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Title: Social and Economic Impacts of Irrigation on Smallholder Agriculture in India

Dissemination of irrigation technologies lies at the base of the agricultural development process. If irrigation is being implemented successfully, it has the ability to increase and stabilize yields and to shift production into higher value crops, thus increasing and stabilizing incomes of smallholders; and decreasing poverty rates. Yet, successful implementation of irrigation depends on the farmers' abilities to abandon some traditional practices and adapt new ones instead. The failure to do so have raised criticism regarding the role of irrigation in increasing risk, debt, instability and inequality, thus eroding traditional community structure and safety nets. In extreme cases, such far-reaching socio-economic processes may in turn lead farmers to extreme manifestations of distress in the form of suicide.

The objective of my research is to investigate the socio-economic impacts of irrigation on farmers in India by utilizing suicides as a socio-economic proxy of farmers' distress. First, I will analyze the relationship between irrigation usage on farmer suicide rates. Then I will analyze the role of irrigation in mediating the effects of drought on farmer suicides. By doing so, I hope to contribute important evidence-driven knowledge on the transformative role of irrigation usage on farmer suicides. Assuming suicides are an extreme manifestation of distress that is prevalent within the wider farming community, the analysis may be also relevant for the effects of irrigation on a much larger segment of the population. The investigation will be based on a longitudinal data set consisting of state-year observations of each state in India states between 1995-2014.

Yet, merely analyzing the relationship between irrigation usage and suicides may fail to paint a complete picture of the socio-economic effect of irrigation on farmers, as it does not take into account the adaptation process that farmers face. Even if reaching what some may consider as a very intuitive conclusion of a negative relationship between irrigation usage and farmer suicides, one could not conclusively deduce that increasing irrigation cover will necessarily reduce suicides. There may be many challenges in successfully adopting new irrigation technologies once such are available. My dissertation will therefore also focus on the challenges of adopting new irrigation technologies once they are readily available. I will do so through the analysis of an ambitious irrigation project in the state of Karnataka, called the Ramthal Irrigation Project.

My research will hopefully provide a holistic contribution to the understanding of the challenges and opportunities irrigation on farmer welfare in developing countries; and will assist to devise policy measures to assure effective and sustainable access and adoption of irrigation technologies.

Research Progress

Farmer Suicide: In the past year I have assessed the socio-economic impact of irrigation usage on farmers, by comparing the relation between irrigation cover and farmer suicide rates. Results indicate that higher prevalence of irrigation is related to lower farmer suicide rates. In contrast, irrigation cover does not seem to have any significant relation to suicides among other occupational groups. This provides strong evidence that the effect of irrigation cover on suicides is driven by factors related to farming.

Further analysis reveals that most of the effect is related to variation in canal irrigation cover, rather than well irrigation. This distinction is important because canal irrigation is more favorably distributed among small and marginal farmers, while well irrigation is more advantageous to larger farmers. The fact that canal irrigation is better correlated with farmer suicide may therefore indicate that smaller farmers are more affected by variation in irrigation cover.

I have included in my analysis other potential causes of farmer suicide which were depicted in the academic literature, such as debt, temperature and cultivation of cash crops. While this analysis is still in progress, initial results indicate that the effects of such control on suicide is limited and do not alter the statistical significance of the irrigation coefficients.

This analysis enriches the research which I carried in the academic year of 2017-18 that showed that droughts have a strong causal impact on farmer suicides in India, and that economic mechanisms in the form of irrigation cover are driving the association.

A paper regarding the drought-suicide relationship has been sent to review in a leading scientific journal. I expect to finalize the analysis and writing of the irrigation-suicide chapter in the upcoming months; and to publish a paper in the topic thereafter.

Ramthal Project: In order to assess how access to irrigation affect farmers, who may or may not make use of the irrigation, I am analyzing an ambitious irrigation project in the state of Karnataka, called the Ramthal Irrigation Project. Ramthal project has started operation in September of 2017 and we have conducted a survey between April and August of 2018 to oversee its progress.

Results of the 2018 survey indicate that very few farmers used drip irrigation so far, and accordingly so, there are no statistically significant differences in cultivation and production between project farmers and non-project farmers. Most farmers continued to cultivate the same crops that they cultivated under rainfed conditions. Other crops that are more suitable for irrigated cultivation were hardly harvested. Furthermore, there is no statistically significant increase in the yields due to the use of irrigation. A Sample of the analysis is presented in Figure 1.

I have recently drafted a phone questionnaire that will follow up on the progress of the project after another cultivation season. The survey will be held in the upcoming months.

Correspondence with the project implementors indicate that more farmers have started to use drip irrigation in the past cultivation season. If I will find this to be true, the statistical analysis should yield improved results regarding the ability of farmers to adopt the right cultivation practices, and regarding the challenges and impediments which they face, when provided with advanced irrigation systems. I further intend to enrich the survey data with remotely sensed NDVI data to assess changes in vegetative cover over time.

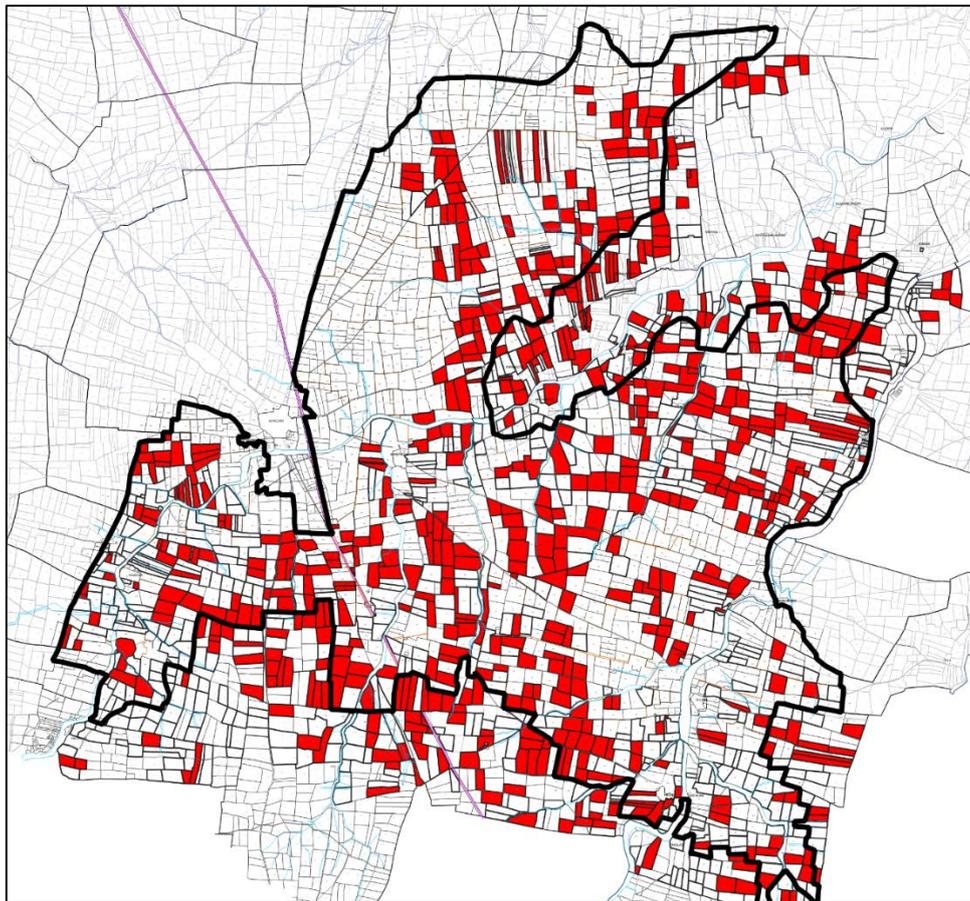


Figure 1. Demonstration of Spatial GIS Analysis of the Project: The black borders represent the project command area. The shaded (unshaded) areas represent survey numbers, within which the sampled farmers cultivated (did not cultivate) Bengal Gram. The results are based on a midline survey that was carried in April 2018, after the first cultivation season under the Ramthal project. Such spatial analysis is also used to analyze the various outcomes of the household surveys, the data that will be provided by the project implementers; and remotely sensed NDVI data. **Analysis of the map:** The implementers of the Ramthal Project aim to shift farmers from cultivation of bengal-gram, which is widely cultivated in the region, to higher value crops with higher returns to irrigation (such as sunflower and maize). The binary indication of bengal-gram cultivation therefore sheds light on whether farmers within the project have adopted different cultivation habits compared to non-project farmers. The map indicates that the cultivation habits of farmers within the project have yet to diverge from the habits of non-project farmers during the first cultivation season.