MODELING SURVIVAL AND CONFLICT IN EAST AFRICA

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ABSTRACT

We developed an agent-based model (ABM) of pastoralists (herders) and private landholders (farmers) in a specific portion of East Africa and conducted experiments to investigate the origins of conflict in the area. The model is based on regional environmental data, human and herd animal basic needs, two herder clans, and basic herder behaviors. Through 100 year experiments, we found that the carrying capacity of the land was increased with additional water wells and greater environmental scarcity led to faster domination by a single clan. We also found that a 20 percent decrease in rainfall over a single year led to the total herd size dropping by 60 percent and with three consecutive years of this level of drought, there is a 90 percent drop. We found that there is little, if any, decline in the herder populations with the introduction of farmers occupying the best land and including the farmers, the carrying capacity of the area is increased by almost a factor of two. In addition, the introduction of farmers provided a barrier between the two clans of herders reducing the previous trend toward hegemony. We are conducting further research to extend this mode to a larger, more diverse region.

PRIMARY TRACK

Understanding and Modeling Human Behaviors.

SECONDARY TRACK

Valid Model Use and Validation.

DESCRIPTION

To study the origins of conflict in East Africa, we selected a representative 150km by 150km area with no cities, towns, lakes, or rivers. The area is occupied primarily by nomadic pastoralists. Pastoralism is a very old method of survival involving moving a family with its grazing animals over the local semi-arid, scrub and grassland in search of food. Peoples have been surviving in this area through these activities for hundreds, thousands, or possibly tens of thousands of years. We modeled their environment, herds, and herd movement decisions to investigate the origins of conflict in the region. The approach we used was to build an agent-based model (ABM)[1] of individual family units and their associated herds in a specific region near the Mandera Triangle, the juncture of Kenya, Somalia, and Ethiopia. With a data-driven model, we ran experiments exploring factors that could lead to conflict.

Our model was develop using MASON[2]. MASON provides a simulation environment in Java with the necessary modeling tools including agent scheduling and visualization. A major strength of MASON is its ability to decouple the visualization such that extensive statistical runs may be made without the encumbrances of their visualization.

Models in MASON, like any ABM, are dependent on three key components: the environment, agents, and interactions between them. We modeled the region as one biome made up of 1km by 1km parcels. Each parcel has a fertility based on satellite data. The rainfall was based on average monthly data, which has two "peaks" annually. These features determine the vegetation available on each parcel. A farmer agent, representing a farming family unit, occupies a parcel and increases the parcel's yield. Pastoralists (herders) represent family units and are of one of two clans. Their survival is dependent on their herd's number and health, which are based on meeting the animals' needs daily. Each day a herder decides where to move the herd. Four factors drive that decision: meeting the herd's water need, need for vegetation, whether the parcel was already occupied, and how far away it is. Herders minimize conflict by avoiding other herders and farmers. If a herder's needs drive the herd into an occupied parcel, one of three results occurs. If the occupier is of the same clan as the incoming herder, they will share (average) their resources. If the occupier is of a different clan, there is a transferring of a portion of the other's resources (representing cattle raiding). Finally, if the occupier is a farmer, the invading herder loses a portion of his herd based on the presumption that the farmer is more able to defend himself. If a herder's resources are lost, the agent is removed. If a herd grows large enough, the herder divides into two herder agents each with half of the herd. A model run is initialized with a number of herders placed randomly over the region and randomly assigned to a clan. Farmers are placed in the parcels with the highest fertility. Finally, a specified number of watering holes are placed randomly over the region.

In the first experiment, we varied the number of watering holes to evaluate the conflict associated with resource scarcity without farmers. As expected, we found that the carrying capacity of the area increased with the increased water sources. Conflict between the two clans appeared to end in almost all runs. However, conflict ended the vast majority of runs because one clan came to completely dominate. These results were presented at the conference on modeling human behavior[4].

In the second experiment, we introduced rainfall variation in the form of periodic year-long droughts and droughts lasting three consecutive years. (A "drought" is an annual rainfall more than 15 percent below the average.) We found that a 20 percent decrease in annual rainfall in a single year led to the total herd size dropping by about 60 percent and with three consecutive years of this level of drought, there is a 90 percent drop. These results were presented at an environmental modeling conference[5].

In the third experiment, we introduced farmers occupying the best land up to the numbers of farms estimated from satellite data. We found that there was little, if any, decline in the herder populations and, including the farmers, the carrying capacity of the area almost doubled. In addition, the introduction of farmers provided something of a barrier between the two clans of herders reducing the previous trend toward dominance by a single group. These results were presented at an international conference on social simulation[6].

The validation of these results has been based on the modeling techniques used, the experimental process, and the peer review of the results. Agent-based modeling is a bottom up approach that models of agents based on first principles and then looks for aggregate or emergent behaviors. Our agents' behaviors are based on lower-level models of herd animals in units of TLU (Tropical Livestock Units) and their daily food intake requirements in kilograms of dry matter and liters of water. The vegetation production is in the same units and is based on observed fertility and rainfall data. The agents' movement rules are based on the key factors affecting their daily decisions. We therefore claim that our model is data driven and based on available literature. Our experimental results are based on 30 runs of our model each for a period of 100 simulated years and we report general trends observable from the overall results. Our model and results have been peer reviewed in three different venues.

Future work will involve a similar but expanded study of the Rift Valley of East Africa, a thousand mile square around Lake Victoria. This area includes many more ethnicities and type of occupations, major and minor cities, major and minor lakes, major and minor rivers, and diverse biomes and climates. It will also include several national governments. With this diverse simulation, we will model many types of conflicts from local, resource driven to international wars.

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BIOGRAPHY

William G. Kennedy is a Research Assistant Professor with the Krasnow Institute for Advanced Study at George Mason University. He holds a B.S. from the U.S. Naval Academy, a M.S. from the Naval PostGraduate School, and a Ph.D. from George Mason University. He is also a retired Navy Captain (30 years of service in submarines and the Naval Reserve) and a retired civil servant (Nuclear Regulatory Commission and U.S. Department of Energy). He joined the Mason faculty in 2008 after a post-doctoral fellowship at the Naval Research Laboratory in cognitive robotics and human-robot interaction. His research interests focus on advancing computational cognitive modeling of human interactions with other intelligent agents and on integrating cognitive science into computational social science. The majority of his research effort is basic research on the use of agent-based modeling to understand conflict and is sponsored by the Office of Naval Research.

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