**Project Brainstorm and Literature Review**

**Harrison Smith**

**02/06/2018**

**Topic Identification**

The phenomenon that I am interested in modeling is farmer decision making in response to climate change. More specifically, I would like to understand how individual decisions made by farmers ultimately results in a complicated and heterogeneous agricultural landscape. This process involves many variables, ranging from an individual farmer’s wealth, land, and access to irrigation, to environmental factors such as rainfall, soil quality, and rate of climate change. Complex systems is therefore ideally suited to address this question because it can provide a more holistic, bottom-up explanatory model that incorporates the complex heterogeneity of farmer decision making. An AMB approach might further enhance our understanding of this issue by giving us insight into what factors at the individual level may become significant for understanding farmer decision making at the landscape level. From this model, I hope to gain a greater understanding of the factors that affect farmer decision-making and more specifically address the potential impacts of climate change on farmer decision-making

**Literature Review (2-3 paragraphs)**

Of particular importance will be the substantive information you expect to use to design of your agents, interactions, and environments.

Understanding the dynamics of farmer decision-making is an important tool for policy and decision makers, and plays a significant role in the process of agricultural adaptation in response to climate change (Howden, 2007). Coming to a definitive understanding of farmer decision-making is difficult, however, because of the fact that farmer decision-making is complex and heterogeneous (Jain 2017). Farmer decision making falls into the category of coupled human and natural systems, which are notoriously difficult to model using more traditional, top down models. For this reason, ABMs are well suited for the study of farmer decision-making (Kramer 2017).

Numerous examples of ABM of famer decision-making can be found in the literature, the majority of which incorporate some economic and social parameters (Acosta-Michlik, 2008; Berger, 2001; Schreinemachers and Berger, 2011; Soman et al., 2008; Troost and Berger, 2014). Each of these models has a specific focus, however, ranging from diffusion of agricultural technology, to environmental interactions in agricultural systems, to agricultural adaptation research. The model I will construct will focus on adaptation, and will be concerned with the effects of climate change on farming.

It is well understood that weather variability poses a significant risk to agriculture, and it is believed to increase the risk of crop failure (Wood et al., 2014; Jain, 2017). Understanding the potential effects of climate change on agriculture and how farmers can adapt to those changes is therefore of particular importance in order to ensure adequate food production. In order to construct my model, I will rely on current literature about agricultural adaptation (Howden 2007; Jain 2017), along with established crop science literature and a survey dataset from India collected by Dr. Meha Jain and her research lab. The survey data includes information on famer wealth, access to water, crop type, sow date, and many more factors.

**Approach**

In it’s most basic form, this model will simply seek to identify how climate change affects sow date among wheat farmers in India. Specifically I will look at how rising temperatures or the associated changes in season (delayed monsoon, for example), may affect when farmers choose to sow their crop. Eventually, I would like to also incorporate other parameters such as wealth, access to water, and the ability to switch crops.

The agents in this model will be farmers, who will base their decisions on both factors inherent to them and on environmental conditions such as temperature. These farmers will therefore have interactions with the environment, and if I am able to accomplish it, will also have interactions with other farmers in close proximity to them. In this case, farmers may decide whether or not to delay sow date based on the decisions of other farmers around them. In order accomplish this I will most likely use a cellular automata typology. This is the most appropriate typology for farmer’s plots which are spatially related to each other. Another option would be to use a GIS, but this is likely beyond my skill level and therefore not appropriate for this project.

In addition, I would also like to program the environment so that there is an option for crop failure. If, for example, farmers choose not to delay their sow date and the monsoon season is delayed, then their crops may have a higher risk of failure. This sort of outcome would be programmed into the environment associated with each farmer. In increasingly complex iterations of this model, I think it would also be interesting to introduce a way to incorporate yields into the model, where farmers with larger plots of land may have large yields and affect their wealth.

In order to construct this model, I will rely on similar models for some insight. Existing models of farmer decision making usually involve economic and social factors, but fewer of them incorporate climate variability. One notable exception is the ABM by Troost and Berger (2014). This model looks at climate change adaptation among farmers in Germany, and how different process may result in varying yield amounts. This model is very similar to what I will be seeking to model, so I will likely use this as the starting point for my model. I will parameterize my ABM using the survey data mentioned previously, collected by the Jain lab.

The model outcome I am most interested in measuring and understanding is when farmers choose to delay their sow date and when they don’t. Additionally, I would also be interested in what factors affect crop failure or success, and what variables might influence crop yield variation.

**References**

Acosta-Michlik, L., & Espaldon, V. (2008). Assessing vulnerability of selected farming communities in the Philippines based on a behavioural model of agent's adaptation to global environmental change. *Global Environmental Change*, *18*(4), 554-563.

Berger, T. (2001). Agent-based spatial models applied to agriculture: a simulation tool for technology diffusion, resource use changes and policy analysis. *Agricultural economics*, *25*(2-3), 245-260.

Berger, Thomas, and Christian Troost. (2014). "Agent‐based Modelling of Climate Adaptation and Mitigation Options in Agriculture." *Journal of Agricultural Economics* 65, no. 2: 323-348.

Jain, M., Naeem, S., Orlove, B., Modi, V., & DeFries, R. S. (2015). Understanding the causes and consequences of differential decision-making in adaptation research: adapting to a delayed monsoon onset in Gujarat, India. *Global Environmental Change*, *31*, 98-109.

Kramer, D., Hartter, J., Boag, A., Jain, M., Stevens, K., Nicholas, K., ... & Liu, J. (2017). Top 40 questions in coupled human and natural systems (CHANS) research. *Ecology and Society*, *22*(2).

Howden, S. M., Soussana, J. F., Tubiello, F. N., Chhetri, N., Dunlop, M., & Meinke, H. (2007). Adapting agriculture to climate change. *Proceedings of the national academy of sciences*, *104*(50), 19691-19696.

Schreinemachers, P., & Berger, T. (2011). An agent-based simulation model of human–environment interactions in agricultural systems. *Environmental Modelling & Software*, *26*(7), 845-859.

Soman, S., Misgna, G., Kraft, S., Lant, C., & Beaulieu, J. (2008). An Agent-Based Model of Multifunctional Agricultural Landscape Using Genetic Algorithms.

Troost, C., & Berger, T. (2014). Dealing with uncertainty in agent-based simulation: farm-level modeling of adaptation to climate change in Southwest Germany. *American Journal of Agricultural Economics*, *97*(3), 833-854.

Wood, S. A., Jina, A. S., Jain, M., Kristjanson, P., & DeFries, R. S. (2014). Smallholder farmer cropping decisions related to climate variability across multiple regions. *Global Environmental Change*, *25*, 163-172.