If the hillock does not survive, the community does not survive: Insights from the SD Winter Institute in Andhra Pradesh

Bambry Xiao
Masha Serdyukova
Washington University in St. Louis
1 Brookings Dr.
St. Louis, MO 63110
(314) 935-5000
zhu.xiao@wustl.edu
masha.serdyukova@gmail.com

Abstract

This paper is a documentation of the process and insights from a two-week intensive course in Andhra Pradesh India through the Winter Institute. This course was attended by students from Washington University in St. Louis, and staff members from the Foundation for Ecological Security based in India. The authors will detail the specific village setting in which the work took place. Next, we will elaborate our research and skill-sharing process using participatory rural appraisal, group model building and systems thinking. This will be followed by an explanation of the reference mode, system dynamics model and results of simulation runs. Finally, we will conclude with the pivotal insights we learned throughout the entire process, and ideas for next steps.

Background

This paper will document the process and insights of an effort that put system dynamics, group model building and participatory rural appraisal techniques in to practice. The goal of this work was to interpret the system related to resource management in Chennappagaripalle, a rural village in Andhra Pradesh province in India. This experience took place during a two week intensive program called the Winter Institute. It was comprised of students from Washington University in St. Louis (WUSTL) in collaboration with employees of the Foundation for Ecological Security (FES). FES is predominantly interested in relieving the weight of chronic poverty due to poor management of resources, particularly through watershed management.

The purpose of the Winter Institute was ultimately to assist the work of FES by incorporating systems thinking and methodology in to their village planning processes, as well as by introducing FES staff to SD skills and modeling. By combining the System Dynamics skills of the WUSTL students, with the PRA expertise of the FES staff, the teams were able to situate SD modeling within participatory research methods. FES staff served as local experts and field visit facilitators/translators and worked with WUSTL students in developing exercises and questions to ask community members that would give us a comprehensive and clear understanding of the systems relevant to the village we were working in. The students served as the expert modelers and taught FES staff how to build models that focus on endogenous factors, how to use Vensim, and also a more scientific approach to gaining system level insights.

The purpose of this paper is to detail the research process, modeling process, and the insights we experienced throughout the two-week institute. First, we begin with an overview of the social setting in which the Winter Institute took place. Followed by a review of relevant literature we then delve deeper in to our process through a discussion of the field work, problem structuring, and the iterative modeling process. After establishing the context, we will discuss our reference mode, model, and simulation results. And finally we will conclude with a detailed account of our insights and limitations, and suggest next steps.

Chennappagaripalle is made up of 57 families, with a population of approximately 219 people. Agriculture has been the main source of income for the families, primarily through groundnut cultivation. However, due to water shortages many are shifting to animal husbandry to stabilize their livelihoods throughout the year. Families are able to sell livestock, and milk to supplement their income.

FES has been working in this village since 1991. Collaboration with the residents of the village has resulted in a strong village institution known as the Tree Growers Cooperative Society (TGCS) that has succeeded in organizing and leveraging grassroots power. For over 20 years this institution has been instrumental in the protection and restoration of a nearby hillock, which the village collectively maintains legal rights to as a result of the work of the TGCS. The institution's tangible victories have motivated village-reported complete participation in the TGCS from all those who are able to. Therefore, through the

village institution the residents are able to have democratic participation in a consensus process that enables the sharing of information, and collective decision making over common resources. Additionally, the TGCS has strengthened the traditional practice of the village fund, which collects a portion of the residents' earnings for projects that benefit the entire village.

The staff of FES is made up of experts in PRA activity facilitation. FES deliberately engages all identified stakeholders in the village planning process through time intensive exercises, and multi-level research that spans oral history to legal documentation. Consequently, the plans developed by FES are comprehensive and sensitive to village life. Additionally, the plans developed by FES are made publically available on the village level for reference in TGC meetings, or whenever necessary. Consequently, the individuals participating in a TGC are able to turn the plan in to a living document that is alterable based on social and biological changes; thereby empowering the community to take control over the TGC once FES staff complete the rigorous facilitation process.

Through the focus groups, conversations and other PRA activities the vision that the community had for itself was illuminated. Most importantly, the participants in our sessions communicated their sense of cohesion and consensus over common resources. The level of information shared and democratic decision-making in the village was extremely high and a point of pride for people. Therefore, this translated to a desire for equitable water, fodder, and non-timber wood product cultivation and usage. For example, it is common knowledge among the people in the village that building more bore-wells will deplete their aquifer, and is not an acceptable option. As a result, people are committed to building more water-catchment structures on the hillock with the help of FES. Therefore, ensuring participation and consent from all the families in decisions related to resources is critical.

Another important aspect to the community's vision relates to their livelihoods. Thus far, the families have been able to be resourceful and adjust their income sources to offset agricultural losses. However, they recognize that their current situation is not ideal because of the depletion of soil quality and their inability to predict future yields, which also relates to droughts and other natural variables that are out of their control. For some individuals, migrating to cities for work opportunities has been an occasional option to increase their yearly income. At this point, the village has very little migration out, and it is largely temporary. So, increasing income opportunities is closely related to the gravity they place on preventing out migration.

The community's desire for more income opportunities is also related to their vision for improved soil fertility. Individuals expressed a hope to become less reliant on cash crops, and the chemical fertilizer associated with their cultivation. Additionally, they would like to have more land used to diversify their harvests and save more for personal use. Another potential avenue to increase income comes from the success of their hillock restoration and preservation efforts. Participants in our activities suggested that the potential for renting more wasteland from the government for restoration purposes in

order to increase fodder, non-timber forest products and water catchment structures is an interesting option for them, and one that they are willing to explore in more detail.

Review of Literature

There is abundant research on the topic of joint forest management (JFM), which is an instrumental strategy in poverty alleviation in rural areas in India. This policy evolved from being primarily run through the government's Forest Department, to include a second model facilitated by non-governmental organizations (NGO) in order to address the numerous critiques of its efficacy and exclusionary tendencies when operated by the state (Baruah 2010). FES has been a crucial player among non-governmental organizations implementing this policy in rural villages and hamlets throughout India. The set of PRA strategies utilized by FES mirrors community forest management systems that have historically been the process for management of forests in these communities (Baruah 2010). This represents an alternative JFM approach, contrasted to the top-down, project based strategy put forth in areas dominated by Forest Department intervention (Baruah 2010).

Evaluations of both models of JFM suggest that FES' methods result in policies that are flexible and relevant to the particular circumstances that exist in the lives of the participants. The effectiveness of PRA in policy planning is in a comprehensive understanding of the needs of individuals, including historical practices and relevant legal concerns (Murali Murthy Ravindranath 2006). Additionally, participatory decision making in village institutions have shown to be more sustainable, transparent, and demonstrate more effective use of resources, as well as more efficient reforestation efforts (Hovmand Yadama 2010). Unlike FES, the Forest Department does not make the research and policies available to the communities in which they work. Consequently, Forest Department plans are rigid and based on specific models that do not incorporate feedback from the individuals impacted by them (Murali Murthy Ravindranath 2006).

JFM is a policy and set of practices that maintains a stable role in the future efforts to alleviate poverty in rural areas (Yadama Hovmand 2010). Consequently, in order to meet the changing environment it is important for the implementation methods to have an iterative and evaluative process imbedded, similar to that which SD requires. JFM claims to increase participation and democratic decision making, however history has shown otherwise in areas where it is implemented by the Forest Department (Conner Deal 2010).

FES has attempted a solution to this problem from its inception by grounding its work in a PRA framework. Moreover, through the Winter Institute FES is improving its efforts for greater inclusion and participation. System's thinking and GMB methods are critical to the organization's answer, particularly in terms of a culturally competent attempt to include women and other marginalized social groups. Our work in Chennapagaripalle was reflective of this intention as the students and FES staff planned exercises that were sensitive to this reality utilizing our respective skill sets.

JFM institutions that are facilitated by NGOs are able to root their village plans in the customs and traditions of the people that are participating through the use of PRA (Scholl 2004). This presents another intuitive opportunity to include SD methods in effectively revealing the most useful leverage points for the policies to focus on. Therefore, integrating system's thinking and group model building in to the regular activities of the TGCSs presents a future that can accommodate iterative policy re-evaluation that can adjust to natural changes in the village. This is unlike typical governmental bureaucratic legal reforms that often perpetuate conflict in this setting, instead of problem solving (Baruah 2010). Therefore, the plans that are grounded in participation become tools owned by the village, and they have the power to adjust them to their needs. Incorporating SD thinking in this process can provide strategies that streamline the plan development process and identify the most critical leverage points to focus policies and maximize desired behavior in the intervention variables.

Another potential benefit of the integration of SD thinking in FES' work is related to the conflicts that naturally arise in democratic, community processes. Utilizing participatory approaches already affords village institutions opportunities to address the problems that arise, unlike those villages that did not involve residents in plans (Murali Murthy Ravindranath 2006). Adding the dimension of modeling to the work may prevent conflicts by identifying the feedback loops involved in the system, and engaging those who live in it.

Methodology

The Winter Institute commenced on January 3rd and ended on January 12 (see Table 1). In that time we conducted field research, and through experiential learning developed models with the FES staff that focused on livelihood and its limits based on initially on water scarcity, and later evolved to consider other resource concerns.

Table 1. Project Timeline

Date	Work
January 3	Intro to Andhra Pradesh region and intro to problem structuring
January 4	Intro to SD, preparing for field visit
January 5	Field visit 1, debrief and begin modeling CLD
January 6	Lecture, develop first Stock and Flow, prep field visit
January 7	Field visit 2, debrief
January 8	Lecture, further develop stock and flow
January 9	Lecture, modeling continues
January 10	Field visit 3, debrief
January 11	Lecture, finishing up final model
January 12	Final Presentation

The first field visit consisted of resource mapping with village men and social mapping with village women. In both activities community members used rangoli (colored chalk) to paint the physical and human resources in the village as they see it. These exercises also helped us start conversations about what resources were lacking and in what areas

problems arose. Our second activity was a transect walk to see the physical space of the village. During this activity we were able to see the hillock that is so vital to the sustainability of the village. It is government owned land rented and managed by the TGCS to ensure fertile grazing land for livestock. To ensure that the hillock constantly provided fodder for livestock the community established and collectively enforced rules that prevented over-grazing, and other behaviors that may harm the vegetation. Additionally FES has worked with the community to build water conservation structures on the hillock while simultaneously increasing plant diversity and quantity. Increased vegetation and water catchment rock beds stop soil erosion and they also allow for groundwater recharge, which ensures that the water table is able to supply for the entire community to consistently water their flocks. We also saw a large dam that was constructed in association with 3 neighboring villages and through the assistance of FES. This dam created a functional lake to improve groundwater recharge, as well as provide a source of water for everyday household and livestock use.


(Figure 1. PRA activity with women)

The second field visit consisted of several PRA activities carefully selected and tailored to answer our questions. The first activity consisted of community members ranking the most pressing problems in their environment. The group differed to the village elders, all men, to answer the questions. Consequently, encouraging women and younger men to participate was key to the successful accumulation of data. They ranked four main problems: unstable electricity, lack of work, no rain and agriculture. The FES facilitator then asked the participant's evaluate on a one to one basis which problem was more pressing than the other. The problem that was consistently rated above the rest was lack of work. This data helped us structure our model based on lack of work and interest in increasing wealth became our focus. Next we had the community participants build their own cause and effect chart, asking them to consider what conditions reduce the availability of work, and what the consequences of lack of work are. We also had a questionnaire prepared to help us elicit more specific information about the pricing of livestock and average lifespan, data that would allow us to build the necessary equations. These PRA exercises are all techniques that FES expertly employs to establish a comprehensive understanding of the community's strengths and needs.


(Figure 2. Modeling with the village)

In the third field visit we presented the community with a nascent causal-loop diagram (CLD) written in Telegu, the local language. This CLD served as a dialogue tool based on the stock and flow we had developed. We were particularly interested in developing our understanding of collective action as it pertains to the feedback loops contributing to livelihood. We recognized that cooperation was integral to their success as a community and we wanted to explore their notions of collectivized power through the TGCS. We also had a questionnaire prepared for this field visit in order to collect crucial data that to build equations in the modeling process. Upon completing these tasks we took a walk through the village with community members and were invited in to in their homes. Social activities like this assist the development of relationships and trust, which would improve the outcomes of further field visits.


(Figure 3. PRA focus group discussion)

System Dynamics Modeling

As part of the Winter Institute we were taught the concept of problem structuring as a way to guide the groups understanding of the models function and purpose. The problem structuring chart shows the way problems are framed on two spectrums (Appendix A).

The vertical has to do with whether the community's problems are radical or regulatory within common views of society, while the horizontal deals with community's problems based on a spectrum from objective to subjective views of social science. We understood our community's problem- wanting more work- as an analysis problem. It is situated in the regulatory side of society because it is limited by inability to produce a high export crop yield due to a decrease in soil fertility over time as an effect of fertilizer and high yield crops subsidized by the Indian government. The problem is positioned in objective views of social science because the aim of the modeling process was to find leverage points that were found amongst objective facts of societal limits. Finding the right leverage points, for the community, involves seeing the structures in which they exist that limit their ability to increase income.

Description of the Reference Mode and Model

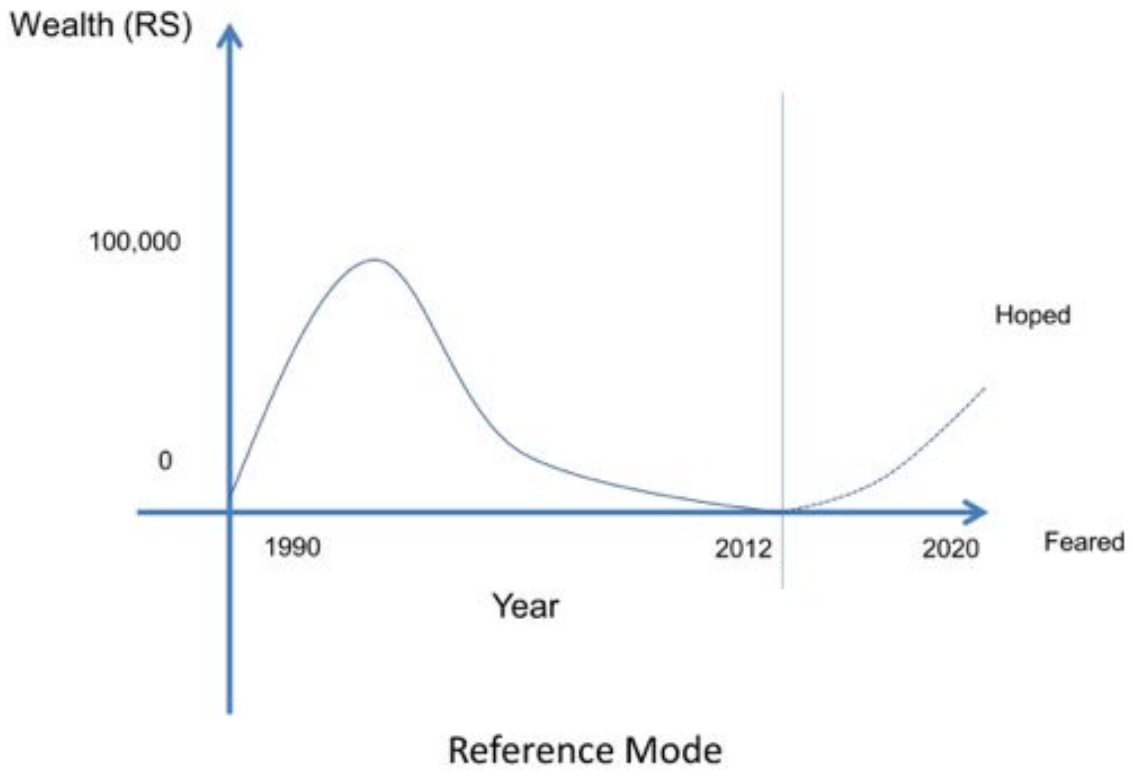


Figure 5. Reference Mode

For the reference mode, we regarded increasing wealth for households as the priority issue to address in the village because it determined villagers' well-being. More specifically, since villagers switched to livestock as a coping strategy to the loss of yield, they are converting their wealth to the ability of buying new stocks. Different from the terminology used by asset-building researchers, debt and some substantial assets (like electric appliances, furniture) are currently out of discussion (but should be addressed in the future). With the unit of Rupees, wealth was regarded as a stock in the model, and was defined as the average amount of money that is accumulated throughout years for

each household. It has inflows and an outflow, which represent income and expenditure. To illustrate the reference mode, initially the switch to chemical fertilizer caused an increase in wealth but as chemical fertilizer continued to be used, it began degrading soil fertility. Soil fertility is now so low no matter how much chemical fertilizer is used, the yield cannot increase and so the villagers have switched to livestock to stabilize their wealth. The behavior of wealth has been goal seeking, and is now stagnant but they hope it will increase.

After much deliberation we arrived at the following model (see Figure 4). It tells the story of two competing feedback loops. The first loop models the relationship of fertilizer on soil fertility, measured in yield. As fertilizer is first applied it increases yield and a reinforcing loop is created. Over time the fertilizer and the mono-crop agriculture exhausts the soil and yield decreases thus creating a balancing loop and this change in behavior is represented as a delay. The dynamic that we are interested in is that the cost of fertilizer (and seed) is now more expensive than the income generated from yield and so agriculture becomes a drain on wealth for families.

The second loop is one that models animal husbandry. It is a reinforcing loop that allows families to raise livestock, make a profit and eventually reinvest. This profit is made possible by collective action. The community protects their communal land (the hillock) by monitoring and limiting grazing and maintaining the watershed system through planting vegetation and building water conservation structures. In doing so they ensure that there is enough fodder and water to raise healthy sheep for sale and healthy cows, which provide quality milk for sale. The relationship between these two loops is that they even each other out and families break even at the end of year.

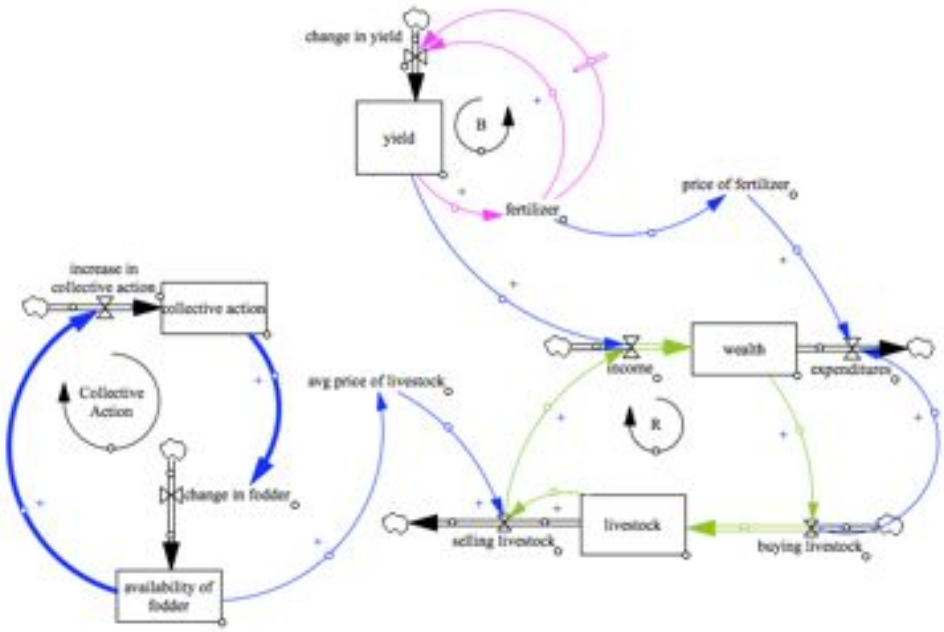


Figure 4. Simplified Model

The above figure shows a simplified form of our model[1]. The model is composed of five stock and flow structures. Stocks include yield, livestock, availability of fodder, collective action and wealth. Yield and livestock are essential to wealth as they pertain to income and expenditure. Though the dynamic interaction between yield and fertilizer was significantly affecting wealth approximately 10 years ago, its impact has been leveraged since families adopted raising livelihood as a living strategy. With that being said, farming activity is still playing an important role in villager's daily life, and the loss from agriculture is affecting households' wealth, and further influencing their ability to invest on livestock.

One essential dynamic takes place among the structures of livestock, availability of fodder, collective action and wealth. As mentioned, collective action is the coping mechanism in managing fodder in the village for livestock as it pertains to resource conservation. As the availability of fodder goes up, the average price of livestock and milk is also going up because the current market price is depending on the weight and productivity of each livestock. As a result, the income from livestock should go up and increase household's wealth.

[1] This is not an actual model but for the convenience of explaining the main feedback loops in our model

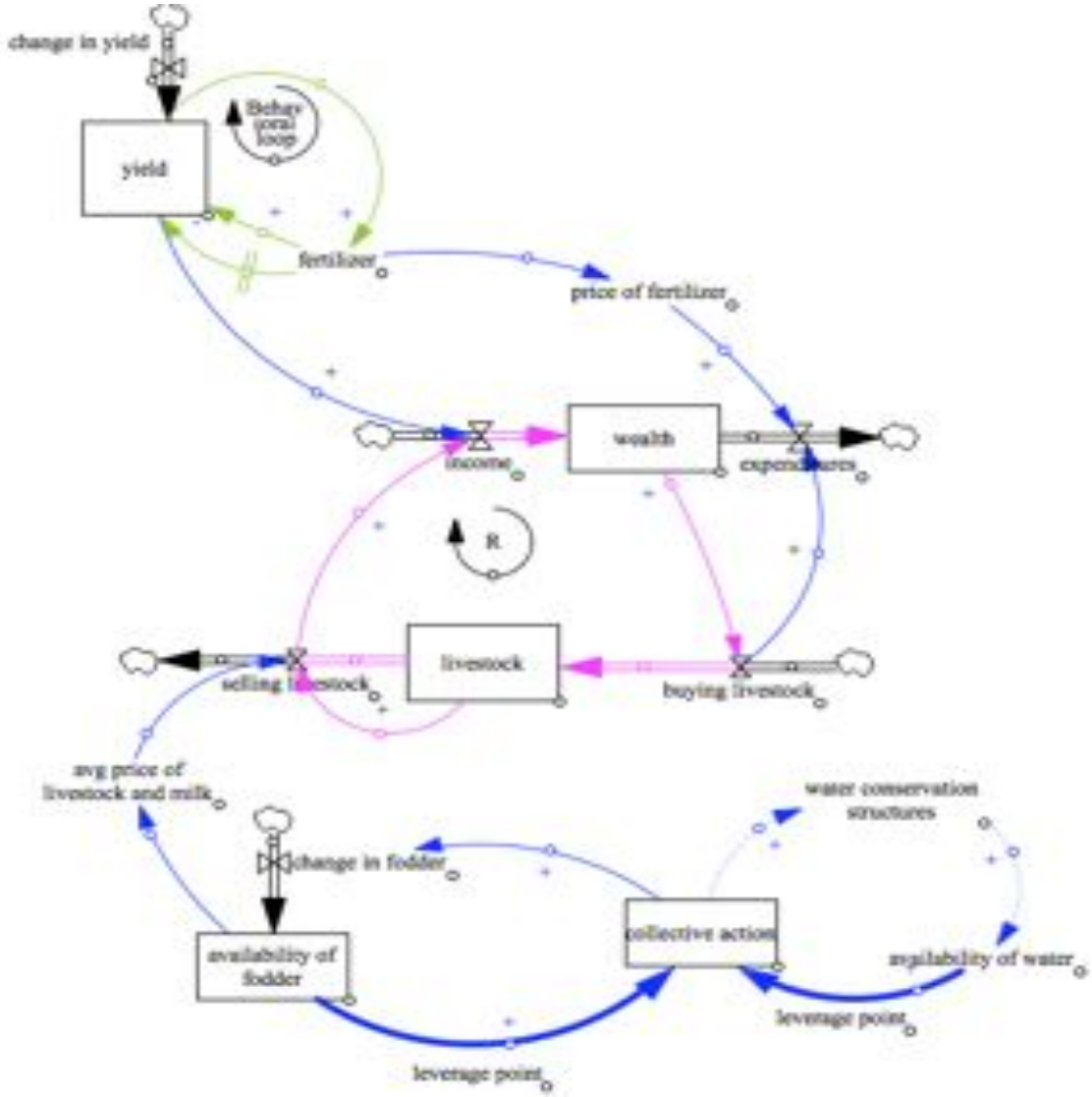
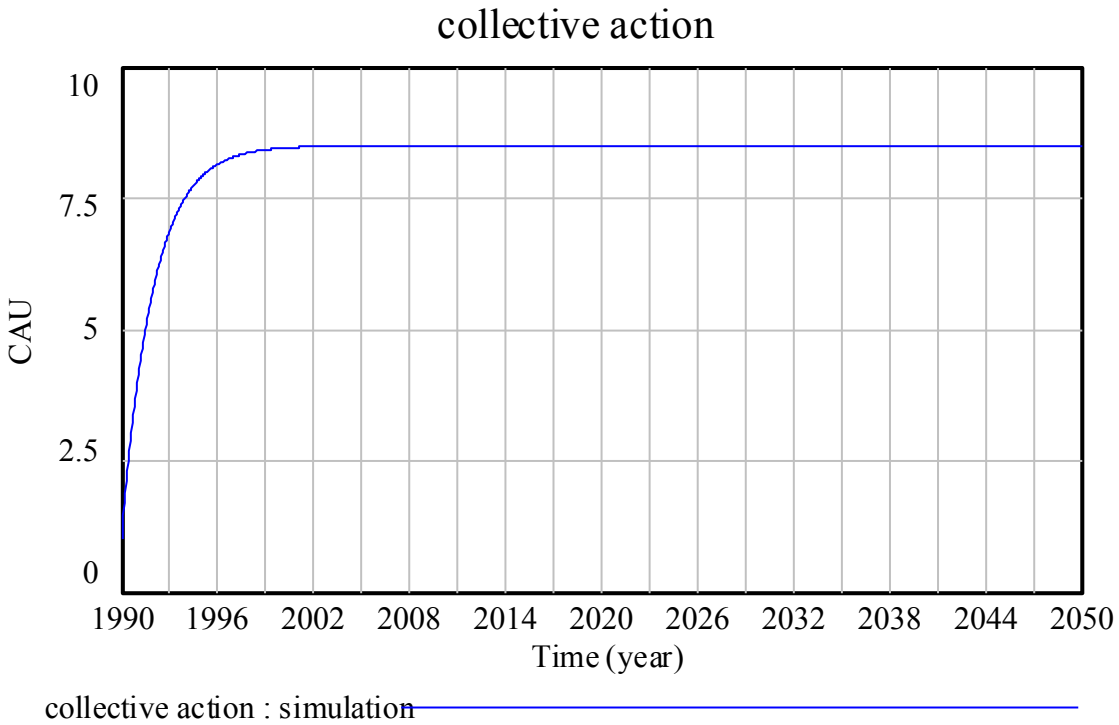


Figure 5. Conceptually Simplified Model

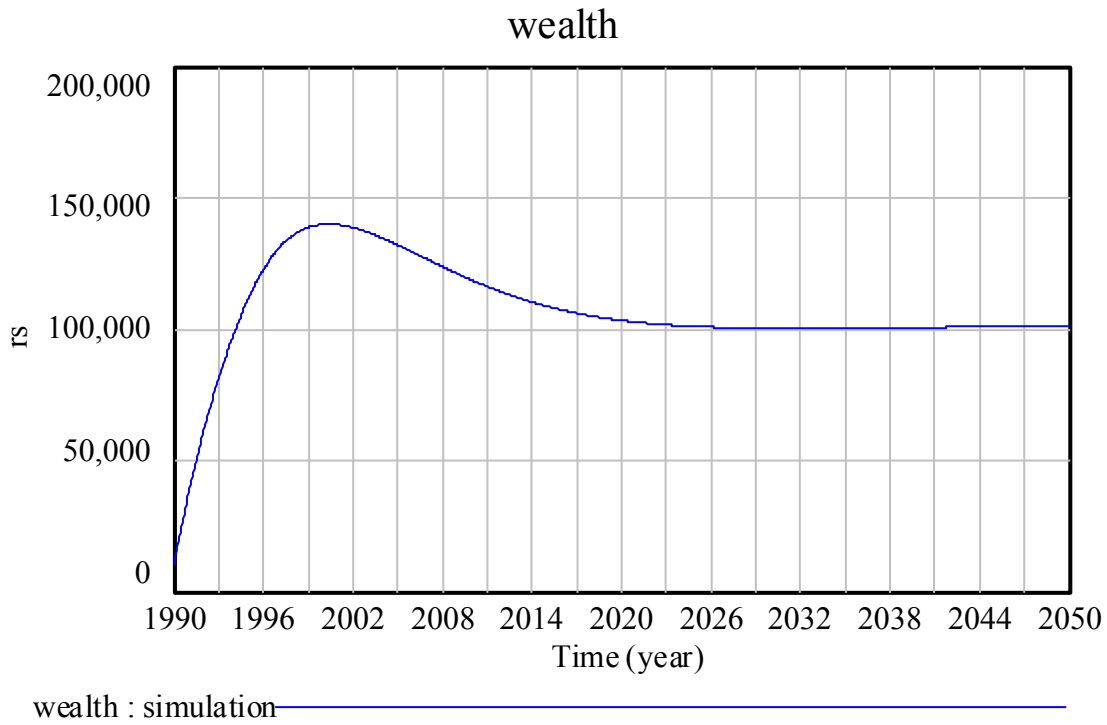
It should be noted that what allows the reinforcing feedback loop between the livestock and wealth structure is the collective action. In this model, our focus should be leaning toward checking how collective action is ultimately affecting wealth. However, it is challenging to model collective action as endogenous by figuring out how it is interacting with people's incentive to participate in collective action. More specifically, the question to ask here is how villagers are incentivized to devote themselves to collective action. This topic has not been fully addressed during our visit to the village. Another thing is that managing fodder is not the only activity in the TGCS. While they help build the water conservation structures to help village restore water, this structure should also be included as a key leverage point. To illustrate, we used a dotted line and bold lines to point out these missing links in our actual model, hoping that they will be addressed in the future (see Figure 5).

Simulation



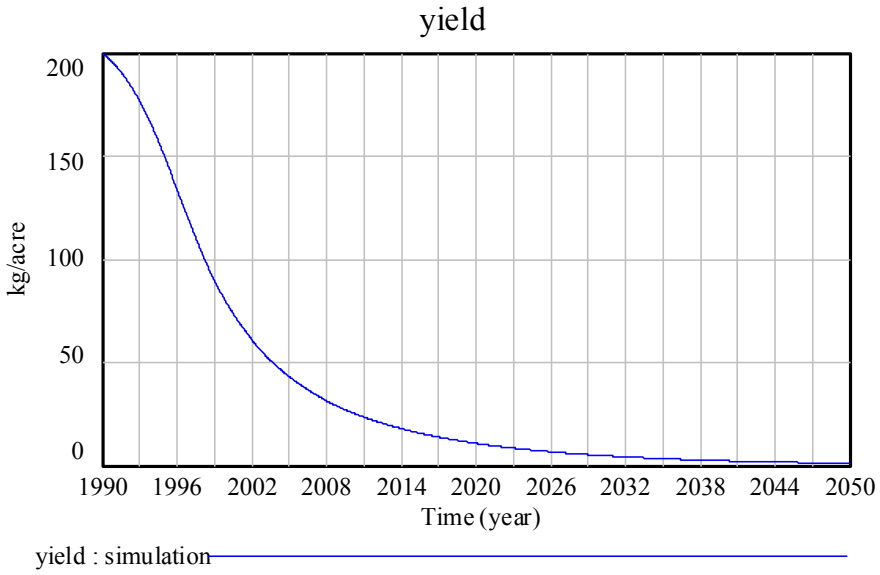
Graph 1. Collective action over time

Collective action (see Graph 1) was modeled through a scale from 0 to 10. It is now showing a goal seeking behavior implying that it is reaching its upper limit. In this village in particular, it seems that TGCS is reaching its full capacity by sustaining the effectiveness from current projects. As a result, it raised the availability of fodder in the first few years, and increased the average selling price of livestock from 1990 to 2000.

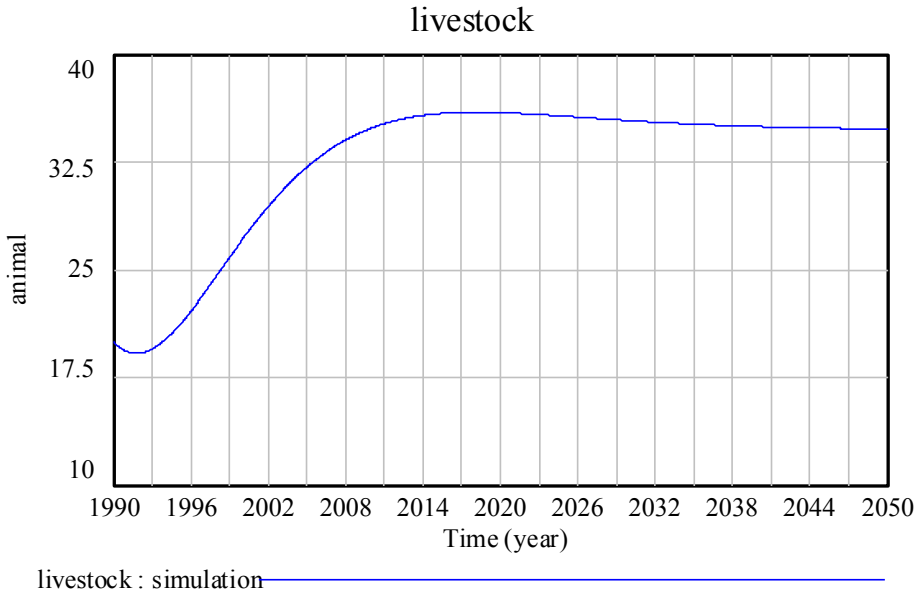


Graph 2. Wealth over time

Highlighting the behavior of wealth over time, it is reflecting the behavior trend we expected from the reference mode (see graph 2). We treated it as a stock because we think its accumulating throughout years depending on families' income and expenditures in each year. In the simulation, wealth went up for the first few years. As the yield decreases due to continued loss in soil fertility, families turned to livestock to offset losses. Collective action initially had a positive impact because it increased the market price for livestock by effectively manages resources, thus resulting in more livestock income. However, wealth came down and stagnated after 1998 (see Graph 2) because of the continuing loss from agriculture, while income from livestock did not fully compensate the loss (see Graph 3, 4). From this model we can conclude that collective action helped the community to maintain livestock income within a specific time range, but was not able to save recuperate the losses over time. It should be noted that we did not fully model the villagers' other income resources in the structure such as non-agriculture income, labor wages, welfare allowances, small business, etc. Consequently, we did not fully model all the living expenses that contribute to the outflow of wealth on daily basis. We did not include these in the model because we were unable to model the complexity in all of their financial systems. Furthermore, we also did not take into family assets in to consideration (furniture, house, and livestock) that also make up wealth.



Graph 3 Yield over time



Graph 4 Livestock over time

Discussion and Next Steps

The key insight is about collective action. This insight emphasizes what FES has already shown through TGCS organizing; that cooperatives are structures that lessen the burden of drought and poverty. This insight is reflected in the representation of community action in a stock and flow model where it further articulates they way it enables a steady income from livestock, and also reveals the insight that cooperation has the potential to uncover other leverage points in the future. It also allows the community to get perspective from the day-to-day realities such as the debt scheme in which they are

entrenched that involves buying seeds and fertilizer. A systems view allows them to visualize such specific strains on the larger system and to think about how community action could help a desired transition from export crops to a more sustainable form of agriculture, or how the community could use the cooperative to sell crops that are less intensive for the soil. The community may also see the cooperative's potential to allow them to become less dependent on agriculture despite their deeply rooted identity as farmers. This would allow the land to recover and in the interim the potential to rent more land to protect from the government allowing them to focus on livestock.

A non-SD insight gained from simply spending time in the village was that there is power in community cooperation. Many neighboring villages were experiencing population decline. Parents were sending their children to work in cities as the future of farming in the region was looking less possible. In the PRA process, the Chennappagaripalle explained that there was virtually no migration out of the village. They explained that the hillock provided enough fodder to ensure that all the families had sufficient food for livestock, providing a steady income from the sale of milk and sheep. The collective action and retention was a reinforcing loop as village members became dedicated and enhanced by the cooperative, they took care of each other and the collective took care of the individual. Spending time in the village made us reflect on the value that comes with an organized supportive community model.

The primary purpose for FES to host the WI was to incorporate SD models and insights from the institute into their VPPs for the selected villages. As mentioned elsewhere, SD lends itself very well to creating a holistic resource management model village perspective planning as planning is about creating that maps the web of resources and relationships into a development plan for villages. It is a process-oriented approach and so through engaging the community in discussion and planning, a shared reality is established and a common understanding of needs and solutions is too. The same can be said for group modeling building using SD.

FES employs the LEAP method to implement VPP: learn about the issue; experience and evaluate the knowledge; adapt to knowledge; promote the knowledge. Because the VPP attempts to give communities a systems view, SD can help with every step of this method whether it is a means to learning and evaluating the system or adapting and promoting it. Additionally, the methods used to bring the community to a systems-level awareness are methods that lend themselves to SD modelers who are working with groups including: direct and participant observations, semi-structured interviews, analytical games, PRA exercises, stories and portraits, diagrams and maps, and workshops. All provide necessary information to create a correct yet simplified model that reproduces behavior and captures the feedback loops that drive it.

SD is a particularly interesting tool for analyzing systems and designing intervention plans with communities. Using feedback perspective, SD models visualize the behavior and offer a helpful place to start the conversation about whether the system modeled is accurate and why. Additionally, a benefit of simulation is that policies and interventions can be tested resulting in better investment decisions that will address root causes. Once

the model is built it offers a common ground to discuss interventions and leverage points within a community because all involved share a similar reference point for system behavior.

Our model is one that can be used to tell the story of rural Indian farmers who face decreasing soil fertility and increased reliance on livestock. This model can be shared with communities to explain the position for greater protection of collectively managed land, and how that can support the livelihood of the entire community. Additionally, it can serve as an example for FES when approaching new communities to establish cooperatives.

As student modelers, our next step is to refine the model in order to better identify and test interventions and policies in Vensim. At this juncture, our recommendation for FES' future work in this village is based on what the strength we observed in the village institution. Farmers will not change their occupations, and it is not our role to suggest such a drastic change, therefore we recommend that the village utilize their community institution in novel ways to further uphold their livelihood and improve sustainable management of resources.

Self-Reflection and Feedback

When building models with communities it is important to be aware of the scale of the problem, being sure to place it in relation to factors within, as well as consider those beyond the control of the community. This also leads modelers to the desired insights as it helps reveal the communities leverage points in relation to the forces that they see as disabling. Keeping in mind that Systems Dynamics focuses on an endogenous perspective is helpful in establishing the correct scale as well because, for example, rainfall is exogenous and therefore it is not a helpful leverage point. Seed subsidies may also be exogenous but modelers may be inclined to include them because they provide an integral pressure that shifts behavior of farmers to purchase these seeds and the necessary fertilizer. But the most helpful scale, if one's reference mode emphasizes income, is to focus strictly on yield and what creates a decline over time in income.

A critical insight for our team was to understand that creating a properly simulating model should not necessarily be the end goal when working with communities. If we are applying SD to problem solve and to help communities gain perspective on the implicit feedback structures that create delays and vicious loops, then it is the questions we ask of and modeling process that is most useful. It is the discussion that spurs when we must decide where model boundaries lie. It is about distilling problems into a reference mode that brings clarity to attainable goals and possible barriers. For example, we struggled to figure out whether we should represent fertilizer and yield as stocks, or auxiliaries, or whether we model the behavior using a table function, or using two distinct feedback loops, one with a delay. Ultimately the behavior produced from our model was less important than the insights this decision making process afforded us. In having to adjust the scale and explore different model boundaries, larger understandings of systemic oppression came to light that contributed to the accuracy of our model; but, more

importantly such insights encouraged the team to think about leverage points that lead to intervening in terms of social issues and access to power.

For the FES staff the process is helpful as well because of SD's focus on the endogenous perspective. Implicit feedback loops are hard to detect and so learning SD allows FES staff to build a system level view, communicate that story and ultimately change mental models. It also allows them to hold the dynamics in their proper place. For example model building allows them to see that resilience is a characteristic of a system and not a factor within it or to understand that biodiversity is a product of a system that functions properly. It also allows them to more precisely think about collective action, an establishment that is central to their interventions through understanding how it relates to behavior trends. This helps change mental models of FES staff and mental models of the communities they work with.

The insights from our work in Chennapagaripalle principally reveal an intuitive direction to improve upon the successes achieved by FES. Systems thinking and group model building can contribute to village planning, policy implementation, and iterative evaluation of the systems involved in resource management. The main leverage point for the utility of SD in these contexts is through community empowerment and an emphasis on collective action as an endogenous variable in the system.

Our work illustrated that shifting focus to such intangible variables as critical components of the system highlighted useful leverage points and supported innovative thinking in our group activities with the village. Specifically, in terms of resource management SD has the potential to focus time intensive planning processes by clarifying the behavior of a system over time. As well as providing an opportunity to test reforestation techniques to make successful and transparent policy decisions.

Ultimately, model behavior is less important that the insights we came up with because most of the variables are dependent on external forces. This idea is consistent with Harich's (2010) analysis of failure of historical environmental interventions that target individual behavior instead of root system failures. The implications of that study support the notion that collective action is the solution to social, specifically sustainability, issues. While it is important to understand how the relationships play out to improve or impoverish the lives of people, ultimately the strongest leverage point comes from collective action. Therefore, collective action is a useful variable to include because it is something that people have the most control over.

References

Baruah, Mitul. "Joint Forest Management (JFM) and Role of NGOs: Cases from Rajasthan, India." PhD diss., State University of New York, College of Environmental Science and Forestry, Syracuse, NY, 2010.

Conner, D., A. Deal, et al. (2010). The Livelihood-Energy-Conservation Nexus: Intervention strategies to promote conservation in forest villages. Proceedings of the 28th International Conference of the System Dynamics Society. Seoul, Korea, System Dynamics Society.

Hovmand, P., G. Yadama, et al. (2010). Combining Group Model Building and Participatory Rural Appraisal in Southeast Rural India. Proceedings of the 28th International Conference of the System Dynamics Society. Seoul, Korea, System Dynamics Society.

Kuhlberg, J., P. Hovmand, et al. (2012). Transdisciplinary Learning in Rural India: Reflections and Considerations from an Intensive Two-Week Course. Proceedings of the 30th International Conference of the System Dynamics Society. E. Husemann and D. Lane. St. Gallen, Switzerland, System Dynamics Society.

Murali, K.S., Indu K. Murthy, and N. H. Ravindranath (2006). Sustainable community forest management systems: A study on community forest management and joint forest management institutions in India. *International Review for Environmental Strategies* 6:23-40.

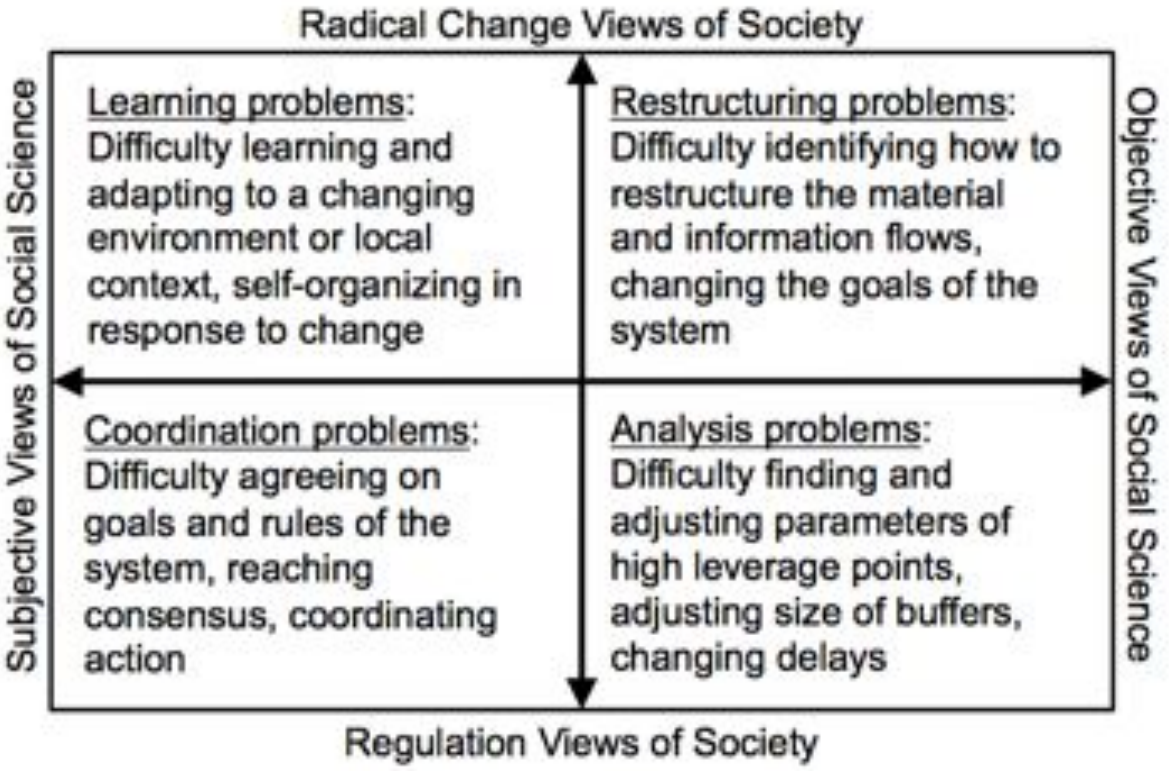
Scholl, H. J. (2004). Can System Dynamics Models Have Greater Relevance to Practice When Used within Participatory Action Research Designs? Proceedings of the 22nd International Conference of the System Dynamics Society. Oxford, England, The System Dynamics Society.

Yadama, G., P. Hovmand, et al. (2010). Community Driven Modeling of Social-Ecological Systems: Lessons from Andhra Pradesh, India. Proceedings of the 28th International Conference of the System Dynamics Society. Seoul, Korea, System Dynamics Society.

Acknowledgements

The authors would like to acknowledge the tremendous staff of the Foundation for Ecological Security; all those who participated in the Winter Institute, and in particular Snigdha, Raman, Siddharth, and Raghu. Additionally, we would like to thank the instructional team: Peter Hovmand, Guatam Yadama, and Jill Kuhlburg.

APPENDIX A: Problem Structuring Chart



Adapted from Burrell, G., & Morgan, G. (1979). *Sociological paradigms and organizational analysis: Elements of sociology of corporate life. London: Heinemann;* Lane, D. C. (1999). Social Theory and system dynamics practice. *Journal of Operational Research Society, 113, 501---527;* and, Meadows, D. (1999). *Leverage points: places to intervene in a system.* Hartland, VT: The Sustainability institute.

APPENDIX B: Full Model