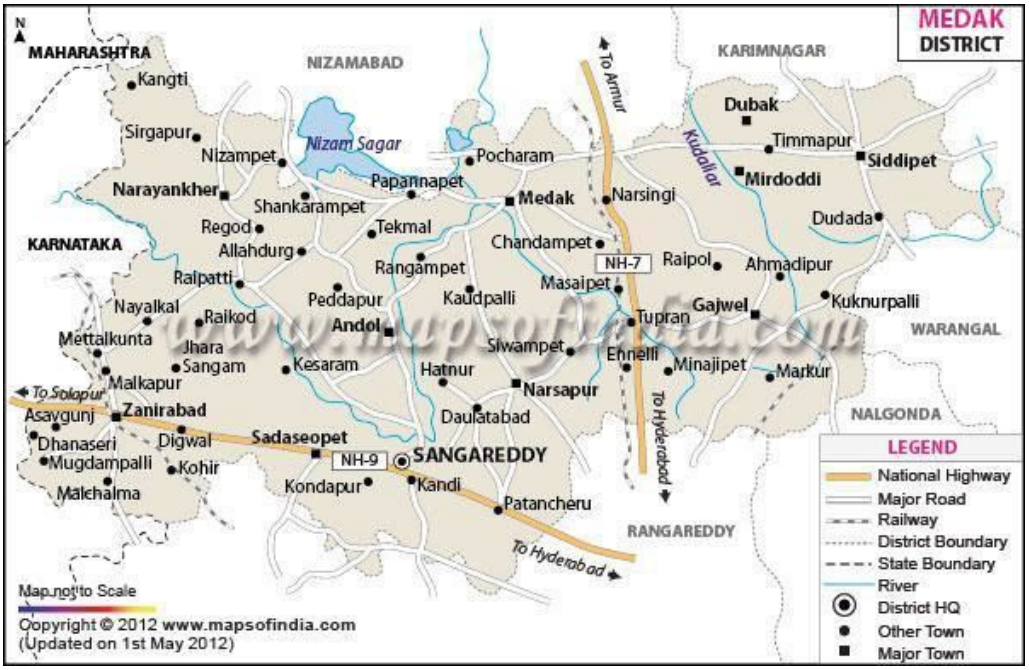
SOCIETY OF POWER AND TELECOM LIMITED

CLIMATE CHANGE:

CLIMATE INTELLIGENT GREEN VILLAGE PROJECT PILOT



WADDEPALLY, HATNUR MANDAL, MEDAK DISTRICT,

- **Latitude: 17.99266950000000000 N**
- **Longitude 79.51959390000020000 E**
- **Sun Full hours : 4.5 hours**

Need assessment of project area:

Groundwater is the main source of irrigation in the Medak district. The increasing exploitation of groundwater during the last two decades and deficit in the rainfall for the last few years have driven the farmers to a distress situation, resulting in suicides in some cases. Increasing population with decrease in size of land holdings, increase in input cost, market fluctuations for agricultural produce, deepening of borewells / digging of new bore wells indiscriminately without any scientific advice, low quality of seeds, dependency of farmers on loans for agricultural inputs etc. and failure of monsoon since 1998 have led to a distress situation in the district.

Though the Manjira river is a perennial river, there are no major irrigation projects worth mentioning in the District. The other available surface water resources are large and small irrigation tanks numbering about 14,000. Out of the total cropped area of 5,25,000 ha., an area of 19,000 ha., (3.6%) is being irrigated by surface water sources and an area of 1,01,000 ha (19.2%) is being irrigated by groundwater, which indicates that groundwater plays a major role when compared to surface water. The various crops raised are rice, jowar, bajra, sugarcane, black gram, red gram, bengal gram, cotton, groundnut.

The average annual rainfall received in the Medak district is 873 mm. The cumulative departure of annual rainfall from normal indicates the extent of drought at a place. In the district, the cumulative departure of annual rainfall was categorized as ‘scanty’ ‘i..e., more than 60% below normal, in 33mandals and ‘deficit’ i.e., below normal by 20% to 59% in 8 mandals. In the remaining four mandals, the rainfall was below normal by 0-20%. On an average, the district rainfall condition was ‘scanty’.

Due to scanty rainfall and ever increasing population, majority of the dug wells/dug-cum bore wells have gone dry. At present, maximum irrigation needs are met through bore wells. Bore wells of 102 mm are common in the District and utilized for domestic supply. The depth of these bore wells ranges between 20 to 45 m yielding 1.5 to 75cu.m/day. In weathered granite and alluvium, the transmissivity value ranges from 100 to 150sq.m/day and the specific capacity ranges from 0.005 to 0.16cu.m/m per unit cross-section.

DSM USING AGRICULTURE CONCEPT NOTE

Definition of Demand Side Management

Energy demand management, also known as demand side management (DSM), is the modification of consumer demand for energy through various methods such as smart metering, incentive based schemes, payments for turning off loads or rescheduling loads. Usually, the goal of demand side management is to encourage the consumer to use less power during periods of peak demand, or to move the time of energy use to off-peak times. Peak demand management does not necessarily decrease total energy consumption, but could be expected to reduce the need for investments in networks and/or power plants for meeting peak demands.

Electricity use can vary dramatically on short and medium time frames, and the pricing system may not reflect the instantaneous cost as additional higher-cost that are brought on-line. In addition, the capacity or willingness of electricity consumers to adjust to prices by altering elasticity of demand may be low, particularly over short time frames. In the scenario of Indian grid setup, the retail customers do not follow real-time pricing and it is difficult to incentivize the utility companies for continuing the peak demand supply. A question for the future is how deeper penetration of renewable will be handled? This is a challenging problem since one has to deal with high variability, while managing loss of load probabilities.

Understanding the Energy Scenario of India

The failure of entire northern grid is during September of 2012 gives more emphasis on the problem of demand side management using agriculture. Many people attribute this to various factors like change in the temporal pattern of rainfall, stress in agriculture due to increased dry phases and delayed rainfall and also few states pulling excess energy than their quota. Understanding the impact of climate change in a tropical country like India is essential to emphasize on the need for moving towards demand side management using agriculture. Being in the tropics, the impact of climate change on India could be written in a single line stating, “It rains less often, but when it rains it pours”. The climate models suggest that there will be an increased dry spell during Indian monsoon and this change in the temporal distribution over the years means an impact in the stress in agriculture gets reflected in the stress in utility.

Also during the non-monsoon seasons, the agriculture demand on pulling groundwater increases resulting in various ecological crises, one of them being drastic decrease in groundwater depths. The overall impact of such changes would reflect in the capital accumulated by the state in the agriculture sector. Switching to demand side mapping using agricultural resources provides flexibility to the utility companies to meet the ever increasing demand. Also this would incentivize the penetration of renewable technologies. The next section explains managing the peak energy level scenarios using different techniques of demand side management using agriculture.

Managing the Peak Demand using agriculture

In the case of Gujarat utility UGVCL with more than 50% of electricity going to agriculture, there is the following prospect. In the future as smart metering matures with automatic turn on/off for a pump, it will become possible to provide an ensured amount of water or energy to the farmer, as required by the

farmer, while keeping the grid energized for 24 hours. So if a farmer or group of farmers are allocated a certain amount of water or equivalent energy, the control of their pump can be handed over to the utility and this control can be utilized to manage BOTH peaks and the up and down ramps.

Using data for solar generation from PDPU as well as data from the feeders, we modeled the possibilities and provide quantitative analysis of the potential benefits as well as provide operational algorithms. Supply scenarios will include the possibility of much larger penetration of solar and wind into the grid. While, in absolute terms these sources are small contributors, their role will inevitably grow.

The other option is of advancing or delaying pump operating cycle even by several hours, will still ensure soil moisture requirements met while, balancing the overall system load with generation, reducing critical power mismatches. While these techniques have been applied in the west, the opportunity has not been fully explored or exploited in settings with high agricultural demand.

Offsetting the Solar Capital Cost with increased agricultural outputs at feeder scales

Can increased agricultural outputs offset for the initial capital costs of installing solar panels. With state run utility running very low on treasury after providing subsidy in electricity, the health of utility companies are in the worst stage. Latest report suggests that recently India sees the lowest plant load factor in the last 15 years with power capacities operating at 65% of its total capacity. So in this scenario, private companies could install mini-grid or off-grid solar to provide for the agricultural demands. The presence of these solar installations would further mean an increase in agricultural output from the fields compared to the present scenario. This increased agricultural output could offset for the initial solar capital costs. Solar installations could be integrated with contract farmings and supply chain management techniques to increase the capital output from the field. Also physical models like crop models and climate models could be integrated to provide better outcomes and thus offsetting for the initial capital costs of the solar installation.

Utilizing agricultural land for Increasing Solar Penetration

Calculations from the Gujarat region where a field experiment was carried on showed that 1 % of the total agricultural land could provide for the pumping requirements of the land. Even then the 1% of the land provided to the solar could also be used to grow vegetables in the shade in the extreme hot weather of India. Higher solar penetration would mean the farmers could see excess solar to the utility and thus solar farms could be created along with agricultural farms. In the case of Gujarat the agricultural sector costs of electricity is Rs 0.50 while the industry rate stands at around Rs 8. So every unit generated from the agricultural farm could be sold to the utility at Rs 7.50 to the industries. This would mean solar investment in the agricultural land would incentivize the industry in the state.

It seems DSM using agriculture looks like a profitable operations for the state to invest into solar (both offgrid and on-grid). The next sections describes the strategy for finding out the regions of interest in the state where solar investment would be more profitable. It describes the investments into solar pumping setups, smart metering techniques, integrating physical models with the climatological information to make solar investment profitable in the long run.

The following note defines the entire process in a much more systematic fashion:

https://docs.google.com/document/d/1x7f0szRX8av7PJk53AhIbEEEW5ydESamnzeCSQZhQao/edit?usp=sharing

Projects Aligned With UN SDG Goals

Goal 1: Affordable and Clean Energy
Goal 2: Sustainable Cities and Communities
Goal 3: Climate Action
Goal 4: Clean Water And Sanitation
Goal 5: Quality Education

Rollout Plan For Villages

Think Tank
SPTL - SOCIETY OF POWER AND TELECOM PROFESSIONALS

COMPANIES



1) Paripos builds up the initial assessment reports, models and predictions
2) BIRD undertakes thorough surveys in the villages and makes the need assessment reports
3) Ecospace undertakes energy audit of the region and provides report for change in equipments.
4) eFresh sets up the Netizen center and crop advisory services in the villages.
5) Tropical Solar sets up the 1 MW solar plant and EPC related services in the field.
6) DhwanIRS provides crop based monitoring and crop insurance services and develops the MIS.
7) InfinitoDatum provides ICT infrastructure services in the villages.
8) Yobi Technologies provides solutions for weather stations and sensors to be deployed in the villages.
9) Solar Flux Energy Pvt Ltd is the local agency in Karnataka to interact with the farmers.
10) e-Vaidya develops the health care services
11) CloudEmpower is a cloud based analytics company which will develop the narrative for the village based on the data collected from different sensors and studies.
12) Carbon Clean Solutions: Will capture CO2 in the nearby regions of the village and look into the feasibility of developing projects which can help solar being integrated with fuel cells. This could help drive the future vehicles in India.
13) Vedantu: Vedantu will provide for tutors to provide education to the kids in the villages of India in the schools once the infrastructure is in place.
14) Karma Labs: Deploys the Netizen Center

LABS

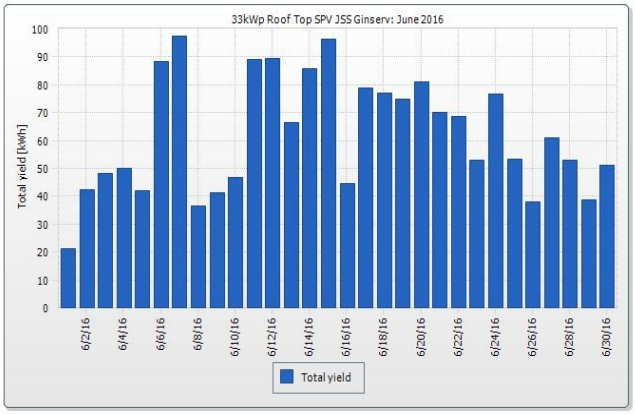
Sustainable Engineering Labs, Columbia University, Dr Vijay Modi: SMART IRRIGATION SOLUTION
Applied Agricultural Systems Modeling Lab, Michigan State University, Dr Amor Ines: CLIMATE SENSITIVE AGRICULTURE
Institute of Information Technology, Ahmedabad, Dr Sanjay Chaudhary: CROP ADVISORY SYSTEMS - SEMANTIC WEB
International Institute of Information Technology, Dr PK Reddy: ESAGU ADVISORY SYSTEM

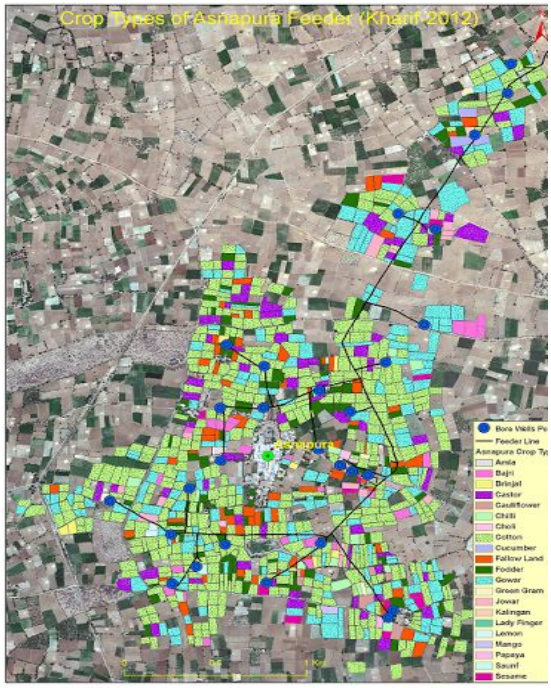
IMPLEMENTATION STRATEGY OF GREEN VILLAGE (SOLAR - A Commons and a Symbiotic Relationship)

MAHALANOBIS AND POVERTY TRAPS: I was talking to famous Indian economist Dr Anik Bhaduri about this project and I asked how can we work with the farmers in India. He said one thing, in India we have to help the corporates to make them help farmers. Without corporates involvement, nothing could work out in Indian agriculture. For this, we experimented with the idea of urban infrastructure could invest into agricultural solar plants - they could achieve carbon neutrality. But in the same time the village output of organic produce can be provided to the organization. So finally there is a state initiative in place: **http://www.thehindu.com/todays-paper/tp-national/tp-mumbai/state-ties-up-with-india-inc-to-develop-villages/article9034823.ece**

Urban Rooftop Solar: 33 KW
Total Electricity Consumption: 26000 units)
Met By Solar Rooftop: 8-10%

Rural Solar Investment Required (500 KW)
Carbon Neutrality Achieved considering building emissions.





Softwares Products To Be Deployed In The Village

1) Solar Smart Irrigation Project in Senegal : http://qsel.columbia.edu/smart-solar-irrigation/
2) Planning Extension : Product: formhub.org
3) Healthcare Solutions: http://smartregister.org/,
4) Energy BaseLine Study: http://ag-energy.modilabs.org/India/
5) Education Social Networking: http://www.myolivebooks.com/
6) Data Collection for IOT: ODK Collect and ODK Sensor https://opendatakit.org/use/collect/
7) Sensors for Reading Photosynthesis Data http://photosynq.org/
8) Crop Model DSSAT Crop Modeling (DSSAT): http://cropmodel.iri.columbia.edu:8080/weatherprediction/,

9) Farmer Friend App
10) E-Sagu Solutions
11) Two way mobile solutions with agriculture MIS

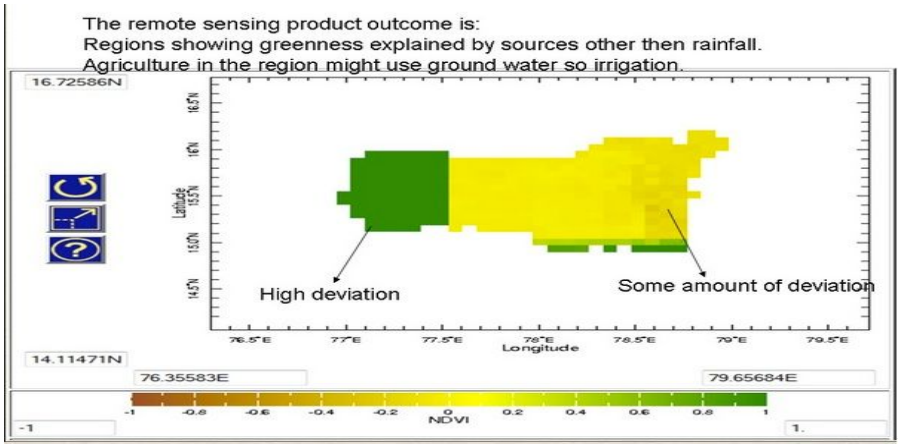
Investing Into People For Making Sensitive Sustainable Professionals

1) Himalayan Walkathon For Climate Change (http://himalayanwalkathon.org/) in the month of May as a retreat event and learn Hatha Yoga Practices at high altitudes
2) High Altitude Expeditions Organized In the Month of September (Leadership Exercise For All Professionals)
3) ThirdElement (http://thirdelement.co.in/) also specializes in Scuba Diving, Para Motor Flying and Adventure sports. Hopefully Green Village region can also be used for these adventure sports activities for the urban dwellers.

Results Of Pilot:

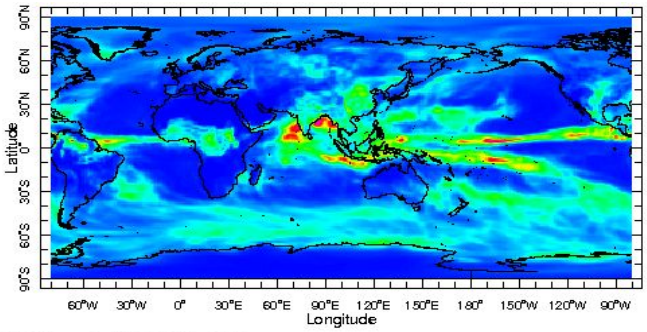
1) Remote Sensing To Finding Regions Under Stress:

Usually what happens is that agriculture is a political subject and CM's adapt a village which is may be from where he belongs. This obviously adds to the problem as what could be seen with Karnataka situation. But may be those who require the resources are ignored. So the following remote sensing application was developed to find the regions of most agricultural stress. So it would be ideal to have a mix of good and bad villages to make a profit in climate change scenario. The technique is defined here:
http://ag-energy.modilabs.org/India/RemoteSensingAnalysis.php

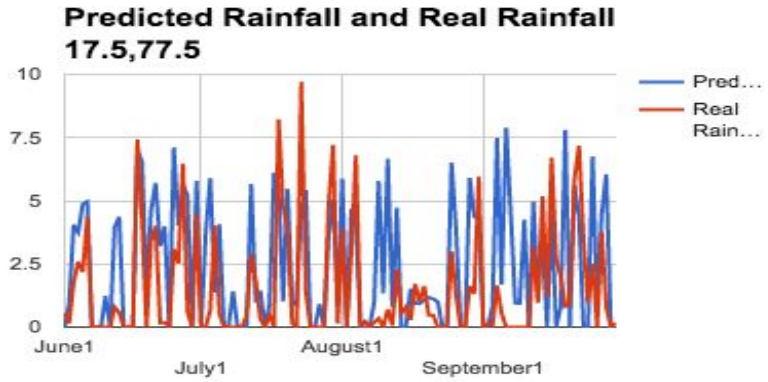


2) GCM Downscaling:

Temporal Rainfall At District Scale Resolution Prediction (June 1). This is used for predicting time series of rainfall. The GCM used in this process is a model from COLA model

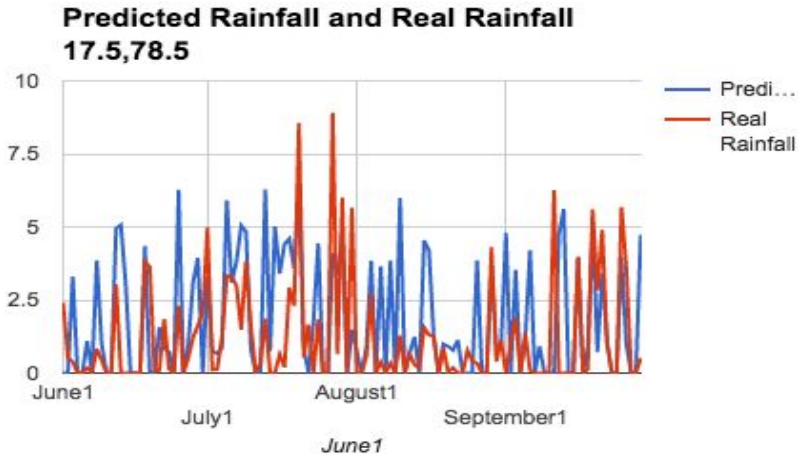


M 3.0 L 0.5 months S 0000 1 Jun 2016



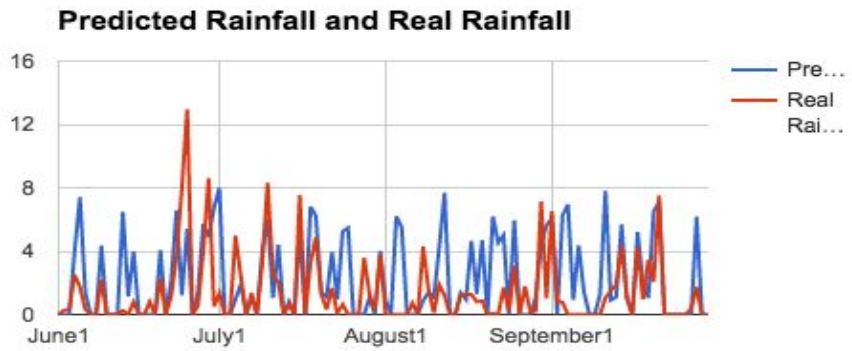
Pred Lat :Lon 17.5, 77.5 vs Real Conditions

TS	MAD	MSE	RMSE	MAPE
67.45555884	1.664881225	5.919314828	2.432964206	48.77575178
Correlation		Covariance Matrix		
0.5410941208		6.179596417	2.935960433	
		2.935960433	4.764251218	



Pred 17.5, 78.5 vs Real Conditions

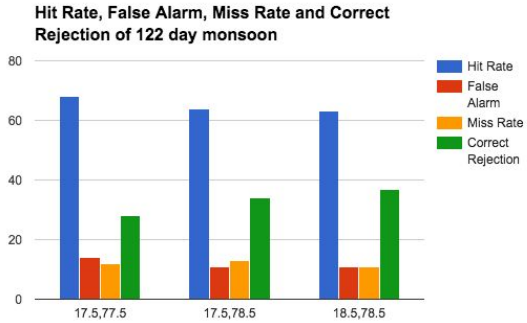
TS	MAD	MSE	RMSE	MAPE
54.79791065	1.351253057	4.358736951	2.087758834	43.98675338
Correlation		Covariance Matrix		
0.468143318		4.087405217	1.741668097	
		1.741668097	3.38630008	



Pred 18.5, 78.5 vs Real Conditions

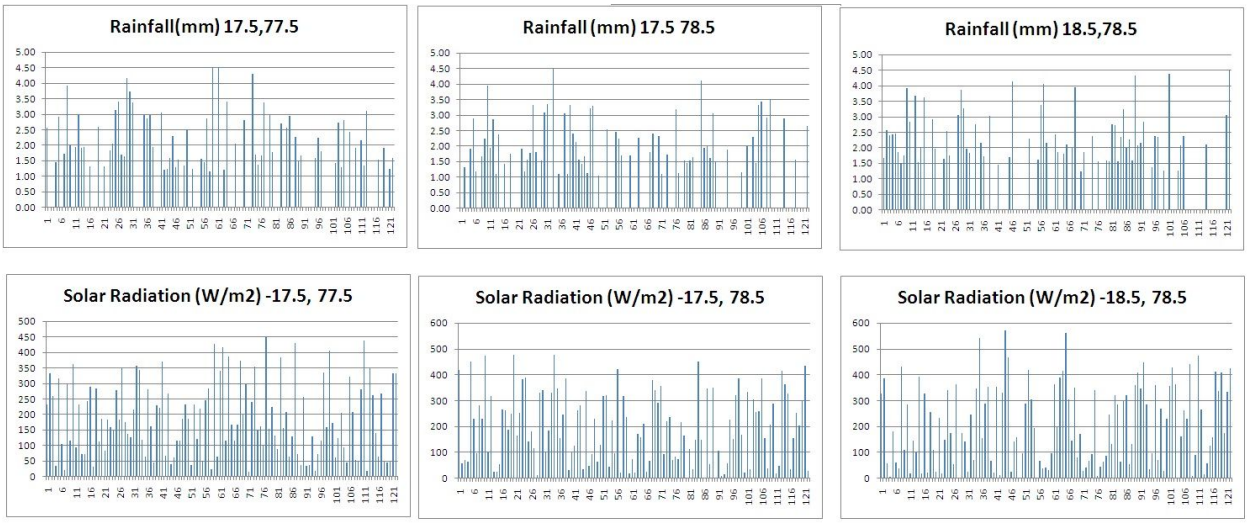
TS	MAD	MSE	RMSE	MAPE
63.3287818	1.690828755	7.314504224	2.704534012	49.10547154
Correlation		Covariance Matrix		
0.4528615054		6.770279727	2.65886791	
		2.65886791	5.091621368	

Comparison: The predictions are compared with values generated by gauge data provided by IMD and also compared with NOAA NCEP CPC UNIFIED_PRCP GAUGE_BASED which they correct using satellite data of cloud cover.The measured and predicted are for little different locations (so one could see little shift) but the pattern is recognizable. So the model has a good hit rate as could be seen.



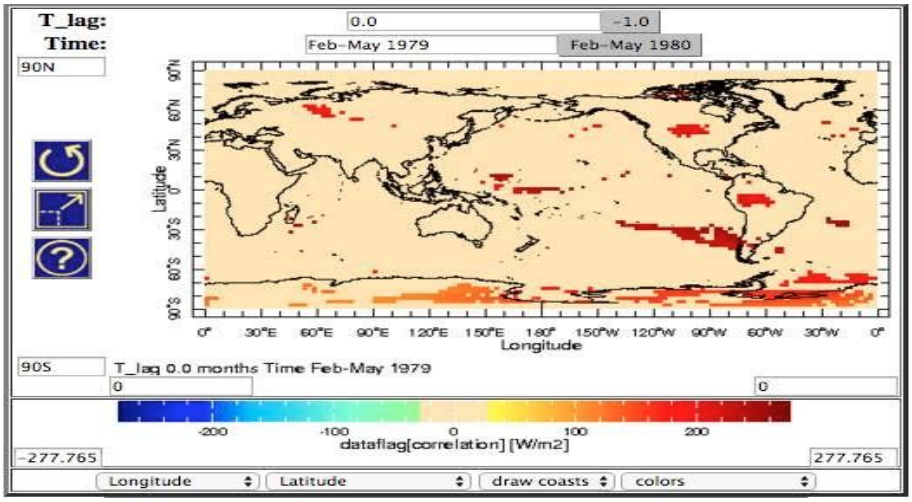
GCM Downscaling Technique For Predicting Solar Radiation

The method of GCM Downscaling was also used to predict the solar radiation over the region. One could clearly see the negative correlation between the rainfall and solar radiations. This technique could be used in the future to build energy trading solutions for solar technology.

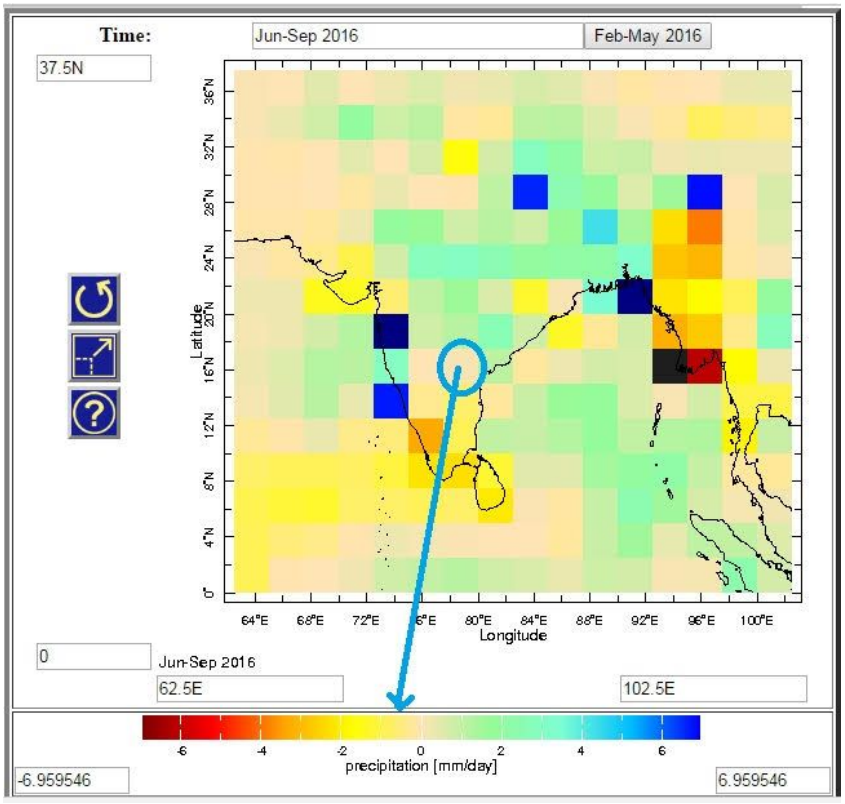


3) Total Rainfall Prediction of Medak District

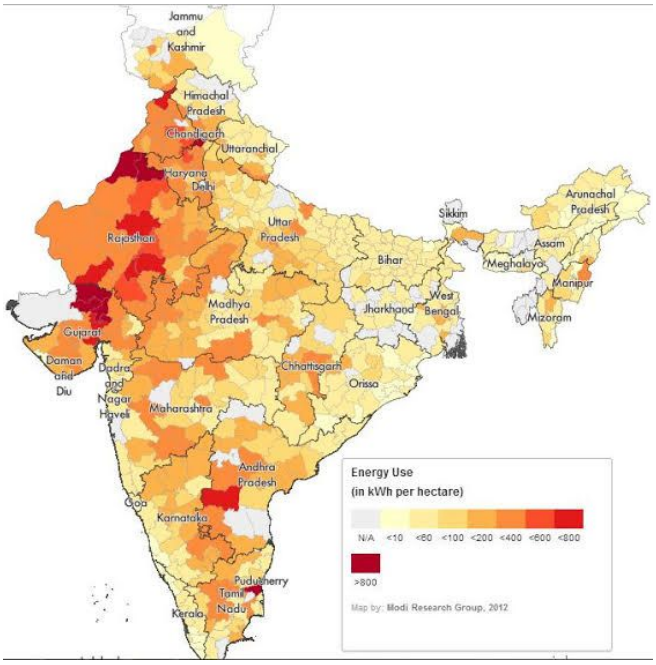
(Seasonal Forecast = -0.20 Rainfall Anomaly corrected to -0.10 after Spring Predictability Barrier)
Technique KNN on Outgoing Long Range radiation



Actual Conditions: Telangana Region is the one with grey lines. Till September end it was showing little below normal rainfall. My prediction was made on May and we have not made any in-season forecast for the spring predictability barrier. Telangana is around 18 N and 79 E.



4) Energy Required For Pumping in the Waddepally village:

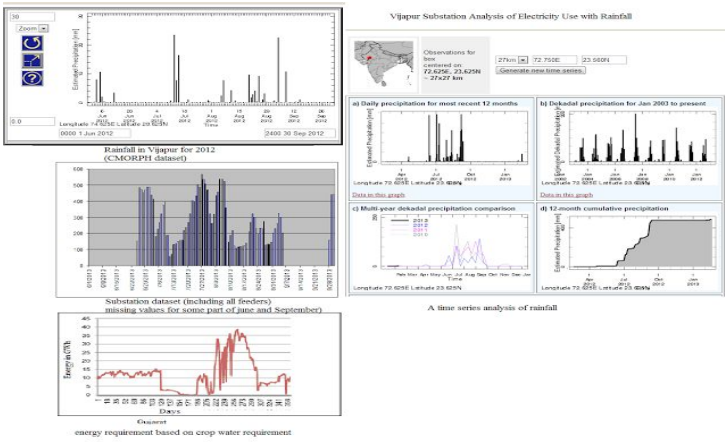


By Replicating Energy Model in the Field which could be used to take a village grid completely solar. This is to understand the demand scenarios.
Energy Used in Pumping: 148.7kwh/ha
Total Energy Used: 22242.84 kwh
(one have to multiply by 9 for agriculture and irrigation efficiency)

This is derived from the following energy model defined in the following paper:
https://docs.google.com/document/d/1ojrQ9-hrLGbRbM2NeB5naK18Nj8zRybbOhOoIUUGPcM/edit?usp=sharing

Size of Solar Required For The Village = 222 MWH or **150 KW** of solar plant. The model has been developed for the entire country and can be used for planning renewable integration in any village.

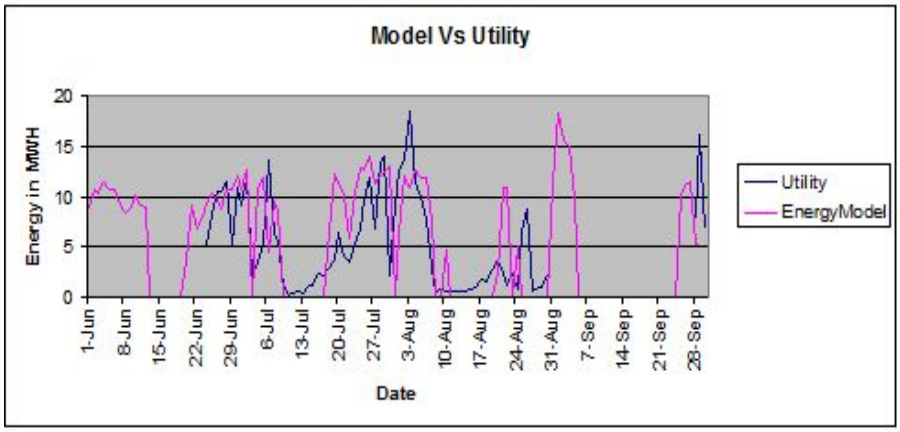
Articulating on the energy model, the following image shows the graphs of energy distribution for the village in the state of Gujarat. The first image on the left shows rainfall distribution of a village in North Gujarat. This distribution is for the season of June-September. The second image shows the substation values for an agriculture feeder in the village in North Gujarat. One could clearly notice the negative correlation between the rainfall values and the utility readings. The third image shows the energy used in GWH for the entire state of Gujarat from the energy model. One could clearly see a rise in demands in pumping during the monsoon season (due to more land under agriculture) at which moment the utility would be relying more on the renewable. On the right image one could clearly understand the impact of climate change. A simple notion of climate change, “It rains less often, but when it rains it pours”. The dekadal distribution clearly shows increase in extreme events which means sudden spikes in demand. The same pattern could be seen on the four years of dekadal comparison in terms of total rainfall.



Predicting The Demands Of Agriculture From The Energy Model in A Feeder

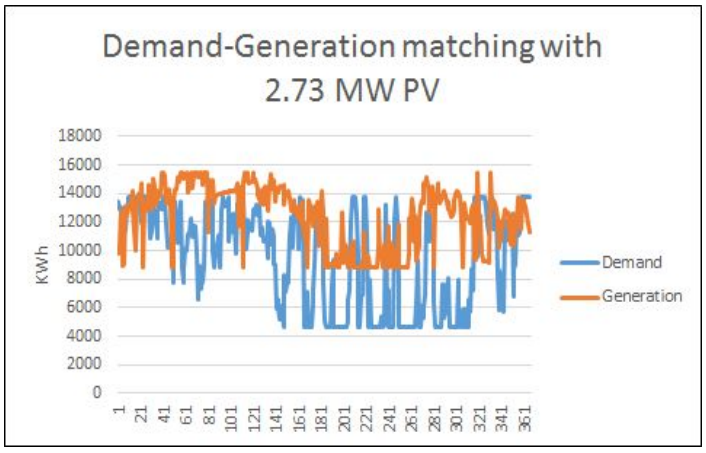
The model was run for the cropping pattern and is plotted against the utility values of the feeder of Asnapura. The utility values for the feeder was missing for major part of June and September, but based on the 70 days of data available, the correlation of utility with model is **0.64**. This is assuming a factor of 9 for agriculture and pumping efficiency. The correlation results of **0.64** means that the model could effectively generate the demand in MWH that is reported by the utility. Further calibration of soil storage and better metering would mean more accuracy in the model values.

The model has provided satisfactory results both at nation and feeder levels. If the model could capture the utility values, would mean that integrating short term high resolution weather prediction could help map the future demands for utility at substation, district or country level.



5) Energy Optimization Model For Asanapura Village of Gujarat To Reduce The Demand

Technique: We can shift to tomorrow as much as the surplus of tomorrow. Although we put a constraint on the postponed demand, this constraint does not guarantee that we can not shift more than 1 day. The technique can be used in all villages and we will bring down the utilization of energy. Make the village carbon neutral. The following experiment was conducted in a village in Gujarat.



Here, linear programming models are constructed to determine the optimal solar panel area and IBM ILOG Optimization Studio (CPLEX) is used to implement and solve them. In the first analysis, we determine the required solar power generation capacity given the potential output curve for 1MW system for the whole year, multiplying with the load factor. If the farmer could

schedule activities at an earlier (shifting the demand to the left in the following figures) or later time (shifting the demand to the right) when the solar generation is possible.

UTILITY READINGS = 4.43MW.
RESULT= 3.30663 MW

6) Optimized Cropping Patterns For Maximum Output From The Village for the season....

Non-linear Optimization on cropping pattern of the village based on the rainfall prediction constraints
crops = [paddy; sugarcane; maize;cotton];
cost of production= [75150;118607;43881;89904]
Market price = [76282;148522;46600;79838];
Present cropingpattern = [142;16;6;2.5]; (present area under cultivation in hectares - paddy:142ha, sugarcane:16ha etc)

Results_optimizedcropping_pattern = [77; 30; 50 ; 16]

Since this was a normal year, it was recommended to decrease the area under paddy and increase the area under maize for this season from 6 ha to 50 ha.

7) Crop Model Integration on Prediction (DSSAT) as part of Extended Range Forecast Solution

Sample Results Using FAO soil Maps of running crop models in predictive mode from parameters provided by Telangana Agriculture University

```
CROP GROWTH   BIOMASS        LEAF   CROP N     STRESS
 DATE  AGE STAGE      kg/ha    LAI   NUM  kg/ha  %   H2O    N
------  --- ---------- -----  -----  ----  ---  ---  ----  ----
 1 JUN    0 Start Sim      0   0.00   0.0    0  0.0  0.00  0.00
20 JUN    0 Sowing         0   0.00   0.0    0  0.0  0.00  0.00
21 JUN    1 Germinate      0   0.00   0.0    0  0.0  0.00  0.00
25 JUN    5 Emergence     29   0.00   2.2    1  4.4  0.00  0.00
 7 JUL   17 End Juveni   147   0.30   8.0    6  4.0  0.07  0.00
12 JUL   22 Floral Ini   172   0.28  10.1    9  5.5  0.89  0.01
16 AUG   57 75% Silkin  1267   0.39  20.8   33  2.6  0.85  0.02
25 AUG   66 Beg Gr Fil  2389   0.31  20.8   36  1.5  0.68  0.02
 3 OCT  105 End Gr Fil  8260   0.09  20.8  109  1.3  0.68  0.10
 6 OCT  108 Maturity    8260   0.09  20.8  109  1.3  0.96  0.42
 6 OCT  108 Harvest     8260   0.09  20.8  109  1.3  0.00  0.00
Maize YIELD :     6322 kg/ha    [Dry weight]
```

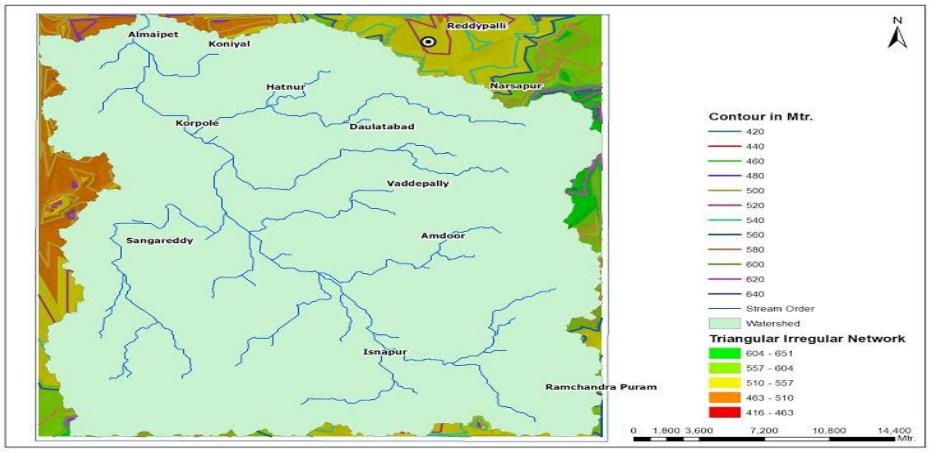
This results tell us when one should optimally sow the crop for the season. 20 June was the right sowing date and the other regions show the dates on which different crop stages are reached. This would help in scheduling irrigation which could come from farmer ponds.

The actual output from the field for all the soils and maize crop
https://docs.google.com/document/d/1VV0_FICfBtz8nugi57yR1chyre0bdswvqEnbBow7d-g/edit?usp=sharing

The next step would involve actual soil reading, installing weather stations, tracking management practices in the field and running crop models in historical mode. This would ensure maximum outputs.

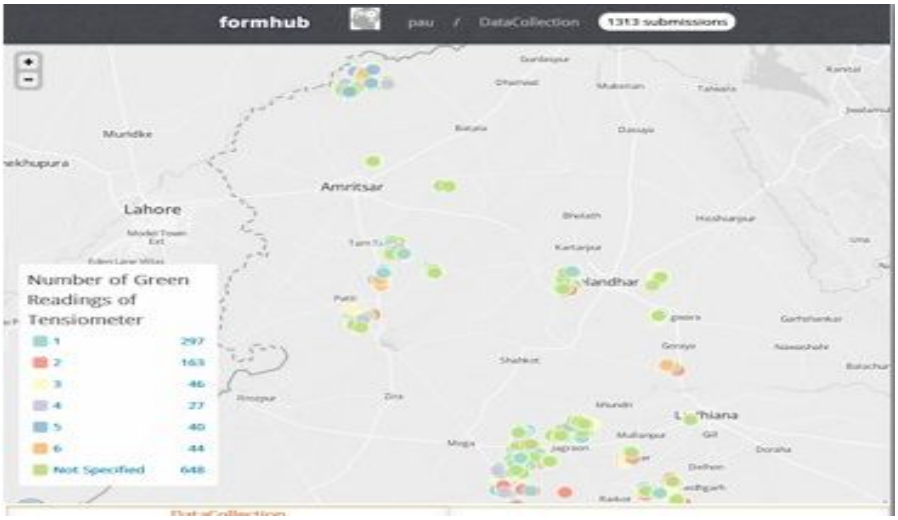
8) Stream Flow Pattern Based On Digital Elevation Model.

Since we have seen that this year there was a lot of flooding and lot of overflow. This model was used to develop farmer ponds in areas where there will be stream overflow. This ponds will be plastic covered in this region. This is to monitor the surface flow due to excessive rainfall. This is a buffer for pumping water in the smart irrigation part and can be used as storage for other seasons.



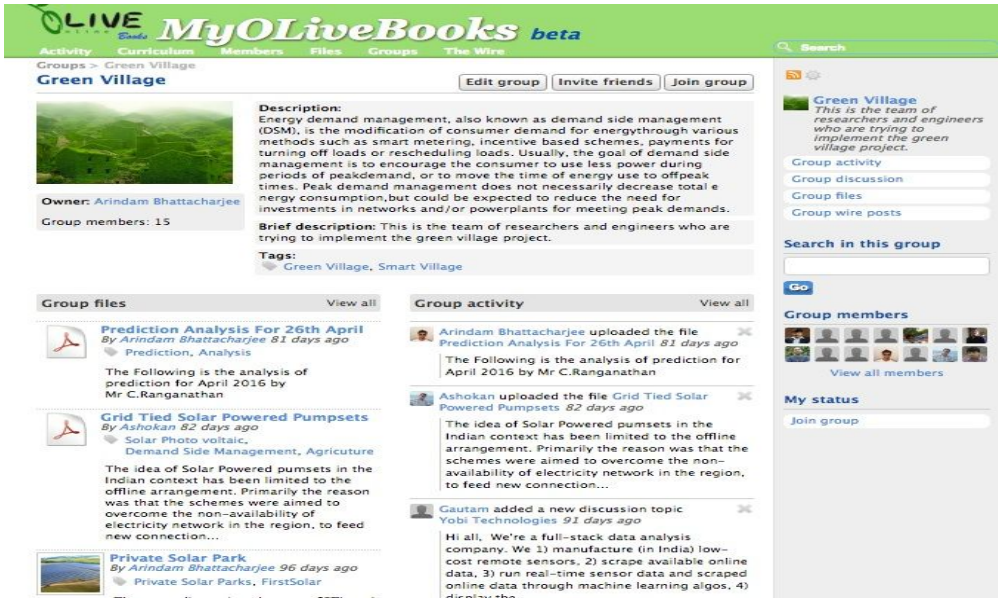
9) Typical Extension Program With Sensor Deployment: This would be used to monitor everyday activity in the field.

This would integrate VRS systems to inform about the conditions to the farmers. Giving the short term and long term forecast and crop practices information.

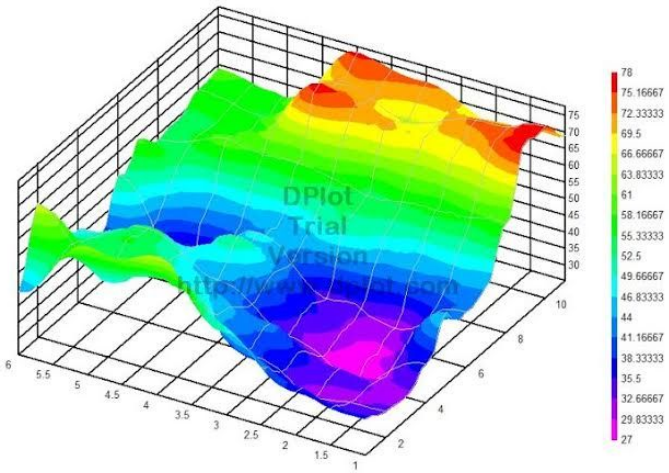


10) Communicating To the Field All Research Outputs (Two Entrances and Four Ways)

The following social networking site is used to communicate with different agencies. This would be one point of contact with all agencies who are investing in the field. This product would be used for all villages to monitor the demands and supply scenarios. Like readings from solar, sensors, prediction, crop inputs would be published in the application.



11) Construction of Check Dams (To Recharge The Ground Waters. This would be measured by the groundwater sensors in the region.) The following site is being used to develop the check dams.



12) SEMANTIC WEB SERVICES (Farmer Friend App)

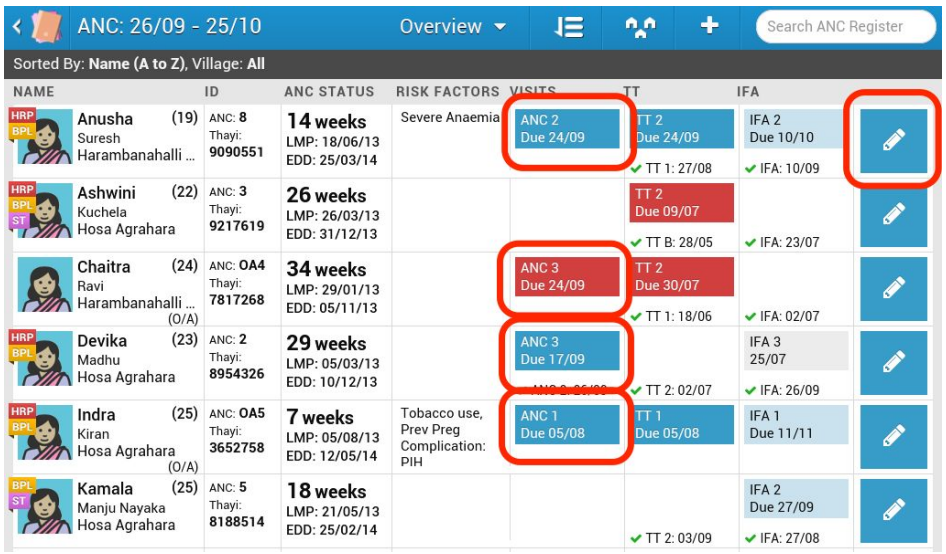
It is important to communicate the information to the farmers. For this Prof Sanjay Chaudhary had developed the Farmer Friend App which is built on the Semantic Web to communicate the information to the field. I am attaching the snapshots of the app. Also the e-sagu system of IIIT Hyderabad can also be used to communicate the information.





13 Mother-Child Tracking System (http://smartregister.org/)

The following mobile app tracks the health of pregnant mothers in the villages. It tells the Asha and ANM's about various stages of pregancy. This project has been tested in the Koppal District for 3 years.



14 Clean Water And Nitizen Center

The following project was developed by SEL and want to integrate with the nitizen centers to provide clean water to the villagers.



