamics (SD) model with a micro-level agent-based model (ABM) inspired by Lim et. al. Agents respond to conflict by relocating, which in turn causes the demographic composition of locations to change and alter the inputs to the macro-level model.

SD is an approach to understanding the behavior of complex systems that uses feedback loops, stock & flow diagrams, and delays that affect the entire system over time. SD models provide a high level of abstraction, have less detail than ABM, and are well suited to framing and understanding macro level issues and problems. ABM is a computational approach for simulating dynamic interactions of autonomous agents (or individuals). Agent-based models provide a lower level of abstraction and are well suited for modeling micro level phenomena.

3.1 System Dynamics Model

The initial ERIS design and development focuses on four states in northern India: Jammu & Kashmir, Himachal Pradesh, Punjab, and Haryana, which together comprise 62 districts and 306 sub-districts.

The macro-level, system dynamics model (Figure 3.1) determines whether conflict occurs within a state based on demographic information. There is a SD model for each of the four Indian states, initialized with variables and parameters derived from the Urdal model.

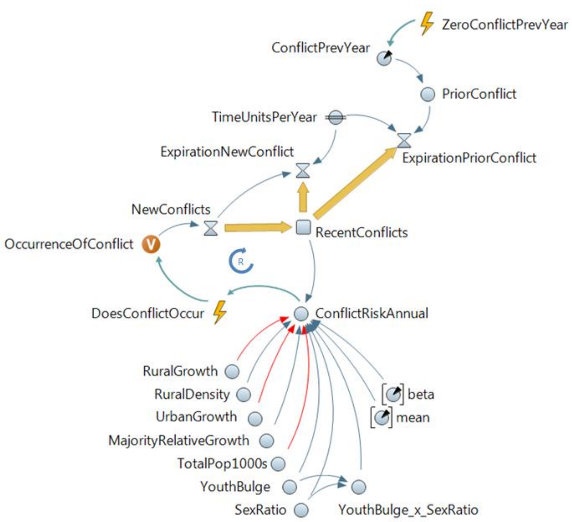

Figure 3.1. System Dynamics model in AnyLogic

The SD model outputs whether conflict occurs within the state as an input to the agent based model. At each time step, the probability of conflict based upon demographic measures derived from the micro-level model (ABM) is computed by the macro-level model (SD). A random draw weighted by this probability is then used to determine whether conflict occurs at the time step. If it does, the conflict stock variable is set to "true"; one year later this state decays and is reset to "false." The system's one-year memory for conflict aligns with a macro-level model input of an indicator of conflict within the previous year.

3.2 Agent Based Model

Agents move over a GIS Map—a shape file of India that includes polygonal representations of the state, district, and sub-district boundaries elected for use in the ERIS system. Agents use true latitude and longitude coordinates to move within the simulation space. Agents move between locations, currently defined as sub-districts. A location matrix determines the "cost" of moving between locations, and agents are allocated a budget that effectively determines their permitted extent of motion.

Agents represent 1000 individuals and are uniform with respect to religious affiliation. Agents are sampled with respect to age and sex ratio; however, skew sampling is used to create agents with different demographic profiles with respect to these attributes. Agents also have attributes to capture propensities to conflict and tolerance, which affect agent behavior and interact in the aggregate with the macro-level model to localize reports of conflict.

A homophily matrix measures tensions between enthnoreligious groups. This matrix is a property of location, and varies from place to place based upon local inter-group conditions and will, in subsequent implementations of the system, dynamically alter as the simulation unfolds. Homophily is used in concert with individual agent propensities to conflict or tolerance in localizing occurrences of conflict and by the logic governing agent movement.

Communication is enabled between agents in direct proximity of one another in anticipation of more complex information transmission and diffusion contemplated for future model development.

3.3 Hybrid Model

The SD model aggregates attributes from the ABM to calculate rural growth, rural density, urban growth, majority relative Hindu growth, total population, youth budge, and sex ratio as additional input variables that affect the probability of conflict occurring within the state. This drives agent movement behavior as intergroup homophily adapts to the presence or absence of conflict. During each time step (currently set to one week), agent tolerance, pressure to move and propensity for violence produce a subset of agents who may chose to change location. The choice of locations is constrained by the location cost matrix and the maximum cost an agent can support. Agent movement logic is comprised of a probability measure that initially determines whether the agent is under sufficient pressure to shift location coupled to a location utility calculation. The utility calculation combines in-group/out-group considerations (the homophily matrix) with transit cost (from the location matrix) and time since instances of conflict at candidate locations. Figure 3.3 shows a snapshot of the hybrid model—the purple links indicate the macro-to-micro and micro-to-macro links.

District level input includes a unique id (Num), the state name (State), the district name (District), total population (TotalPopulation), urban population (UrbanPopulation), rural population (RuralPopulation), the number of males (Males), age ranges (Age0-14, Age15-24, Age25Up, AgeNotStated), and religion (Hindus, Muslims, Christians, Sikhs, Buddhists, Jains, Others, NotStated).

The shape file includes geometry for all the states and districts in India used in this version of the ERIS

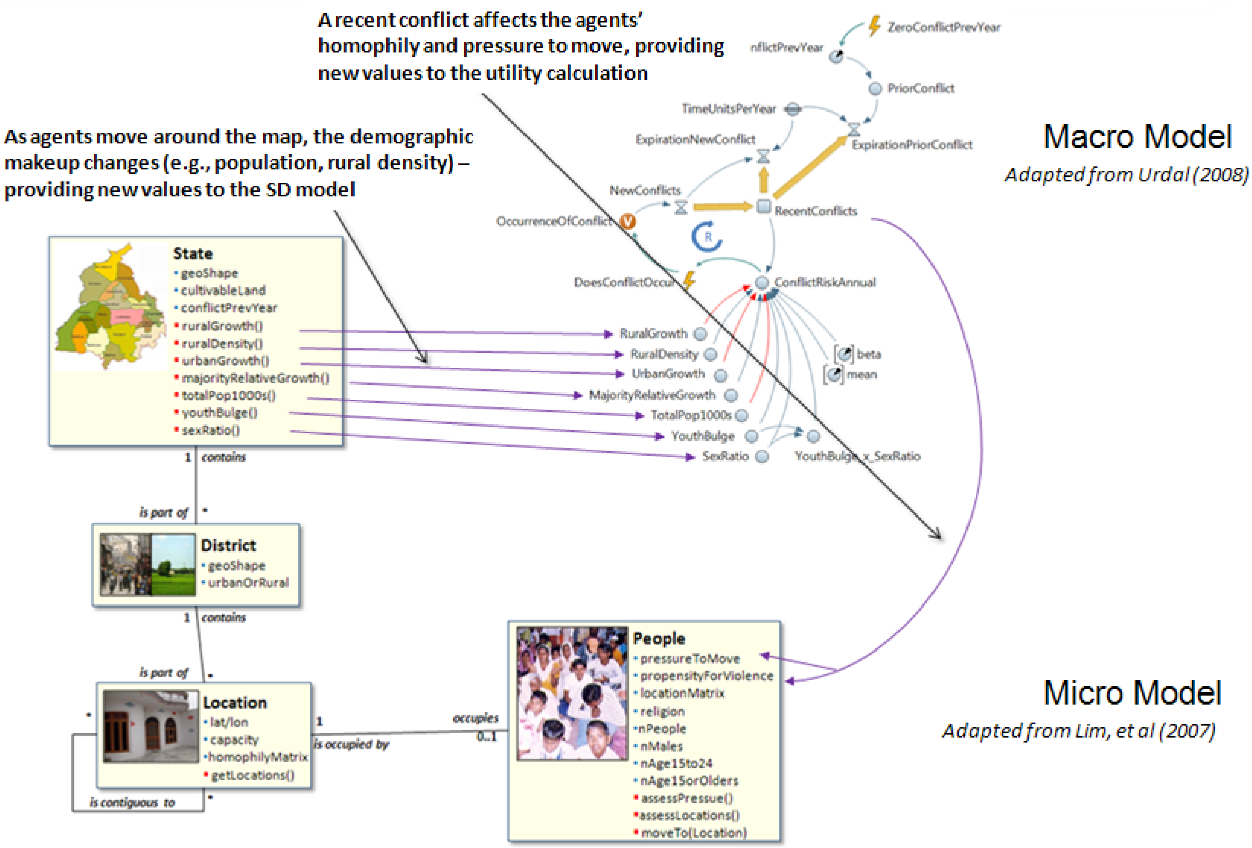

Figure 3.3 Hybrid ERIS model

4. Data, Interface, and Configuration

4.1 Data Design

State level input data includes a unique id (Num), the state name (State), whether or not there was conflict the previous year in that state (ConflictPreviousYear = 1 indicates the presence of conflict during the previous year) and the land available for cultivation (CultivableArea), in hectares.

system (Figure 4.1.1).

Data on Indian states and districts across sources is not consistent. This is particularly challenging for our model due to discrepancies between the census data and the shape file (e.g., shapes without corresponding data, census data for districts not included in the shape file), which forced decisions about those districts to include and those to exclude. The census map showed areas in India covered by the census, with large portions of many districts left uncovered. We assume any districts omitted from the census data were ones where data collection was not physically possible. Population distribution by religion is known at the district level, but not the sub-district level. Much of the available geographic data is in non-geospatial file formats (e.g., tables or other media within PDFs, jpeg maps within documents, HTML tables). This type of data requires significant manual labor to extract into structured format and link to geospatial objects in shape files.

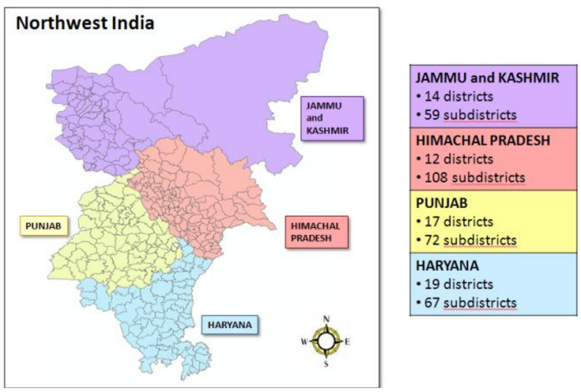

Figure 4.1.1. Geographic scope

4.2 Interface Design

The main interface (Figure 4.2.1) includes the GIS map (shape file of India) that shows agents moving from location to location. Sliders bars can be used to pan the map and there are buttons to zoom in and out. The buttons are used to navigate between the map view, state view (SD model), district view, sub-district view, and person (agent) view.

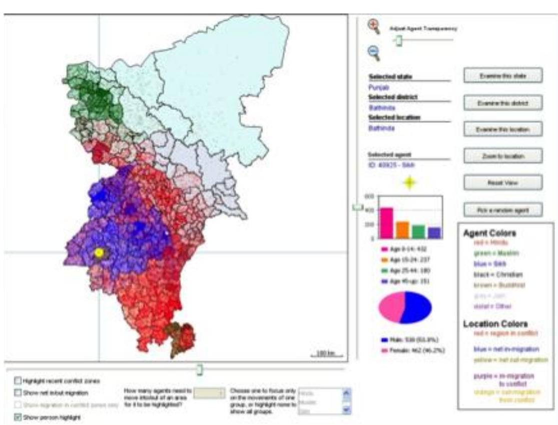

Figure 4.2.1. ERIS – main map interface

4.3 Configuration Design

ERIS currently resides entirely on the analyst's laptop or desktop computer. The AnyLogic Model Development Environment serves as the execution environment for ERIS, providing a platform for model execution, data integration, and visualization and analysis. The ERIS Model, which captures the model's execution logic as well as the graphical analytic interface, is stored as an AnyLogic project file. The datasets for states and districts are stored as Microsoft Excel files, while the map data is stored in an ESRI shape file.

5. Conclusion

ERIS is an evolving project, now in its earliest stages. The development to date has served the dual purpose of advancing the cause of integrating highly nonlinear models of social behavior at multiple levels while unearthing many of the fundamental obstacles to creating such systems, in particular with respect to obtaining and incorporating empirical data suitable to hybrid combinations. This paper presented the design and execution of the current ERIS system and described some of the hurdles confronting this type of endeavor.

6. References

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Author Biographies

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DR. MICHAEL SALWEN is a senior research scientist at NSI, Inc. Prior to working at NSI, Dr. Salwen's professional academic experience centered on mathematics education, with specific focus on the mathematical training of teachers. He served as a Senior Research Associate at MetroMath@CUNY, a Center for Learning and Teaching funded by the National Science Foundation. Outside of academia, Dr. Salwen worked in actuarial research at the Insurance Services Office in New York, where among other projects he was the chief architect of a genetic algorithm-based search of high-dimensional parameter space for insurance premium pricing models. He has also consulted independently on statistical data analysis and online analytic processing and other business intelligence applications. Dr. Salwen holds a Ph.D. in Mathematics from The City University of New York Graduate Center, a B.A. in Mathematics from Hunter College and a B.A. in Politics from New York University.