The Initial Study of Evaluating the Energy Needs of the Poorest of the Poor (PoP) Farmers using Community Managed Sustainable Agriculture (CMSA) in Andhra Pradesh

Summary Report

March 14, 2011

Center for Study of Science, Technology, and Policy

Dr. Niveditha Menon niveditha@cstep.in
Mr. N.S. Suresh suresh@cstep.in
Mr. Badri S. Rao badri@cstep.in
Dr. Eswaran Subramanium sub@cstep.in
Dr. Robin Ann King robin@cstep.in
Dr. Anshu Bharadwaj anshu@cstep.in

EXECUTIVE SUMMARY

The main focus of this study was to investigate the sociological, institutional, technical, and economic aspects of energy use and consumption of the Poorest of the Poor (PoP) families in rural Andhra Pradesh (AP). These families are considered to be the most vulnerable in the rural areas of AP, and most often than not, do not have reliable access to various amenities such as electricity, water, and other fuels. There is a real need to provide them with local energy options to avoid the vagaries and uncertainties of getting power from centralized power stations. Additionally, there is a need to create drudgery-reducing and life-enhancing tools for these families.

The study was also conceptualised to act as a base for further investigation to integrate these local household energy needs and sources with Community Managed Sustainable Agriculture (CMSA) practices in Andhra Pradesh. It also aimed to integrate and evaluate the current energy needs of PoP families in the context of their current lifestyle, the sources of energy, potential needs and aspirations for an enhanced lifestyle, with the help of existing infrastructural and agricultural practices (such as CMSA) in AP.

We found that most of the respondents pointed to water for their household and agricultural lands, sanitation facilities, proper roads, as well as LPG for cooking as their major requirements. They also reported that infrastructural issues such as access to proper roads, water tanks (for regular water supply), proper sanitation facilities, and drainage systems were some of the main problems that they face. According to them, their quality of life would greatly improve if these minimal infrastructural facilities were provided to the villages. These basic infrastructural facilities are likely to be the starting point that is likely to bring relief to the main problems of the villagers. The overall consensus with respect to future aspirations was the security of income that sufficient land and agricultural water promised. It was assessed that if the security of income was provided, they would be able to purchase any amenities that they found lacking in the household.

As in the case of CMSA, energy interventions are an input to livelihoods and a way to reduce drudgery and improve quality of life. So, working to develop energy and livelihood possibilities will require creative design. So, any energy intervention cannot be treated merely as an addition, but as an enabling service. Therefore, it is important to have necessarily a level of infrastructural, human, and financial capabilities in place before any intervention can be successfully created and sustained. Moreover, with any of the energy interventions, the need for a technology does not necessarily translate into demand for the technology. Therefore, the energy intervention has to be reliable and robust in order to be translated into more economic opportunities.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

The main focus of this Initial Study was to investigate the sociological, institutional, technical, and economic aspects of energy use and consumption of the Poorest of the Poor (PoP) families in rural Andhra Pradesh (AP). These families are considered to be the most vulnerable in the rural areas of AP, and more often than not, do not have reliable access to various amenities such as electricity, water, and other fuels. There is a real need to provide them with local energy options to avoid the vagaries and uncertainties of getting power from centralized power stations. Additionally, there is a need to create drudgery-reducing and life-enhancing tools for these families.

The initial study was conceptualised to act as a base for further investigation to integrate these local household energy needs and sources with Community Managed Sustainable Agriculture (CMSA) practices in Andhra Pradesh. CMSA in Andhra Pradesh has been employed for over six years with a federated institutional structure consisting of Self-Help Groups (SHGs) and farmer groups at the village and district levels. Institutions have been designed to provide services such as training in farming, seed, bio-fertilizer and pesticide production along with credit facilities and other services that allow for free exchange of knowledge in the community.

So, this initial study aimed to integrate and evaluate the current energy needs of PoP families in the context of their current lifestyle, the sources of energy, potential needs and aspirations for an enhanced lifestyle, with the help of existing infrastructural and agricultural practices (such as CMSA) in AP.

Genesis of the Initial Study:

The Center for Study of Science, Technology, and Policy conducted this initial study on the behest of The Society for Elimination of Rural Poverty (SERP), a non-profit society of the Government of Andhra Pradesh funded by the World Bank. SERP, apart from successfully introducing CMSA practices, has helped create a federated infrastructure that has enabled and expanded the service delivery of governmental and non-governmental schemes to SHGs of all districts of AP.

With respect to CMSA practices, SERP has ensured that all pesticides are created from bio-resources (leaves from Neem and other plants), bio-residues, and farm animal waste (specifically from cattle). Women, through self-help groups (SHGs), produce and market these fertilizers to farmers. Farmer incomes have increased to uplift them out of poverty, and the area under cultivation has increased from 400 to 1.8 million acres over the last seven years. SERP has plans to scale their reach of SHGs and CMSA practices to the entire state.

It was soon realized, within SERP, that when scaled up, these techniques could provide substantial CO_2 reduction and fixing of soil carbon. Given that bio-fertilizers are energy intensive and any carbon-reducing initiatives, they are likely to bring in more subsidies for poor farmers. To investigate this possibility, it was decided that a preliminary study be done at the ground-level to understand the impact of CMSA practices on the life of poor farmers, and to understand whether their energy needs can be combined with CMSA practices so as to bring about a better quality of life for poor families. Thus, CSTEP with the support of SERP evaluated the possibility of creating new energy solutions by studying the energy needs and consumption of poor farmer and families, in the current sociological, institutional, technological, and economic context of Andhra Pradesh.

Structure of the Final Report:

This final report prepared by CSTEP begins by essaying out the main conceptual framework followed by a description of the methodology that will best fit this conceptual framework. Then, the field visits to the districts of Karimnagar, Kurnool, and Vijayanagaram will be described along with some of the major findings from each visit. A brief analysis of the findings and the implications for the energy analysis will be explained. A conceptual systems dynamics model linking the energy analysis and existing solutions will be illustrated, the utility of which will be presented in a case study from one of the field visits. The report will end with the institutional issues that might affect implementation, along with the future possibilities for small-scale and large-scale energy interventions in the small and large scale in Andhra Pradesh.

CONCEPTUAL FRAMEWORK

There are three factors that are critical in the understanding of sustainable energy solutions to the PoP families: technological needs and resources, current and aspirational capabilities and lifestyle, and the institutional frameworks that can support sustainable solutions. Since the previous programs led by SERP have been modelled on a positive-rights-based approach (wherein each of the programs have been directed and implemented by the families that use them), it is necessary to understand the complete lifestyle of the families that will ultimately benefit from any energy innovations in the area. For this to happen, the current technological amenities as well as the current needs of the families have to be first assessed.

Additionally, given that the SERP has a prevailing model of distributing services that is both extensive and intensive, it is important to understand the institutional frameworks that can help scaling up of a participatory, rights-based, and bottom-up model in a self-sustaining manner. Thus, while assessing the energy needs for the model, ample consideration will have to be given to the particular geographical, cultural, structural resources and considerations. The study, therefore, can be divided into the following tasks.

Project Tasks:

1. An anthropological and sociological study of the social context of the farms to examine the social and cultural practices of energy use.
   Task 1 was to provide the input to understand variation in needs across the sample population. This will entail energy budgeting which includes examining prevailing social practices, such as use of TV, children's school attendance, and other aspects of day-to-day life.

2. A systematic identification and evaluation of energy needs both current and future, including potential for refrigeration and small scale food processing.
   Task 2 would include process flow tracking of production and life needs presently and in the future. This would provide a good estimate of present and future energy needs, economic status, and social aspirations. Given the expected range of variation, a model for composing energy sources based on household requirements can be developed.

3. Mapping of needs to potential technology choices.
   Task 3 will consist of an initial mapping of functional requirements (such as cooking) to available and affordable energy sources and equipment, at different levels of aggregation.

4. Preliminary study of carbon footprint of a paddy field and a 36 X 36 ft. plot.
   Task 4 will include a first-cut calculation of the relative footprints of the CMSA, compared to conventional agricultural practices. Based on this analysis, an estimate of carbon usage for a scaled-up CMSA will be presented.

METHODOLOGY

In order to accomplish the aforementioned tasks, the methodology followed is to maximize the efficiency of the time spent in the field, and minimize the inconvenience to the participants and the supporting personnel from SERP. As mentioned before, we needed three types of data, at various levels of aggregation: technical data, institutional data, and lifestyle data. Apart from the secondary data that has already been collected from SERP and other parties, CSTEP wanted to ensure that we could benefit greatly from primary data from the field.

In order to capture the individual experiences of poor families, including the specific economic, familial, and gendered contexts, separate interview sessions were planned with both the men and women of PoP families. Given that the project required a fairly diverse sample size representing multiplicity of family forms and situations, it was fruitful to sample different areas and different families within each of the areas.

Because of the time constraints on the project, it was decided that for primary data collection, three districts will be targeted – Karimnagar, Kurnool, and Vijayanagaram. Within each district, the primary data collection consisted of personal interviews, focus group discussions, and personal interviews with key individuals in the village (for the conceptual description of the methodology, please refer to Appendix A).

Time-line:

The research team consisting of two energy experts, Mr. Suresh and Mr. Badri, and a social researcher, Dr. Niveditha, spent a little over two weeks in each field site. Based on the time requirements as well as the convenience of the field staff, the following dates had been fixed originally for the research visits:

Ellanthakunta Mandal, Karimnagar: July 2nd to July 17th.

Kallur Mandal, Kurnool: July 25th to August 7th

Mentada Mandal, Vijayanagaram: August 16th to August 28th.

Between each of the research visits, a week gap was planned so as to give the research team time and space to collate, analyse, and reflect on the research findings from each district. While the first visit to Karimnagar was conducted accordingly to the time-line, the trip to Kurnool commenced late, because of the illness of one of the team members. So, the second research visit started a little late, and this delayed the project by a few weeks. Finally, the field visits to the following mandals were of the following duration:

Ellanthakunta Mandal, Karimnagar: July 2nd to July 17th.

Kallur Mandal, Kurnool: August 3rd to the 18th

Mentada Mandal, Vijayanagaram: August 30th to September 15th.

In each of the visits, Ms. Vishwasree (Young Professional for NPM) co-ordinated the trip and accompanied the team to the Mandal office for the first two days and introduced the team to the relevant individuals helping with a smooth transition into the field.

Research Visits:

Each of the research trips was markedly different from each other. Apart from the differences in substantive findings, such as the differences in land holdings, crops, social and cultural differences, the experience of the team in the three districts was also different. One of the primary differences was in the interview length. The interviews in the first visit took an average of 3 to 4 hours, after which the interview periods increased as we included more questions and probed for more detail. As a result, towards the end of the survey, each individual interview took a total of 8 hours, usually completed within a day. The benefit of this approach was that we were able to collect diverse, detailed and rich data from individuals. Given the limited time we had in each field site, the number of the interviews was often offset by the depth of the interviews that we could potentially have in each district. As mentioned in the proposed methodology, we aimed to finish one household (two interviews) in a day. But when the interview lengths increased, two interviews couldn't be conducted as per plan, and a few of them had to be dropped at the end of the field visit because of the time constraints.

Despite the time constraints, we were able to get valuable information from a number of sources. One of the primary sources of information was the Self Help Groups (SHGs). Since we conducted detailed focus groups with each level of SHGs (starting from village to district), we were able to discern patterns of needs and aspirations at all levels. The other source being farmer field schools that were set up to educate the farmers about NPM practices. These were our direct contact with farmers who were clearly in need of new technologies that would enable them to earn income. So, gaining access to them via the schools enabled us to get to the problems and aspiration of the farmers directly.

In each of the villages, we also attempted to interview the Sarpanches and the village elders, or persons of importance (such as prominent social workers or village governance officials) who were able to provide aggregate information on the villages that we covered. Also, regular meetings with some of villagers enabled us to understand the topography of the village, and a tentative village map was obtained from each of the villages. Thus, various kinds of data were collected to put together a cohesive picture of the individual village ecology.

In each of the villages, all attempts were made to interview the husband and wife of the household parallely and separately, but most of the time, these interviews happened sequentially, because of the unavailability of both the husband and wife simultaneously and/or scheduling conflicts. Despite this flaw, we were often able to get information separately from husband and wife which proved to be quite complimentary, thereby fulfilling one of our aims for the study.

In Karimnagar, along with the SERP staff, three villages were identified: Thallapalli, Vanthadupula, and Anatharam. In Thallapalli village, the husband and wife interviews of two CMSA practising households and two PoP households were conducted. We also finished the interview with the Sarpanch, and focus groups with one SHG group, and a VO. In Vanthadupula, three PoP households were interviewed (including one who was practising CMSA). The research team was also able to attend an SHG meeting, although repeated attempts to contact the Sarpanch of the village proved unsuccessful. In Anatharam, one CMSA-practicing farmer was interviewed, although the counterpart was not completed as he was unmarried. Out of the two PoP households that were interviewed, one interview remained incomplete since the respondent has to leave for work towards the end off the interview and could not give us any more time in the remaining days. In all, 17 interviews in Karimnagar were conducted (including one incomplete interview).

In Kurnool, we targeted the following three villages: Thadakanpalli, Obulapuram, Vamasamudram. In Thadakanpalli village, two household interviews with POP farmers were conducted. Both the farmers has recently had RFSA (Rain-fed Sustainable Agriculture) work done in their limited acres of land, and were participating in CMSA practices for the first time. In Obulapuram village, we conducted interviews with three POP households, out of which one household was practising CMSA agriculture for a very long time, another had agricultural fields but had not fully converted to the CMSA practices, and the last ran a grocery shop. Out of these three households, we were unable to complete one husband interview, since he was unable to give us any time for the interview. In Vamasamudram, we interviewed two households, each of whom were POP households who were practising CMSA agriculture. In all, 13 interviews were conducted.

The research team was able to attend at least one SHG meeting in each of the villages, and one VO meeting in two of the villages. Since the three villages came under the same Gram Panchayat, we interviewed the Sarpanch who was overseeing all of the villages on the various problems and requirements of each of the three villages. Additionally, informal interviews with the members of the SERP office at the Mandal and Village level were conducted to understand the institutional structure of the SERP offices as well as the main duties and responsibilities of the Mandal and Village staff.

In Vijayanagaram, we targeted the following villages: Amarayavalasa, Jayathi, and GT Peta. In each of the village, only two POP households were targeted out of which one household had been practising CMSA agriculture, because of the time constraints and the availability of individuals. In Amarayavalasa, we were able to finish a complete household interview, with both the husband and wife, but in the other CMSA household, we were only able to interview the husband, because of time and availability issues. In GT Peta, we were unable to interview the full household interviews, although we were able to interview the husband from the POP household, and a wife interview with the CMSA practising household. Similarly in Jayathi, we were able to complete an entire household interview with both the husband and wife of the CMSA practising household, and the husband of a POP household. Most of the incomplete household interviews were primarily because of the constraints on time and availability for both the team and the respondents. For example, the wife of the POP household in Jayathi, while willing to be interviewed was not able to find the time, because of the work and family obligations during the day and in the evening. In another case, the wife of a POP household in GT Peta was not available since they migrated to Chennai for temporary work shortly after arrived at the village. In all, 9 interviews were conducted.

The research team was able to attend at least one SHG meeting in each of the villages, and one VO meeting in one of the villages. At the end of the research process, we were tried to interview the Sarpanches of all the villages. Although the Sarpanches were not able to coordinate time with us to interview, we were able to interview a social worker in Amarayavalasa and the village revenue officer in GT Peta who were able to give us the information on the various problems and requirements of the two villages.

Additionally, we were able to attend an MMS meeting in each of the districts, and towards the end of each research trip, we also conducted a focus group discussion with the MMS officials as well as the supporting SERP officials including the Area Coordinator (AC) of the Mandal in each of the three districts. We also spoke to the District officials when available.

In all the 9 villages, all attempts were made to interview the husband and wife of the household separately. However, most of these interviews happened sequentially, because of the unavailability of the interpreter and the length of the interviews. The unavailability of the interpreter was especially heavy on the team, since we were unable to finish the husband-wife interviews because of the lack of time. With the interpreter, the team could have managed to get complimentary information on various household tasks, and other necessities. Additionally, it would have helped the team to distribute their energies and perhaps finish the interviews in a much more efficient manner. While it was not necessarily a deterrent to the team, the provision of the interpreter would have improved the data that we collected from the last trip in the data collection process.

MAJOR FINDINGS

General Findings

Given the limited scale and short length of the study, it should be considered as an initial study, and care must be taken to contextualise the findings of the study. The findings being indicative of the conditions on the ground, but not necessarily generalisable. However, these indicative trends must be taken seriously as they point to the evolving complex reality of the villages, and can be used to understand the practices, concerns, and aspirations of the poorest farmers in the area. For the sake of brevity, only the requirements and aspirations related to energy are included in the main body of the report. A more detailed description on demographic details, agriculture, health, and living conditions are included in Appendix B as part of the three district reports.

When asked directly about their immediate needs and future aspirations, most of the respondents, whether in household interviews, or in SHG focus groups, replied that they would like water for their household and agricultural lands, sanitation facilities, proper roads, as well as LPG for cooking. Most of the residents pointed to infrastructural issues such as access to proper roads, water tanks (for regular water supply), proper sanitation facilities, and drainage systems as the main problems. According to them, their quality of life would improve immensely if these minimal infrastructural facilities were provided to the villages. The roads especially were on the top of the list, especially in one of the villages, because of the collapsed bridge that cut the village and its hamlets from the central access road. While agricultural water was available, most farmers wanted a more regularity of access as well as water in the summer, so that they could augment their income by cultivating summer crops. Additionally, many of the villagers and farmers identified that they would like some form of processing unit or a distribution cell to commence operations in the village, so that their produce were sold at a fair price.

These basic infrastructural facilities are likely to be the starting point that is likely to bring relief to the main problems of the villagers. The overall consensus with respect to future aspirations was that they wanted security of income that sufficient land and agricultural water promised. It was assessed that if security of income was provided, they would be able to purchase any amenities that they found lacking in the household.

Energy and Village Livelihood Ecosystems

In order to understand the main elements of an energy and village livelihood ecosystem, we decided to narrow our focus on three primary elements that were common to all of the villages: the water-electricity nexus, cooking fuel, and sanitation.

<u>Water-Electricity Nexus</u>

In almost all of our household interviews as well as focus groups with SHG women, and governing officials, we found that most of the households and individuals were concerned about water for their agriculture, animals, and the household, and these needs seemed to depend heavily on two factors: rainfall and electricity. And given that the former was not always predictable, they identified electricity as a way of ensuring dependable water supply for irrigation, household needs and for their pastoral animals. The water sources that they mostly identified was either ground water, water canals, or nearby streams or rivers. This continued supply of water implied that they were not at the mercy of weather patterns, and if water was supplied during the summer, also assured them a year-round productivity of their lands.

In the case of household water, only two villages out of the 9 villages had water supplied to their house. Water was not supplied everyday through this individual water connection at their houses. The water collection in this case didn't take a lot of time; however, the water collection was still at the mercy of the electricity availability. If there was no power in the village for an extended period of time (which happened often in the summer), households had to travel distances to the hand pumps to augment their water supply.

For most households, the water came in taps a few meters from the household. The water supply came at specific times, which was changed depending on the convenience of the water supplier. In this process, households were dependent on electricity to power the ground water pump in addition to spending approximately one to two hours fetching the water (including waiting time) from the taps. Again, the shortage of water as well as the erratic supply of electricity complicated this process further.

The alternatives to these were, of course, hand pumps and water wells, each were depleted in the summer and the quality of the water for each of these sources was often poor and source of diseases in the village. Additionally, SC and ST colonies were often situated further away from water sources, so most women and men from these poor households often spent a lot of time travelling to and fro from the water source, along with spending time waiting in lines. Thus, poor families were often expending a lot of human energy on acquisition of basic needs.

<u>Cooking Fuel</u>

Another need that was identified is the lack of proper cooking fuel for most households, and a lot of time and energy was expended in collecting and storing firewood. While men collected and stored most of the firewood for the entire year, it fell to women to augment this supply with some daily foraging of dry shrubbery. When asked about their preference, women often said that they would like LPG. This was not necessarily because of the drudgery involved in collecting and storing firewood, but because of the time they had to spend cooking if they used firewood. Time saved was especially important in the mornings, when the food for the day had to be cooked. Because firewood, especially shrubbery and crop waste, are quick to burn, constant supervision is required to keep the fire burning. With cooking gas, the food cooked fast, and required minimum supervision. So, women were able to multi-task during the morning when they cooked. At the same time, women who did have access to LPG didn't always use LPG exclusively. This was primarily because of the high cost of LPG. These women often strategically used LPG weighing the time factor as well as the cost factor, and we found that LPG was often used for preparation of tea and the use of pressure cook, while items such as rice (which doesn't always need supervision and takes a lot of time to cook) were still predominately cooked on firewood. So, provision of a cheaper faster cooking fuel was sorely needed by many of the households.

Sanitation

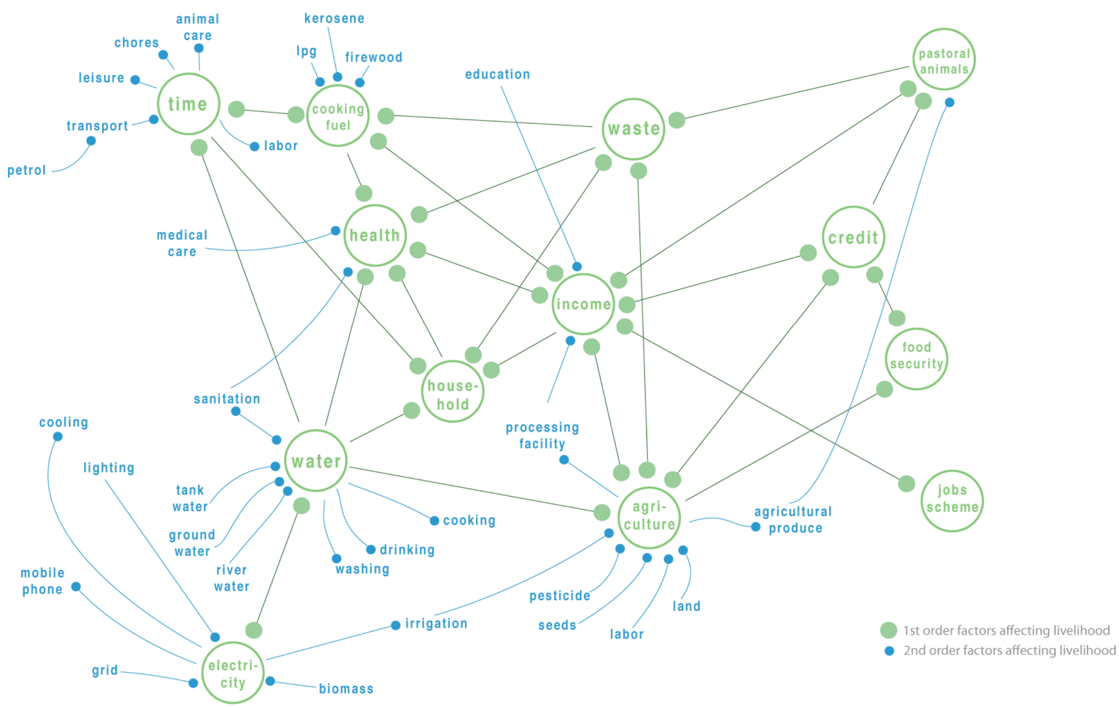
Except for one village, there were no individual toilets in any of the villages that we visited. Almost all of the households we went to were using the open fields for individual sanitation. This was especially problematic for women, who pointed to the lack of sanitation as one of the predominant problems. It was more of a concern in the night times, because often they had to go deeper into the brush and this was difficult and dangerous to do so in the dark. In fact, most of their washing, including bathing, were also likely to be done in non-private quarters, which sometimes posed to be a problem. Alternatively, they often defecated on the roads in the night time, which poses a considerable risk to the overall health and sanitation of the village. Also, the drainage systems were often dysfunctional in many of the villages, posing a health hazard in many of the villages, especially during the monsoon season where the cholera and malaria epidemics tend to be high. So, private clean sanitation facilities and waste disposal methods were one of the primary requirements of the men and women we interviewed.

SYSTEMS DYNAMICS MODEL: For mapping energy ecosystems

Given our fieldwork experience and data analysis revealed that an exclusive focus on energy may not help us with sustainable solutions, We decided to use the techniques of systems dynamics to gain an understanding of the relationships in a village energy ecosystem This is because system dynamics provides a framework, wherein entities are examined as interactive parts of a system and not just as "isolated events" and their "causes" (Forrester 1961). In fact, systems dynamics stems from the notion that "a system is more than the sum of its parts" (Meadows 2008 p.12). Acknowledging the complexity of a system requires understanding the relationships, interactions and boundaries within which different components exist. Thus, adopting this framework forces us to understand the causes for the current problems, before proceeding to explore the desired results (Forrester, 1994; Richardson, 1991).

So, we have decided to create a system dynamics that can help us to identify common patterns of relationships from data gathered from the 9 villages. As mentioned before, our objective was to understand the relationships, interactions, and boundaries within which each different component of a village ecosystem exist. To make it simpler, we have only focused on the primary factors that are important in understanding the relationships with energy and livelihoods. As you can see from Figure 1, the picture that emerges is quite complex.

Figure 1: Conceptual Systems Dynamics Model



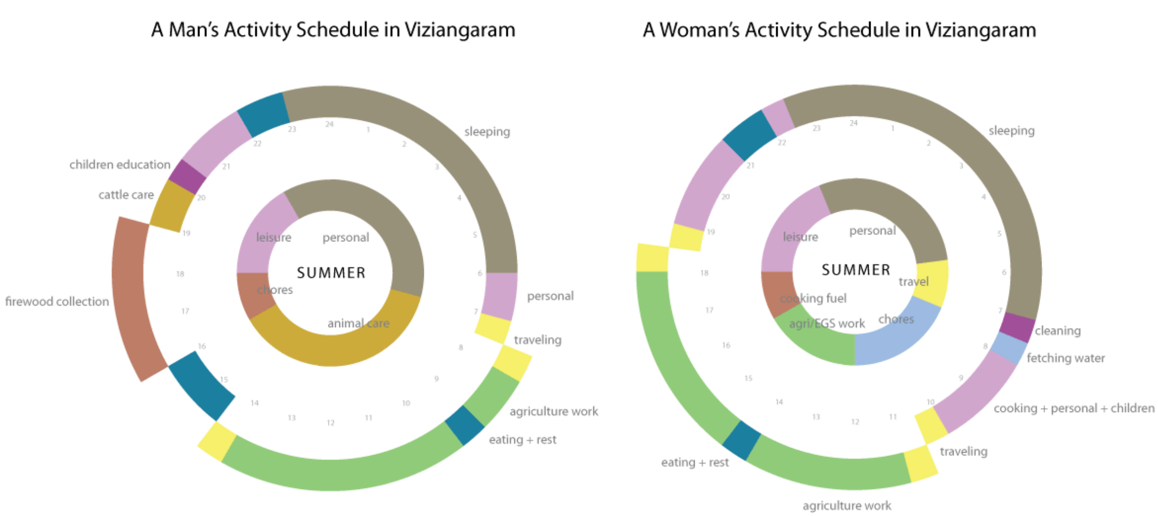
To understand the complexity of relationships, we can start with one end of the spectrum. The predominant form of energy that is used or needed is electricity. As mentioned before, electricity affects water retrieval in many of the forms in agricultural production as well as household needs. Water, in turn, is used for various purposes within the household and for agricultural purposes. If we follow the agricultural activities, we find that it affects food security and income, and which in turn affects the household as well as a number of other variables such as the influence on credit, purchase of cooking fuel, apart from the inputs into agriculture. Increasing or decreasing income will also affect the purchase and upkeep of pastoral animals, which in turn affects the waste collected, which affects the affordability of sanitation facilities, which in turn affects health which affects income. Health is so directly affected by the affordability of care that individuals get, as well as through the collection and burning of firewood.

The analysis revealed that one of the critical elements that influenced each element of energy ecosystem that is often neglected in studies in energy was time. In fact, in many of our analysis, time became a key factor in understanding the relationship between energy and livelihoods. For example, time is the main factor that drives the relationship between electricity-water nexus, especially in the retrieval of water for household consumption. Another arena that time was a critical factor in women's productivity within the household, especially the time they spent in the collection and using of inefficient cooking fuels such as firewood. This critical factor was corroborated when we examined the documented daily life cycles of men and women and the changes that happen over time.

Gender, Time and Productivity

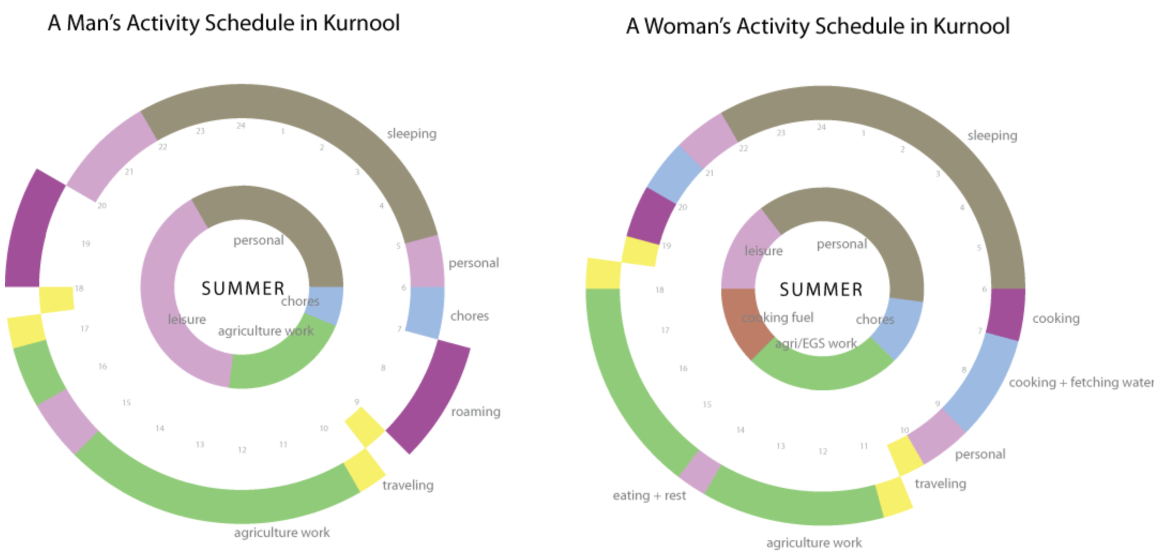
As time started to become an emergent theme in our analysis, we started analysing the time charts exclusively. In each of the cases that we examined we found that examining productive and non-productive time gave us useful indicators on understanding the nature and scope of energy interventions. Following are the examples of the analysis we did. Each graphic represents a single household with men's activities and women's activities clearly demarcated. The changes in the season, in this case, summer are also represented in the inner circle.

Figure 2: Activity schedule of a single family in Vijayanagaram



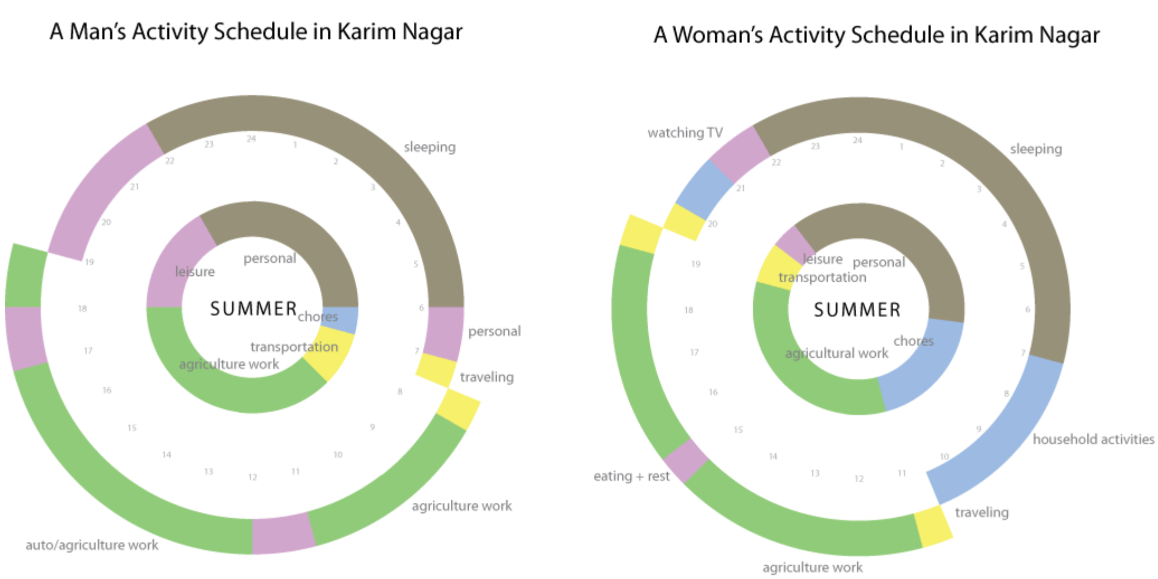
As you can see from this circular graph taken from a household in Vijayanagaram, more than 23% of the day, or approximately 6 hours of the day is filled with agricultural activities for the men and 27% of the day, or about 7 hours for the women. This changes for the men in the summer time who are in charge of animal care in the summer. For women, fetching water and cooking takes up a bulk of the activities they perform during the course of the day. The women's shift during the summer is made to EGS work, household chores such as fetching water, and collection of cooking fuel. The time for leisure for many of these families is restricted to the night time just before sleep. In the summer, this time increases, and it is usually in the afternoons when they are restricted to the household during the hot afternoon towns. In the other districts, these time analysis shifts slightly.

Figure 3: Activity schedule of a single family in Kurnool



For example, in the Kurnool district, in one of the households, the men and the women do not necessarily change the hours that they are working in the agricultural fields, but women's chores regarding cooking fuel increases dramatically, and men seems to have as much as 9 hours of leisure.

Figure 4: Activity schedule of a single family in Karimnagar



In Karimnagar, we find that women and men are working for approximately 9 hours in the day time, which includes spending time in their own agricultural plots either sowing and/or weeding. This pattern can be attributed to the different socio-economic conditions of the families, the availability of labour in the villages, the crops that the households grew, but the most important factor seems to be the time of the season that we visited and interviewed in the village.

During the analysis of the data, we found that because of the differentiation between women's work and men's work in the fields, men's employment during harvesting and sowing season, men's labour in the agricultural fields improved, but in the intervening parts, their productivity and time spent at agricultural activities reduced. Similarly, women were in high demand during the weeding, sowing, and harvesting time, but there were periods of time when they were not able to function as agricultural labourers. We found this difference to be stark especially in the latter part of the season, where we were able to find time with the men very easily who were not working in the fields, and not being able to find time with women who seemed to be out for weeding all the time.

Apart from the changing shifts of men's and women's labour within and across the seasons, we also found that women's working hours were uniformly higher than those of men's. The double shift of working, outside their homes, as well as care-work within the homes was amply documented in the study. Thus, we found that time was a key factor in understanding the distribution of work and the 'productive' activities of both men and women within the village. This concentration on time gave us two powerful tools and indicators by which we could assess energy interventions: time available for engaging in economic activity, and time that can be gained from the removal of drudgery. For example, picking firewood and fetching water from long distances are two activities that can be shifted from having low economic value to high economic value, if the cooking fuel is more efficient, and if water is available closer to households. More indirectly, if women do not have to walk for ten to twenty minutes for open-air sanitation, that not only improves health and quality of life which increase productive time, it also directly increases the time that could be spent on economic activity. Thus, time is the key factor in assessing, evaluating and implementing any energy intervention within a village or a household.

Sustainable Energy Solutions

In the light of these factors, we decided to explore the various energy needs that have been documented, in additional to sustainable energy solutions. As you can see from the graph, there are six primary energy needs: lighting, cooking, transport, irrigation, cooling, and sanitation. We can also consider processing needs as a form of value addition to the agricultural produce. To accomplish this, there are certain sources that are traditionally in use. These can be broadly categorised into Grid Electricity, Biomass, Firewood, Kerosene, LPG, and Petrol. In addition to these traditional sources which, we wanted to consider more efficient and sustainable sources of energy and technologies, such as biogas, solar-based products, wind mills, rainwater harvesting, bio-diesel, and micro-hydral projects.

Figure 5: Energy Needs, Energy Sources, and Energy Resources

	Grid Electricity	
	Coal	
	Firewood	
Lighting	Kerosene	Biogas
Cooking	LPG	Solar-based products
Transport	Petrol	Wind mills
Irrigation	Biomass	Rainwater harvesting
Cooling	Excreta	Bio-diesel
Sanitation	Solar Energy	Micro-hydral projects
	Wind Energy	
	Streams / Rivers	
	Charcoal	
	Rainwater	

We find that the resources necessary for these technologies are: biomass, manure, solar energy, wind energy, streams or rivers, charcoal, and rain etc. However, to create sustainable solutions, availability will not suffice. For example, if we take a few areas of interest, we find that energy interventions can become complicated very soon. For the sake of analysis, let us consider (1) the dependency on grid-electricity in the farms, (2) dependency on firewood as the main cooking fuel, and (3) the use of bio-mass that is produced after harvesting is completed, as three areas of intervention.

While solar is likely to be the most viable alternative for grid-based electricity in the household and in agriculture farms, the affordability of solar interventions are highly dependent on the financial packages that can be put in place for individuals and collectives to make use of. As many solar ventures have shown in India, solar energy is affordable as long as there is a financial structure to support its long term use in rural areas. As regards alternative cooking fuels, while charcoal is a better cooking fuel, and can be sourced to become another income generation scheme, the details of such a venture must take into consideration the efficiencies of time, effort, and cost. Sometimes, the efficiency of the fuel cannot be judged on the merits of its energy output alone. As regards the biomass that is produced after harvesting, creation of bio fuels in a cooperative venture can be one of the ways in which this waste can be effectively used, as are community run toilets and rainwater harvesting, models of which are running successfully in some areas of the country. But as mentioned before, the affordability, the accessibility, and the sustainability of these solutions are highly dependent on the individual contexts of the village ecology and the human capabilities within the system. And we have identified five primary preconditions or prerequisites for a sustainable and scalable energy intervention.

PRECONDITIONS FOR ENERGY INTERVENTIONS

As mentioned before, with regards to energy implementations, it is difficult to assess the particularities of every village individually, so our analysis only points to the general prerequisites that are of importance while introducing any energy intervention amongst the rural poor.

The **first** is the affordability of the energy solutions. Given that any energy solution will take some effort, time, and money on the part of the families partaking of it, any solution must take into consideration the slim margins that poor families already live by. If the solution reduces this slim margin without providing greater returns, it is very likely that these solutions will not be adopted by poor families.

The **second** consideration is capabilities of income generation. In all likelihood, it would be more fruitful to institute an energy solution that not only relieves the burden on individuals within a village, but also increases the household income. In addition, if income generation becomes a critical aspect to an energy solution, it also increases the chances of greater distribution and assimilation.

The **third** point of interest is the level of aggregation. For many poor families, the affordability and accessibility might be a major impediment. However, if some cooperative initiative is undertaken, within the existing institutionalized structure, then the benefits of aggregation might benefit poor families as a whole.

The **fourth** point of interest is the pre-existing conditions of infrastructural and human capabilities of each village. For any energy solution to be effective in improving the livelihoods as well as the quality of life of the villagers, the supporting infrastructural base has to be present and stable in order for the benefits to be sustainable. Additionally, a collective accountability and responsibility might have to be augmented and facilitated for the long term goals of sustainable energy solutions in the area. Without building human and infrastructural capacities and capabilities, any energy solution introduced might prove to be an additional burden, in terms of cost and effort, for the villages.

The **fifth** point of interest that was clearly defined and articulated by the villagers is the social and cultural milieu within which these energy solutions will be introduced, implemented, and sustained. Without understanding the power structure, fuelled by caste, religion, and gender sentiments, and implementing a system of transparency and accountability, it will be very difficult to administer any long-term energy project in any of the villages. Moreover, it is essential for any scaling efforts to address the procedural and negotiation tactics that will help enable and minimise the power dynamics that might hinder the implementation and sustenance of any energy solution. Because the social, political, and cultural climate of the villages are often geared towards privileging the higher order of the social structure, it is imperative that all efforts are made to address and anticipate the resistance and struggle that might ensue after any implementation.

As in the case of CMSA, energy interventions are an input to livelihoods and a way to reduce drudgery and improve quality of life. So, working to develop energy and livelihood possibilities will require creative design. So, any energy intervention cannot be treated merely as an addition, but as an enabling service. Therefore, it is important to have necessarily a level of infrastructural, human, and financial capabilities in place before any intervention can be successfully created and sustained. Moreover, with any of the energy interventions, the need for a technology does not necessarily translate into demand for the technology. Therefore, the energy intervention has to be reliable and robust in order to be translated into more economic opportunities. For example, micro-finance does not typically have financial packages that can fund equipment that can help reduce the dependency on grid electricity.

Energy Interventions and Credit

A number of innovative approaches in the area of providing energy options for the rural folk have been explored in the recent past. . One of our collaborators in another project, Decentralised Energy Systems India Private Ltd, (DESI), has implemented financial strategies that enabled the introduction of a solid biomass gasifier of rated capacity of 70kg/hr biomass consumption that requires an investment of 52 lakhs. Given the high costs of this project, they mitigate the cost of the gasifier by supporting various micro enterprises such as irrigation pumps with cabling, rice huller, flour mill, ice factory, domestic lighting etc. They ensure that the impact of such a high cost is justified by the value addition to local resources, new job creation (in processing and other related professions), institutional impact on the village by women's participation in the project, and the reduction in CO_2, which may translate to carbon savings. Other social entrepreneurs such as Selco Systems have also focused primarily on financial packages to provide solar lighting to the rural areas.

Another way to examine the financial viability of the project is to examine possibility of obtaining carbon credits for any energy interventions. When we analysed the data on cooking fuel, we realised that the usage of firewood for a 4 member family for a year is approximately 2765 kgs to 3285 kgs of firewood. Firewood releases approximately about 1560 to 1620gms of CO_2 per kg of wood, which translates to about 4.3 tonnes (a minimum) of CO_2 released per family in a year. If planned properly, the cost of switching over to a more efficient cooking fuel can be offset by the number of carbon credits gained through the process. This approach is especially useful in the context of CMSA agriculture.

One of the tasks assigned to us for this project was to calculate the first-cut calculation of the relative footprints of the CMSA, compared to conventional agricultural practices. While we could not collect all the information necessary for the analysis, SERP was able to provide us with the necessary data that they had collected that was required to complete the analysis. SERP was able to provide data on the fertiliser consumption used by the production of paddy from four districts. 39 farmers from Chitoor, 55 farmers from Guntur, 11 farmers from Khammam, and 8 farmers from RangaReddy Districts participated. The following are their records of the total area covered under NPM and non-NPM.

Table 1: Total area covered in the 4 districts under NPM and Non-NPM.

District	**No. of Farmers**	**Total Acre for NPM (Acres)**	**Total Acres for Non-NPM (Acres)**
Chitoor	39	42	36.6
Guntur	55	74.3	72.05
Khammam	11	11	11
Ranga Reddy	8	6.25	6.5

Table 2: Life Cycle Energy and Life Cycle CO2 of various Fertilisers

Fertilizer	**Life Cycle Energy (MJ/Kg)**	**Life Cycle CO2 (g-CO2/Kg)**
Urea	22.3	732
Diammonium Phosphate (DAP)	13.2	262
Ammonium Sulphate	4.3	894
Compound Fertilizers	2.0	142
Coating Fertilizers	1.9	137

Reference: A Study on Life Cycle Assessment of Energy Consumption and CO2 emissions in the manufacturing and transportation processes of Nitrogen and Phosphate Fertilizers. Japanese Journal of Farm Work Research.

Figure 6: Yield Comparison for 100 acres of NPM and non-NPM practices

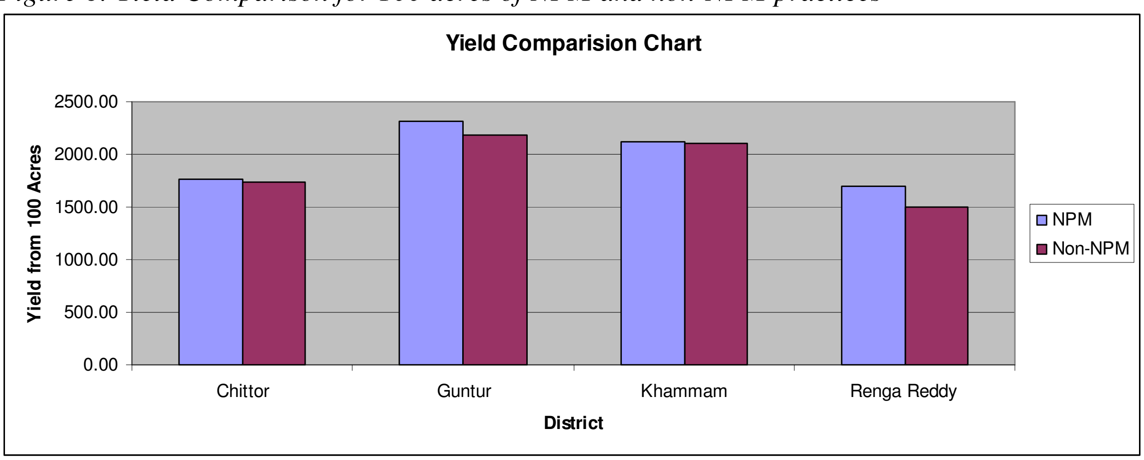


Figure 7: Urea Comparison for 100 acres of NPM and non-NPM practices

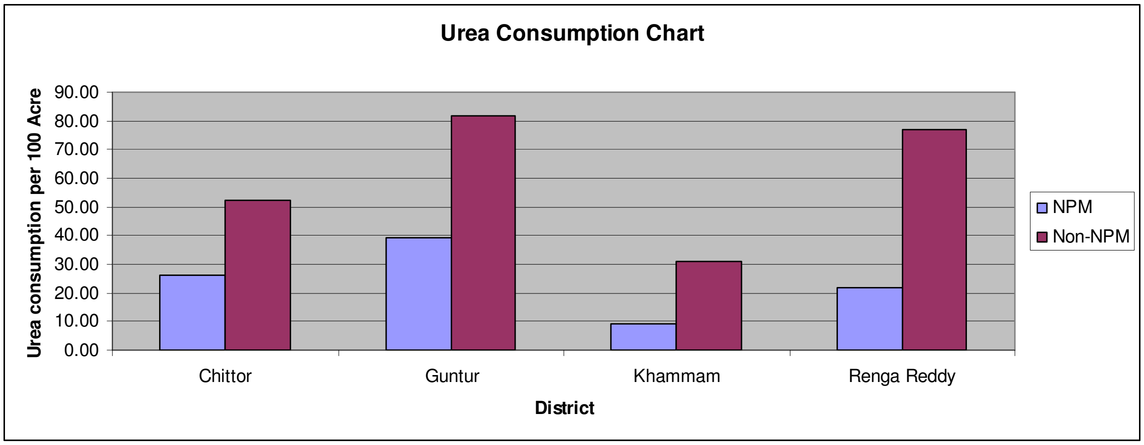


Figure 8: DAP consumption for 100 Acres of NPM and Non-NPM practices.

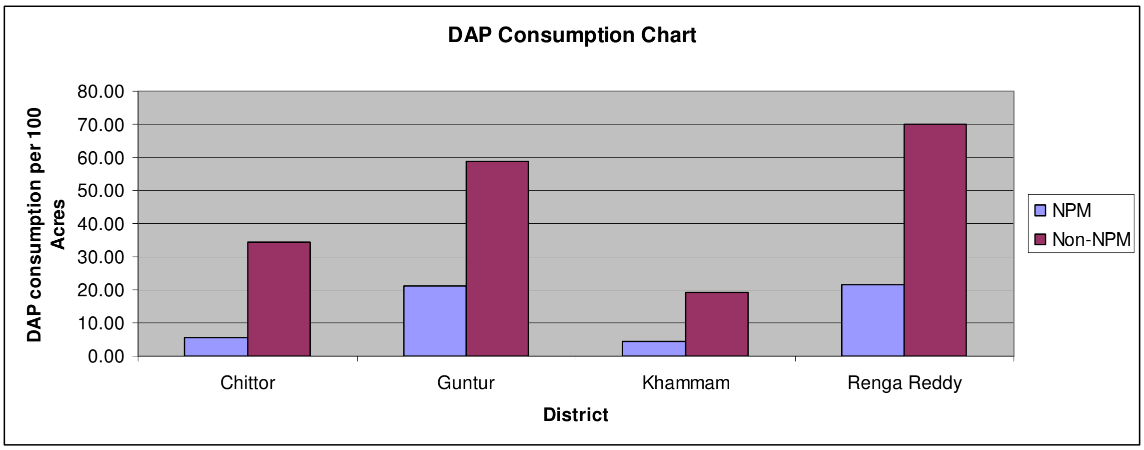


Figure 9: Life Cycle Energy consumption of Fertilizers (Urea, DAP and others) per 100 Acres

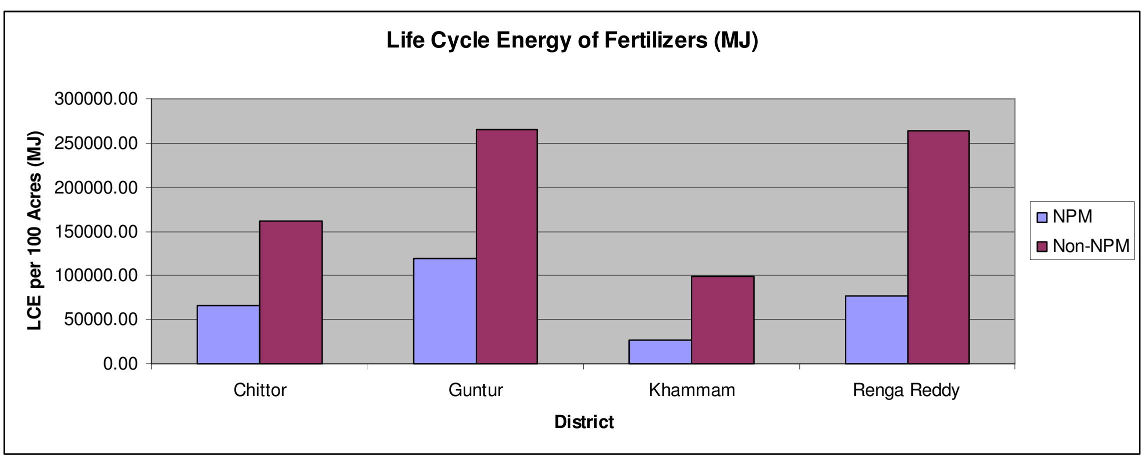
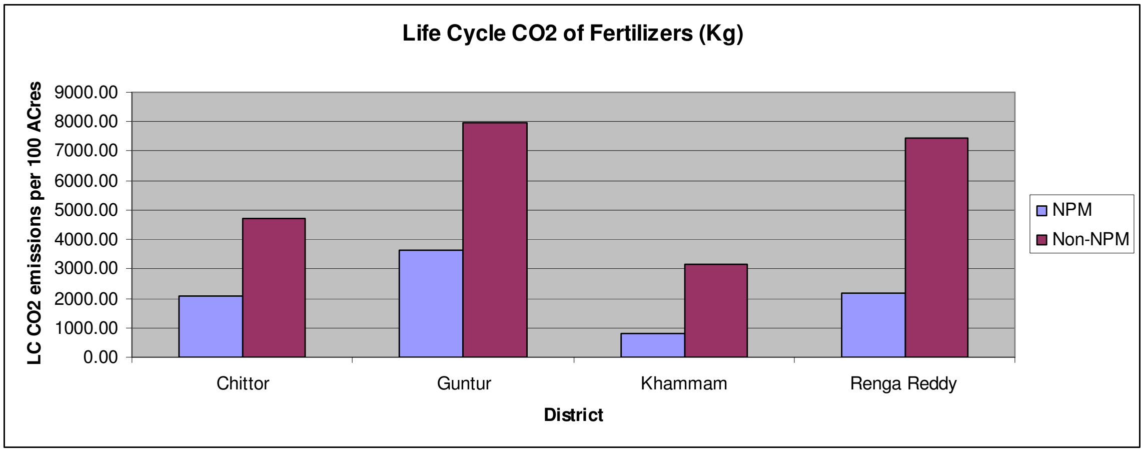


Figure 10: Life Cycle CO2 emissions of Fertilizers (Urea, DAP and others) per 100 Acres.



After taking into consideration the Lifecycle Energy and Life Cycle CO2 output for the various fertilisers used in NPM and non-NPM farmers, the following picture emerged. The usage of fertilisers for non-NPM acreage is dramatically higher than those of NPM acreage, but the yields of the NPM are comparable to those of non-NPM. So the usage of the additional fertiliser seems to have resulted in only small or no changes to the yield. This is an important finding, especially in the light of the analysis of the life cycle of the energy by fertiliser usage by NPM farmers and the lifecycle of CO2 of fertilisers used in NPM farmers. As Table 3 amply indicates, the lifecycle CO2 emissions from NPM farms are only 44% as that of its counterpart non-NPM farms in Chitoor district, and 46% in Guntur districts. The percentages are lower in the other districts, but are still at least 25% as compared to the non-NPM farms. While these calculations are only preliminary, further analysis and data will enable us to establish the enormous decrease in carbon emissions when farmers switch on NPM methodologies.

Table 3: Life Cycle Energy Comparison of Fertilizers of NPM over non-NPM.

District	**LC Energy of Fertilizer for NPM (as compared to non-NPM)**	**LC CO2 of Fertilizer for NPM (as compared to non-NPM)**
Chitoor	41%	44%
Guntur	45%	46%
Khammam	26%	25%
Ranga Reddy	29%	29%

This important finding indicates that carbon credits can be a potential source of financial incentive for introducing energy interventions. We argue that documentation of the extensive carbon offsets of NPM farmers, along with the reduction of carbon by energy-efficient cooking fuels and other devices can be used creatively by employing carbon credits can enable a poor farmer to increase the level of investment into sustainable energy technologies that can further be used to increase the margins of income.

While the exact financial packages and incentives of using carbon credits for boosting the affordability of energy interventions are beyond the scope of this study, we would like to present a case study of G T Peta as a way of illustrating the need for a holistic intervention model.

CASE STUDY: G T PETA

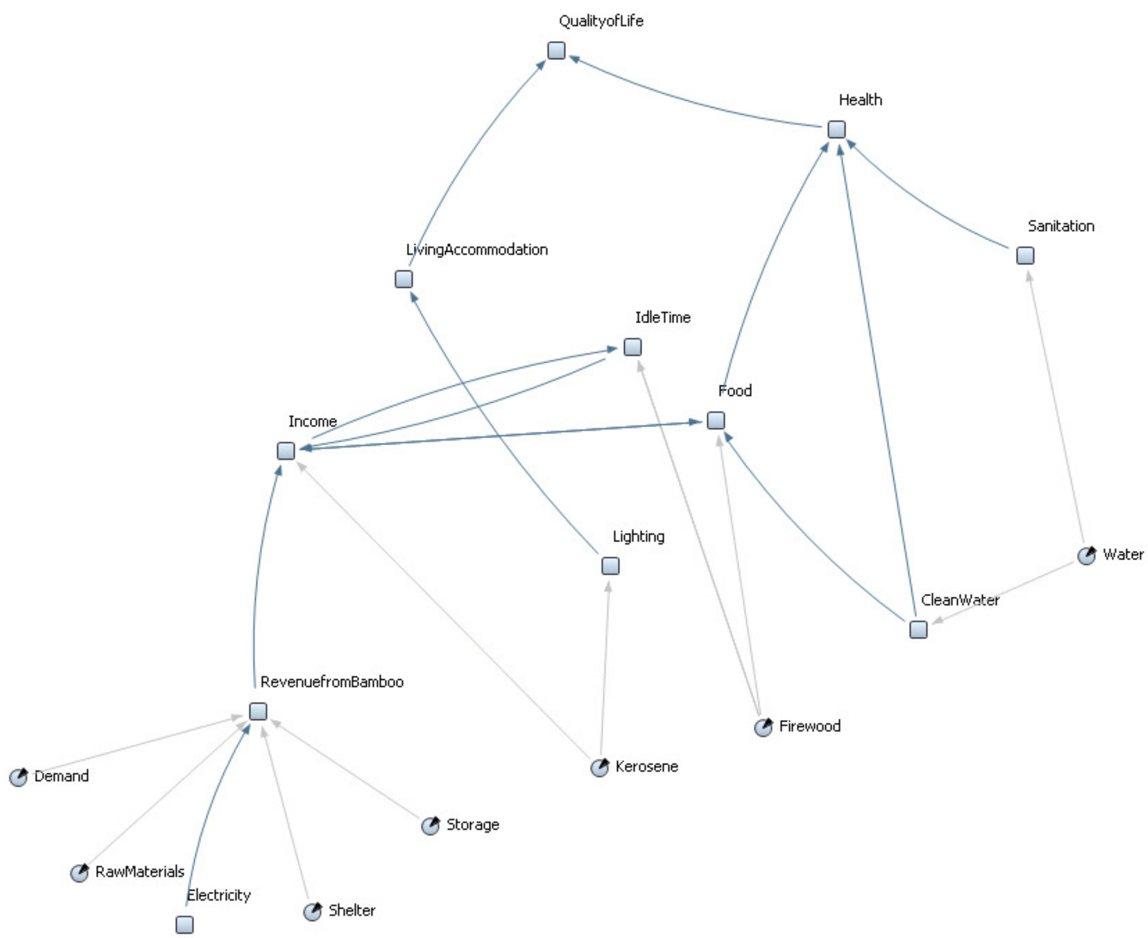
G T Peta is one of the villages that were selected as part of the study in Vijayanagaram. Motor access to the main village and its hamlets are severely limited because of a collapsed bridge. The bridge was supposed to assure truck and auto access to the village, but because of the poor quality of materials that were used during construction, the bridge collapsed after the first monsoon season. Now, the only access that the villagers have to the main town is through an extended mud road that does not allow for many automobiles to the village. So, the infrastructural facilities provided for the village were limited at the time of survey. G T Peta was also one of the villages where we found that an ST community, composed of predominately bamboo basket weavers, had no households with access to electricity. The entire community has access to a solitary bulb in the main road leading up to the ST colony. Moreover, the space assigned for their housing was such that they were closed in from all sides by the fields and could not expand their living space. The lack of room for expansion also had consequences for their trade. Since most of the baskets were made in the open area between the huts and on the main road of the village, the lack of expansion meant that there was a limited space in which to make and store the bamboo space. The open area used for their trade was exposed to the elements, thus being severely hampered during monsoon season and at times of intense heat in the summer.

When we surveyed the village, most of the villagers stated electricity, water, and employment as their main requirements. Their lighting needs were particularly acute. They argued that if they were provided electricity, they would be able to work during the evening and the night hours, so as to improve their basket production. They also wanted access to potable water. Their only access to drinking water was the hand-pump in the neighbouring colony, the water of which ran muddy during the monsoons. Their washing and cleaning needs were met by the stream nearby, but because they were cut off from the stream through several fields, they had to walk for at least 5 to 10 minutes by road to get to the stream. Another acute requirement was their need for alternative employments or alternate markets. The community produced baskets which were predominantly used to store and transport mangoes during the season. During discussion with the community members, it was brought to our notice that the increased use of cardboard cartons had reduced their market share considerably. The members also pointed out that corruption at the local levels hampered their ability to augment their income through NREGS. So, the primary requirement of the community was to ensure a steady income, either through an alternative profession or an expanded market base.

The reasons for studying this community were two-fold. First, they had no access to land, which meant they had no income from agriculture. They also had very limited access to any form of energy source. So, their income potentials were limited to the bamboo trade and any employment available in the village. At the same time, they had a much-valued resource that was currently under-used and unrecognised: Bamboo waste. For every basket woven, a certain portion of bamboo was thrown away as waste. This bamboo waste was collected in one corner of the colony and was collectively burned regularly. When we calculated the biomass that can be generated with this waste, we found that approximately 15kg of bio waste is created every day during the season. This bio waste can potentially be used to generate electricity in a biogas plant or other alternatives.

So, we decided to run a minor version of the system dynamics model for this particular village. We are still in the process of creating a more comprehensive model, but even the minor simulation is able to tell us a complex story. For the sake of brevity, only the effect of electricity and shelter are shown and discussed.

Figure 11: Systems Dynamics Model for GT Peta



When we run the model, we find that provision of electricity and shelter are very critical in improving the revenue of bamboo. When we examine the effect of the revenue on net income, we find that there is no substantial increase in income. However, their quality of life improves with the increase in revenue. So, with small changes such as provision of electricity and shelter, we will be able to increase their quality of life and affect changes in the quality of life. However, it must be noted that in order to obtain more accurate and precise results, further iterations of the model and more detailed information is required.

Additionally, more social factors such as the isolation of the community from village resources, and the problem of constricted space cannot be completely captured in the model. For instance, if we do not account for social isolation, the long-term maintenance and service to any technological intervention is severely handicapped and can counteract the positive effects of such intervention. At the same time, the model can be used effectively as a way of assessing the impact of increased demand for bamboo, alternative sources of income, and the access to electricity, and can be used as an effective tool to project and advocate for energy interventions in the field.

CONCLUSIONS

The challenge of rural development includes the need to improve access to assets and markets, improve productivity, design new financial and risk management techniques, manage ecological resources, create more and better jobs, and improve voice and accountability of the rural poor (World Bank, WDR, 2008). The needs of the region in question are quite well known in the Indian policy context (VBF, 2009; Dreze and Sen, 1995; Kadekodi and Viswanathan, 2009). According to the Indian Government's Development Gateway, 21% of the villages and about 50% of rural households are not electrified (www.indg.in) although other estimates are in lower 40% range (as cited by World Resources Institute which maintains cross country statistics).

Therefore, the need for systematic introduction of energy technologies cannot be underestimated. However, our claim is that even small scale intervention such as solar lighting must take into consideration the creation of a service mechanism and training network to sustain its use and financial viability. To have a larger effect on the community itself to improve the quality of life than includes income, health, water and sanitation, an innovative collection of technologies, institutional structures and financial packages will have be combined to see the viability of any energy intervention in the short and long term.

Therefore, to introduce an energy intervention program through SERP, a small scale intervention that examines the institutional, social, and cultural structure must first be undertaken. While making blueprints for change is essential, the goal of sustainability ultimately rests on the nature of co-learning and engagement that can exist between the various actors in a social milieu. This engagement can not only bring about positive (and occasionally negative) change, it primarily uncovers social, economic, and cultural barriers to the proposed change. With careful participation, facilitation, negotiation, these barriers can be systematically addressed, and increase the long-term sustainability of any proposed plan.

APPENDIX A

Methodology

The proposed research procedure is as follows: In each of the identified districts, three villages will be targeted. These villages are likely to be in different stages of having instituted CMSA, so that we get an understanding of the process of institutionalization of CMSA in the villages. Given that we do not have direct historical data on the process of assimilation of new technologies, it is more productive to compare villages who have had CMSA instituted for 5 years and villages who have recently been introduced to CMSA.

In each village, a minimum of three households will be targeted based on their PoP status. Depending on the institutionalization of CMSA in the villages, some of the households who have been identified as PoP *and* are practicing CMSA techniques will be part of the targeted sample. In each of the households, head of the household and his/her spouse will be interviewed separately. The interview with the household is carried out with the help of a semi-structured questionnaire (a modified version is attached as Appendix C). The questionnaire records basic demographic characteristics (age, education, labour force participation), availability and use of various amenities (water, electricity, transportation etc), income and expenditure details, as well as any agricultural practices of the family. The questionnaire also attempts to detail the energy expended on daily activities, and tries to essay out a life-process cycle of the family. The questionnaire is very detailed and on an average takes about 3 to 6 hours to administer, per person.

While the bulk of the information for our project tasks come from these questionnaires, information about the macro-level data, as well as institutional data can be received only after conversations with key individuals in the village. In order to maximize efficiency of time, a minimum of interactions is also included in each village visit. So, in addition to the household interviews, the research methodology comprises also of focus group discussions and individual interviews (where available and applicable) with the District SERP office, the Mandal coordinating unit, the Panchayat, key CMSA farmers in the village, with at least one village organization (the first-level federation of individual SHG groups), and at least one SHG group.

Additionally, given one of the main objectives of the study is to examine the current energy capabilities of the household and the village, and some of the solutions are likely to come from the local contexts, the measurement of various variables of interest will also be undertaken. Amongst these measurements is the average temperature of the region, the topography of the village (including main buildings such as schools, Panchayat office, water towers, post office etc), the main water sources, the condition and location of access roads, distribution of fields and dwellings in the area. Since locally available but untapped potential sources of energy use are often the source for the most viable solutions, an estimate of the biomass and bio waste, drainage, and the foliage will be assessed during each village visit.
This triangulation of data sources, i.e. using different methods to collect similar forms of data (such as interviews, focus groups, and measurements) will enable verification of data

in addition to allowing for various aggregation of data that will be useful for understanding the differential needs of the household (with respect to the village needs). Given that the research process is very intensive, it has been mutually decided that a minimum of two weeks should be spent for each of the three districts. This gives the research team time to interview at least one household per day in addition to conducting a focus group with a VO or SHG per day. This also enables the research team to maximize time and efficiency in the field, and affords minimum disturbance to the SERP personnel working in the field.

APPENDIX B

Bibliography

Agriculture and Rural Development Unit. (2008). *India: Taking Agriculture to the Market*. South Asia Sustainable Development Department, South Asia Region.

Easterly, W. (2002). *The Elusive Quest for Growth: Economists Adventures and Misadventures in the Tropics.* Cambridge: MIT Press.

Eric von Hippel. (2006). *Democratizing Innovation*. Cambridge: MIT Press.

Forrester, J. W. (1961). *Industrial Dynamics*. Cambridge: MIT Press.

Forrester, J. W. (1994). *System Dynamics, Systems Thinking, and Soft OR.* Summer Review Series.

Frame, B., & Brown, J. (2008). Developing post-normal technologies for Sustainability. *Ecological Economics*, *65*, 225–241.

Hartmut, B. (2007). *Systems and Models. Complexity, Dynamics, Evolution, Sustainability*. Norderstedt, Germany: Books on Demand.

Higgins, A. J., Miller, C. J., Archer, A. A., Ton, T., Fletcher, C. S., & McAllister, R. R. (2010). Challenges of operations research practice in agricultural value chains. *Journal of the Operational Research Society*, *61*(6), 964–973.

IDA. *IDA at Work: India: Andhra Pradesh Economic Restructuring Project*.

Kadekodi, G. K., & Viswanathan, B. (2009). *Agricultural Development, Rural Institutions and Economic Policy.* New Delhi: Oxford University Press.

Kleine, D. (2010). ICT4What? Using the choice framework to operationalise the capability approach to development. *Journal of International Development*, *22*, 674–692.

Kobayashi, H. and Sago, R. (2001). A Study on Life Cycle Assessment of Energy Consumption and CO2 Emissions in the Manufacturing and Transportation Processes of Nitrogen and Phosphate Fertilizers. *Japanese Journal of Farm Work Research*; *Journal Code* - G0627B, *ISSN:* 0389-1763, *VOL.*36; *NO.3*; *Pages.141*-151; *Accession number;* 01A0939700.

Konda, S. L., Monarch, I., Sargent, P., & Subrahmanian, E. (1992). Shared Memory: A Unifying Theme for Design Research and Practice. *Research in Engineering Design*, *4*(1), 23–42.

Lall, S., Singh, S., & Bairiganjan, S. (2010). *Expanding the Market for Clean Energy in Rural India*. IFMR.

Levin, M. (2003). Action Research and the Research Community. *Concepts and Transformation*, *8*(3), 275–280.

Meadows, D. H. (2008). *Thinking in Systems: A primer*. Chelsea Green Publishing.

Mukherjee, A., & Zhang, X. (2005). *Rural non-farm development in China and India: The role of policies and institutions*. DSGD Discussion Paper. International Food Policy Research Institute.

Ravishankar, T. (2003). Traditional Knowledge and Conservation of Biodiversity for Sustainable Livelihoods by Tribal Communities in Southern India. In *XII World Forestry Congress*. Food and Agriculture Organization.

Richardson, G. P. (1991). *Feedback Thought in Social Science and Systems Theory*. Philadelphia: University of Pennsylvannia.

Sreyamsa Bairiganjan. (2008). *Bringing clean energy to rural India: a case study of the Bagepalli CDM biogas project*. Centre for Development Finance, Institute for Financial Management and Research.

World Bank. (2008). *World Development Report 2008: Agriculture for Development*. WDR.

World Resources Institute. *EarthTrends: The Environmental Information Portal*.

FAO. *Agri-Gender Database: A statistical toolkit for the production of sex-disaggregated agricultural data*.