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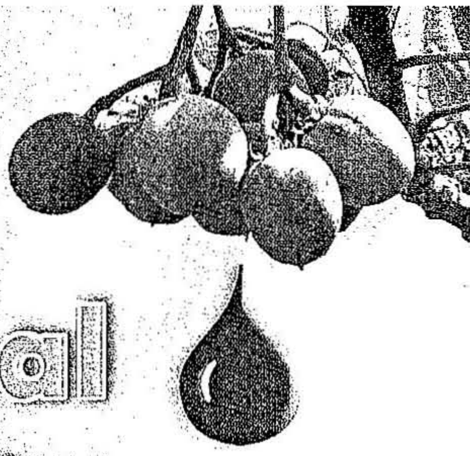

6th International Biofuels Conference

March 4-5, 2009: Hotel Le Meridien, New Delhi

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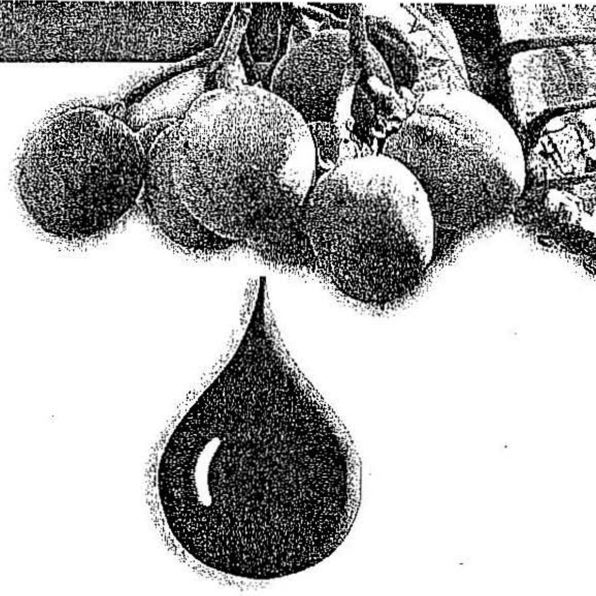

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CONFERENCE PROCEEDINGS

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Jatropha and Pongamia Rainfed Plantations on Wastelands in India for Improved Livelihoods and Protecting Environment

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ABSTRACT

Jatropha and Pongamia as biodiesel plantations are promoted by a large number of developing and developed countries as a source for generating biodiesel. Achieving food security, meeting the demand for sufficient food production to cater to the growing demographic pressures the competitive demand for water and its scarcity, calls for consideration of the fact that good, productive lands used for food production cannot be diverted for Jatropha and Pongamia cultivation.

Results from literature also suggest that when Jatropha is grown on good quality lands, with irrigation and intercropping with baby corn, it is not economically superior to the sole cultivation of baby corn. In order to improve livelihoods of the rural poor by providing opportunities for additional income from Jatropha and Pongamia plantations, ICRISAT in partnership with Civil Society Organizations (CSOs) and Community Based Organizations (CBOs) has developed a model to rehabilitate degraded common lands in a village. Three hundred ha of Jatropha plantation, which is three years old, has started producing yield. The grain yield from the third year onwards was 100 kg per ha and was expected to reach upto 1000 kg per ha by the sixth year. Growing intercrops on areas where good soil existed provided additional income for the farmers. The Jatropha and Pongamia plantations on waste lands have not only created employment in the rural areas but also provided additional sources of income through usufruct rights, by selling Jatropha seeds. Other impacts in terms of social capital development, building of institutions in the villages, improving soil health through recycling of organic matter and enhanced soil water conservation measures, reduced soil erosion and land degradation were also recorded. With the unique institutional mechanisms adopted in this model for development of CPRs through collective action, landless people were organized into self- help groups and took up labour work in the development of degraded common property resources, such as soil and water conservation measures, supported by the project. The District administration of the Government of Andhra Pradesh gave them usufruct rights

over the plantation for harvesting the produce. Farmers are growing good quality grass and supporting their livestock and feed requirements from grass grown in-between the rows of plantations. Now, with the support of GTZ and Kirlosker Engineering Pvt Ltd., we are operationalizing a value-chain model for extracting oil through decentralized electricity generation in the village. This model plantation of 300 ha in two villages has set a live example of how degraded lands can successfully be used for producing Jatropha and Pongamia, without sacrificing good quality land and food security, which is very critical. Results of the social, economic and environmental impacts from this novel, collective action model of required degraded lands, are discussed.

Background

The first decade of the 21st century has put the major challenges of poverty, food security, water scarcity, energy crises, land degradation, population, and most importantly, the changes associated with climate change due to global warming, at the center stage. During the last five years, biofuels have attracted attention worldwide largely due to the increasing prices of fossil fuel and the policies in the USA and European countries to enhance use of biofuels for increasing reliance on domestic energy security and greenhouse gas (GHG) abatement . Developing countries are also in the biofuels race to augment local energy sources. As a consequence of diversion of maize, rapeseed and soybean for biofuel production in developed countries, and the occurrence of drought, the worldwide prices of food grains have increased causing social problems and riots. The issues of food security, water security, poverty, and energy security are all interlinked and call for careful consideration while dealing with any one of them, by taking into account the impact on other aspects.

Most countries in the world depend primarily on rainfed agriculture for its grain food. The importance of rainfed agriculture varies regionally, but produces most of the food for poor communities in developing countries (60% for South Asia and 95% for Africa) (FAO Stat, 2005). Despite large strides made in improving productivity and environmental conditions in many developing countries, a great number of poor families in Africa and Asio still face poverty, hunger, food insecurity and malnutrition, where rainfed agriculture is the main agricultural activity (Wani et al. 2009). These problems are exacerbated by climatic variability, the risk of climate change, population growth, health pandemics (AIDS, malaria), degrading natural resource base, poor infrastructure and changing patterns of demand and production (Ryan and Spencer, 2001). There is a correlation between poverty, hunger and water stress (Falkenmark, 1986). The "hot spot" countries in the world suffering from the largest prevalence of malnourishment, coincide closely with the countries hosted in semiarid and dry subhumid hydroclimates in the world, i.e. savannahs and steppe ecosystems, where rainfed agriculture is the dominating source of food, and where water constitutes a key limiting factor to crop growth (SEI, 2005). Of the 850 million undernourished people in the world, essentially all live in poor developing countries, which predominantly are located in tropical regions (UNStat, 2005).

Biofuels and food production need to be considered together as land and water resources are limited. An insight into the inventories of natural resources in rainfed regions shows a grim picture of water scarcity; fragile environments, drought and land degradation due to soil erosion by wind and water, low rainwater use efficiency (35-45%), high population pressure, poverty, low investments in water use efficiency (WUE) measures, poor infrastructure and inappropriate policies (Wani et al. 2003a, 2003b; Rockström et al. 2007). Increasing production of biodiesel in India, to bridge the gap of 86.43 metric million tonnes between demand and supply, in 2006-2007, looks attractive. In India, edible oils are in short supply and therefore they, as well as fertile agricultural land, will not be available for producing biofuels. For this reason, the Indian Government has identified non-edible tree-borne seed oils as possible sources for agro diesel production. Out of 300 different tree species producing oil-bearing seeds in India, only a few, such as Pongamia pinnata (Karanja), Jatropha curcas (Ratanjot), Mohuca indica (Mahua) and *Azadirachta indica* (*neem*) are under consideration, to be primarily exploited for growing on waste lands under the "National Mission on Biodiesel", announced in 2003. The National Mission on Biofuels estimated that out of the 197 m ha in under-stocked forests, protective hedges around agricultural fields, agro forestry, fallow lands, wastelands under integrated watershed programs and public lands, about 13.4 m ha has the potential for Jatropha curcas and Pongamia pinnata plantations. Once success is achieved on the potential lands, it should be possible to include lands with low fertility soils under Jatropha curcas and Pongamia pinnata plantation in an economically feasible manner, so as to rehabilitate these degraded lands.

In this paper, a case study of 300 ha Jatropha curcas and Pongamia pinnata mixed plantation on common property resource (CPR) waste lands in Ranga Reddy district, and 200 ha private degraded lands in Kurnool district under rainfed conditions, undertaken through collective action by the self-help groups (SHGs) of landless and marginal farmers, is discussed.

Project Area and Objectives

This project on integrated development of biofuel promotion in Andhra Pradesh was initiated in July 2005 as the ICRISAT-NOVOD (National Oilseeds and Vegetable Oils Development Board) model demonstration project to rehabilitate the wastelands. The project was implemented as a model plantation on 300 ha common property resources (revenue land) of two villages, namely, Velchal village in Mominpet Mandal and Kothlapur village in Morpally Mandal of Ranga Reddy District (Figure 1), and 200 ha of Pongamia and Jatropha plantations in private degraded lands in Rollapadu, Cherakucherla and Sunkesula villages in Midthur Mandal of Kurnool District in Andhra Pradesh, with the following objectives.

- To establish a model Jatropha plantation to rehabilitate degraded wastelands located on upper topo-sequence in a watershed;
- To enhance employment generation and improve livelihoods of the rural poor by triggering a chain of livelihood activities such as nursery raising, plantation development, seed collection, oil extraction; and

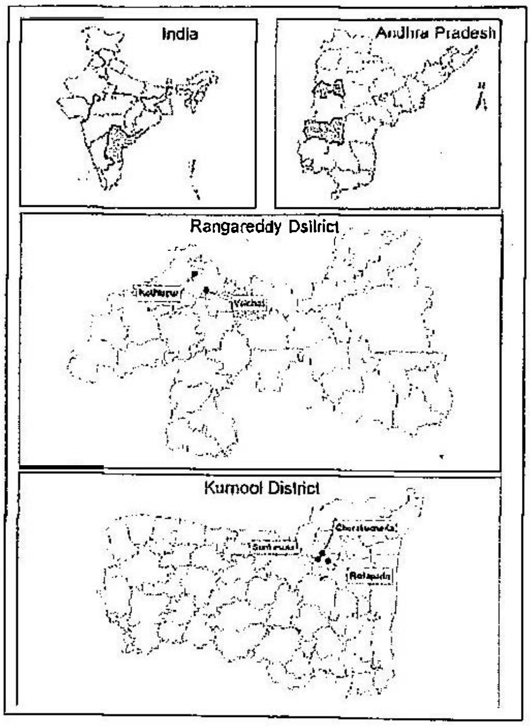


Figure 1. Map showing project sites in Ranga Reddy and Kurnool districts in Andhra Pradesh

- To increase energy availability in rural areas and protect the environment through enhanced rainwater use efficiency, minimizing land degradation, and reducing emissions of GHGs;

Site Selection

From the beginning we adopted a participatory approach involving the district officials, local Panchayat Raj Institutions (PRIs), villagers, and selected NGO partners and explained the details about the project to stakeholders. As the CPRs are most difficult to get access for development, involvement of district officials and the local PRIs proved very effective for identifying suitable wastelands for establishing biodiesel plantations. The ICRISAT team along with the partners conducted a feasibility survey and identified government wastelands (common pool resources) in Velchal and Kothlapur villages. Local PRI and NGOs undertook social mobilization in both the villages and ensured the involvement of local people in the project from the beginning.

Institutional Arrangements

At the beginning of the project, a committee under the chairmanship of the District Collector, Ranga Reddy, with the following membership was formed; to organize the working arrangements, including financial arrangements, and the responsibilities for the project. Committee:

Chair : District Collector, Ranga Reddy District
Members : District Water Management Agency (DWMA)
Rural Education and Agriculture Development (READ), NGO
HELP, NGO
Village Panchayat Sarpanches of Kothlapur and Velchal
Self-help groups (SHGs) of agricultural labourers and farmers in the villages
ICRISAT

This committee guided the project activities as well as provided the necessary support for the SHGs and the PRIs to operationalize the project,

Another important aspect of this project is that the beneficiaries were identified before the plantation was initiated. Through the Gram Sabha, landless and marginal farmers in the villages were identified and called for the meeting. The details of the project, such as the purpose, working arrangements, objectives and potential benefits, were explained to them by Dr. SP Wani and Dr. TK Sreedevi from ICRISAT and Dr. Rama Linga Reddy, DWMA, Ranga Reddy. Once the people who were to undertake the establishment of plantation were identified, the partner NGO staff through a social mobilization and awareness building process, formed the SHGs. In brief, the SHGs managed the plantations with guidance and technical support from the Committee chaired by the District Collector.

Process

The partner NGOs conducted the Grama Sabha (village assembly) in these villages and the respective village Gram Panchayats along with the farmers and labourers, passed the resolutions to co-operate and provide assistance for establishing biodiesel plantations in their village government wastelands. The SHGs elected their leaders and through social mobilization and capacity building measures were empowered to undertake execution and supervision as well as disbursal of payments for the work undertaken by the members. One staff from the partner NGO helped the groups to distribute the project work and also to supervise the members. The SHGs took up the responsibility to ensure completion of the targeted project work. There are eight SHGs in Velchal and seven SHGs in Kothlapur villages for biodiesel plantations.

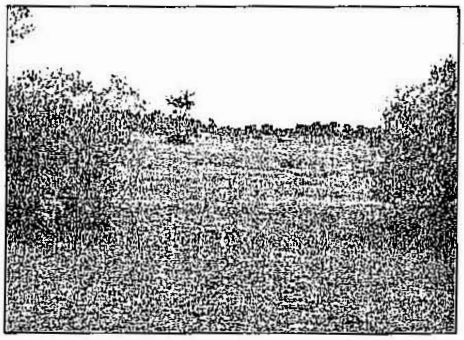
The important issue was to develop the ownership for the project amongst the SHGs. Continuous discussions by the project team with the SHGs highlighted the benefits of biodiesel plantation for them and also for their village. Dr. SP Wani and Dr. TK Sreedevi (ICRISAT) and Dr Ramalinga Reddy, Assistant Project Director of DWMA, along with local PRI and NGOs held a meeting with the labour groups and finalized the wage rate for working in the plantations. The members agreed to work together in the plantations at a lower rate than the government projects, because they took collective ownership of the plantation. Another important aspect was that men and women were paid equal wages in the group and this was contrary to the practice of differential wages for men and women in vogue in the villages. The SHGs were encouraged to open bank accounts in their group's name and initiate thrift and credit activity to bind together the SHGs, and harness the power of collective action. This was necessary to help the wage earners have a stake in the development of the government lands and inculcate ownership of the process. The groups are fostered so that they can nurture the plantations and derive benefits through harvesting rights (usufruct rights) once the plantations reach the stage of economic production of oil rich seeds.

Eight self-help groups were formed with a total of 80 labourers in Velchal village and bank accounts were opened in Deccan Grameena Bank, Velchal branch, for group savings. Seven self-help groups with a total of 78 labourers were formed in Kothlapur village and bank accounts were opened in Andhra Bank, Marpally branch, to save the amount and carry out the plantation activities. The identified lands in the two villages are revenue wastelands having hillocks, bushes and sheet rocks in some places (Figure 2).

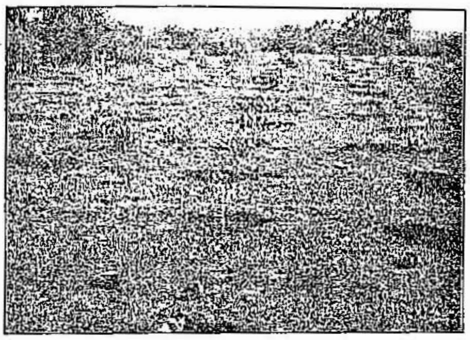
Usufruct Rights

As indicated above, the beneficiaries were identified before establishing the plantations at Velchal and Kothlapur and the SHGs were formed. Through discussions with the District Collector, to avoid the conflict once economic production starts in these plantations, usufructs rights were negotiated with the district administration to ensure that the targeted beneficiaries get the benefits from the project. Working with the district administration and evaluating the SHGs interest in maintaining the plantations, the Collector, Ranga Reddy District, awarded the usufruct rights to the SHGs. Using GIS, the plantations at Velchal and Kothlapur were divided into eight and seven equal parcels of land (Figure 3) and for each group the usufruct right letter (license granted for planting trees in government lands and harvesting the fruits), under the following conditions, was awarded on site in the presence of the Sarpanch (elected PRI head) and the SHGs members. The license confers no right over the land

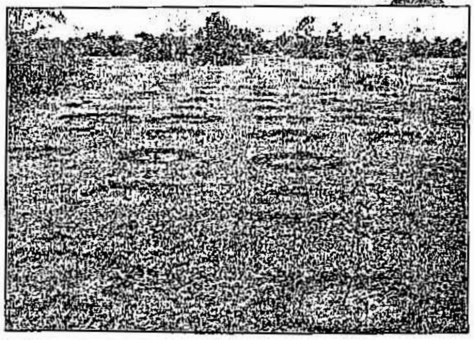
- No trees shall be cut without the prior permission of the Mandal Revenue Officer (MRO).



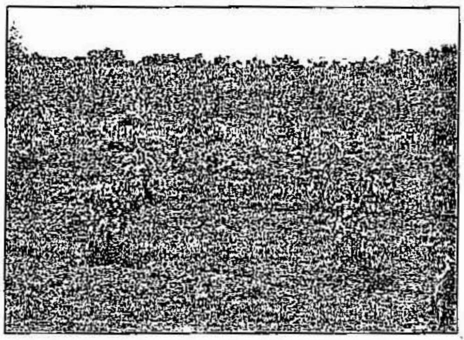
Velchal site before development, July 2005



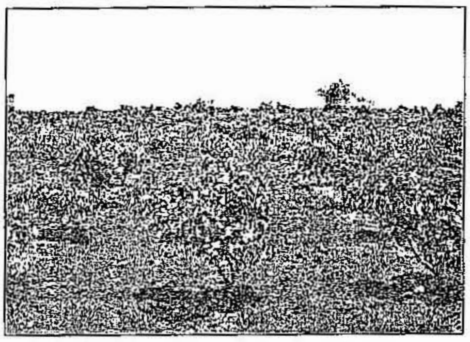
Velchal site after plantation, August 2005



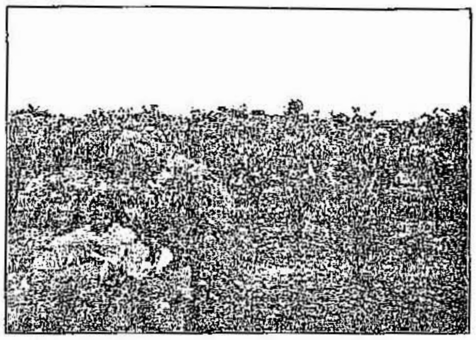
Velchal plantation after establishment, Sep 2005



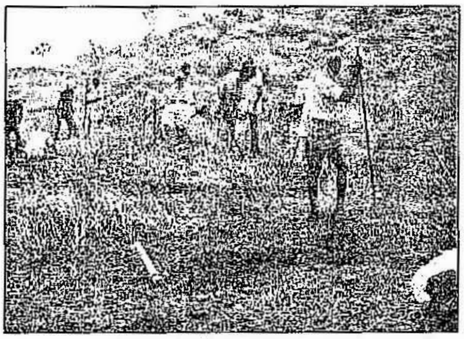
Velchal plantation during August 2006



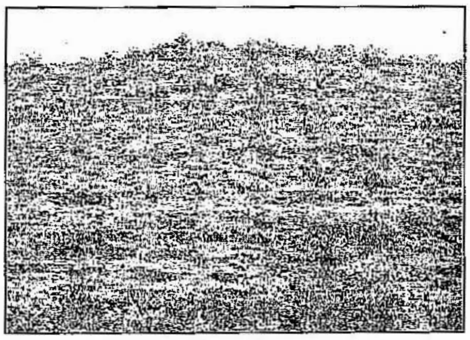
Velchal plantation in August 2007



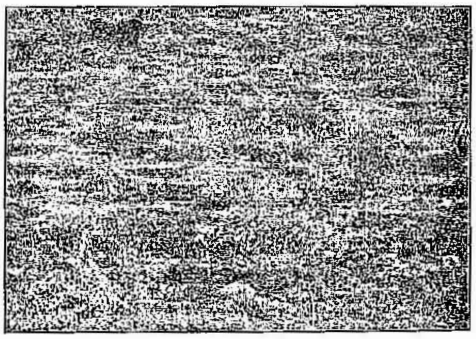
Velchal plantation in August 2008



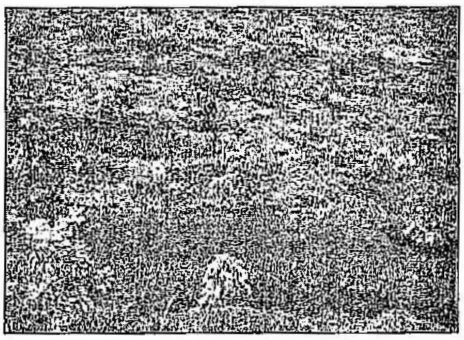
Kothlapur site before development, July 2005



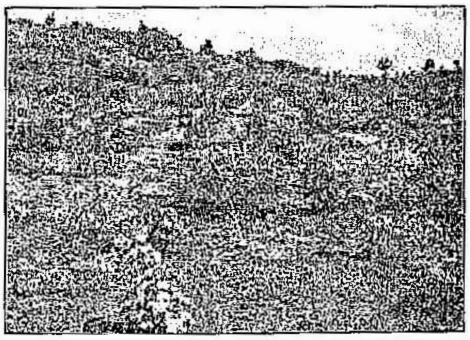
Kothlapur site after plantation, August 2005



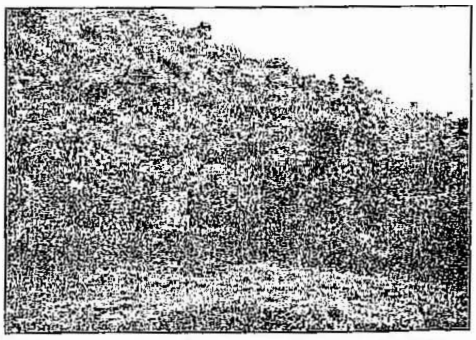
Kothlapur plantation after establishment, Sep 2005



Kothlapur plantation during August 2006



Kothlapur plantation in August 2007



Kothlapur plantation in August 2008

Figure 2. Plantation development in Velchal and Kothlapur villages, Ranga Reddy district, Andhra Pradesh, during 2005-2008

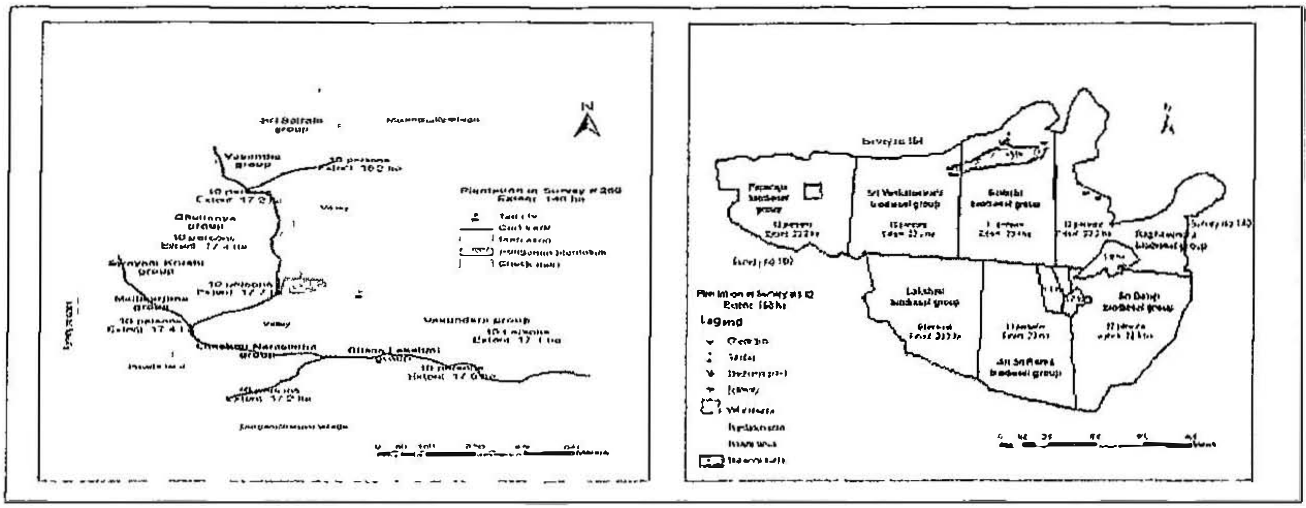


Figure 3. Plantation maps of Velchal and Kothlapur villages

- The usufruct of the trees and the timber will be at the disposal of the licensee, subject to the condition that in case fruit trees that are usually taxed are planted, the annual tax shall be paid in installment when the trees come to bearing and that it shall be recoverable in case of default under section 52 of the Act of 1864.
- The MRO has the power to remove the trees at any time without compensation.
- In case of default with regard to any of the conditions given above, the license will be liable for immediate cancellation.
- The licensee shall not be entitled to compensation for any trees planted or any improvements that farmers or self-help groups may have made to the land.

Soil Analysis

The soil in these CPRs is lateritic, very shallow (<15cm) to shallow (30cm), and at many places the base sheet rock is exposed after the erosion of top fine soil. Soils are highly degraded with moderate to less vegetative bushes and are almost non-existent in some places where there is sheet rock. Composite soil samples were collected from Velchal and Kothlapur villages and analyzed for soil chemical properties before undertaking the plantations. At Velchal, the topography is smooth and at the top of the toposequence of the watershed, there are flat lands and on the two sides are drainage lines. At Kothlapur the terrain is hilly with steep slopes and on the top of the hill is a flat land. These CPRs were uncultivated and the analysis indicated that wherever there is soil, it is suitable for cultivation as the pH is near neutral and organic carbon content is moderate. However, the soils were deficient in available phosphorus, sulphur, zinc and boron in both the villages (Tables 1a & 1b). Soil at Kothlapur was found deficient in potassium content also (Table 1b).

Soil and Water Conservation Interventions

In the 2005 rainy season, before planting with Jatropha and Pongamia was undertaken, the land was cleared of unproductive bushes manually. Well-grown trees were left as such. Land was marked at 2m x 2m spacing and planting basins of 20 cm depth and 90 cm diameter were prepared manually. At Velchal as well as at Kothlapur, staggered contour trenches at

Table 1a. Nutrient analysis of composite soil samples from biodiesel plantation under ICRISAT-NOVOD project, Velchal village, Ranga Reddy district, Andhra Pradesh

S. No	Soil depth (0-15)							
	pH	EC (d'S/m)	OC %	Olsen P mg kg-1 soil	Exch. K mg kg-1 soil	S mg kg-1 soil	Zn mg kg-1 soil	B mg kg-1 soil
1	6.3	0.03	1.33	0.2	56	1.2	0.44	0.52
2	6.4	0.14	1.52	21.4	96	7.8	0.80	0.32
3	5.9	0.07	0.91	2.8	68	8.1	0.52	0.48
4	6.1	0.05	0.81	2.2	117	5.8	0.50	0.48
5	5.9	0.06	1.19	1.4	88	4.6	0.62	0.78
% Deficient			0	80	0	100	80	80

Table 1b. Nutrient analysis of composite soil samples from *Jatropha* plantation under ICRISAT-NOVOD project, Kothlapur village, Ranga Reddy district, Andhra Pradesh

S. No	Soil depth (0-15)							
	pH	EC (d'S/m)	OC %	Olsen P mg kg-1 soil	Exch. K mg kg-1 soil	S mg kg-1 soil	Zn mg kg-1 soil	B mg kg-1 soil
1	6.8	0.03	1.17	0.2	37	0.6	0.48	0 44
2	6.9	0 04	0.91	0.2	34	1.6	0.30	0.58
3	6.6	0.06	1 20	0.2	30	3.6	0.84	0.56
4	6.4	0.38	0.64	0 8	25	11.6	0.38	0.74
% Deficient			0	100	100	75	75	50

specified 5 m intervals with 1:0.5 slope with 60 cm width at the top were dug, upto 60 cms.

Three hundred hectares of land in two villages, 140 ha in Velchal and 160 ha in Kothlapur were planted with Jatropha as the main plantation and Pongamia plantation as mixed rows at fixed intervals. Jatropha was planted at 2 m x 2 m spacing and Pongamia rows were put at 4 m x 4 m spacing at every 50 rows of Jatropha, wherever land was clear, with fewer bushes. Nursery grown Jatropha and Pongamia seedlings of 60 cm height were used for plantation. We also evaluated direct seeding in case of Jatropha. However, we observed that rodents as well as birds and other soil animals damaged seeds and therefore, plant establishment was very unsatisfactory using direct seeding. In the 2005 rainy season, dunng August, the plantation was undertaken. These plantations are totally rainfed and no external water was provided to the plants at any time. Annual rainfall during 2005 to 2008 varied from 1037 in 2005 to 1300 mm in 2008 with an average of 903 mm.

Along with soil and water conservation measures, the plants were trained by pruning them in summer of 2005-06 to promote more branching. Grass grown in between the plant rows

Table 2. Survival percentage of biodiesel plants in Velchal village, Ranga Reddy district, Andhra Pradesh

Group name	Survival (%) in Aug 2006	Survival (%) in Aug 2007	Survival (%) in Aug 2008
Vasantha group	86	75	72
Chaitanya group	79	78	76
Swayamkrushi group	78	78	78
Mallikarjuna group	84	84	83
Laxmi Narasimha group	77	86	82
Dhanalaxmi group	81	82	81
Sri Sairam group	66	55	40
Vasundhara group	60	40	30
Mean	**76**	**72**	**68**

Table 3. Survival percentage of biodiesel plants in Kothlapur village, Ranga Reddy district in Andhra Pradesh

Group name	Survival (%) in Aug 2006	Survival (%) in Aug 2007
Paparaju biodiesel group	73	75
Sri Venkateshwara biodiesel group	67	68
Saibaba biodiesel group	43	65
Laxmi biodiesel group	22	68
Jai Sriram biodiesel group	24	40
Sri Balaji biodiesel group	45	46
Raghavendraswamy biodiesel group	54	55
Mean	**47**	**60**

was cut and put in the staggered trenches or in the basins made around the plants to enhance the organic carbon content in soil, through recycling of organic material. Along with cut grass, the fallen leaves as well as pruned plant material was also added near the plants. Jatropha plants were fertilized with 30 kg N and 12 kg P_2O_5 ha^{-1} in 2005, 50 kg N and 57 kg P_2O_5 ha^{-1} in 2007 using urea and diammonium phosphate (DAP).

Survival of Plants

Observations on survival of the plants were recorded at the beginning of the rainy season during the second and third year, when the plants start sprouting new leaf growth. The survival percentage for each parcel of all the SHGs was recorded. At Velchal surival of Jatropha was 70 per cent in 2008 (Table 2). The loss of 30 per cent plants was where there was no soil left and the base rock was exposed. At Kothlapur, the survival was 60 per cent after the gap filling in 2007 (Table 3). As indicated earlier, the terrain at Kothlapur is more challenging for the plant growth due to hilly terrain and soils that are very shallow.

Equity and Inclusion of Vulnerable Groups

During ICRISAT-NOVOD project initiation in 2005, the selection criteria were based on the voluntary interest of poor people who are in need of livelihood opportunity. In Velchal village, more than 77 % of the biofuel labourers belong to Scheduled Castes and 23% of the labourers belong to Backward Classes (Figure 4). Almost 70% of the selected labourers are illiterate, around 19% have primary education and 11% of the labourers have high school education and above (Figure 5) All the SHGs were mixed groups of women and men, which helped them distribute the works in the groups accordingly. This representative data from the Velchal site clearly showed that planned strategy for inclusiveness and equity in the biodiesel initiatives has ensured benefits to the targeted groups in the society. These members could benefit not only from the livelihood opportunity provided through the project activities, but they took pride in maintaining the plantation on the CPRs. During summer of the first year, when the grass was dry, there was an accidental fire at the plantation site that is 3 km from the village. The members took the initiative and doused the fire and protected the plantation. This incident demonstrated clearly that the SHGs have really internalized the ownership of the plantation.

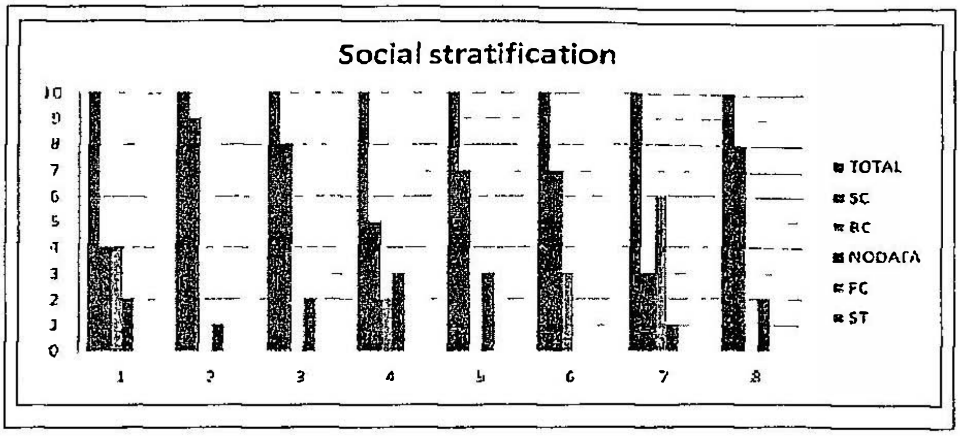


Figure 4. Social stratification of SHGs working for biodiesel plantation at Velchal, Ranga Reddy district, Andhra Pradesh

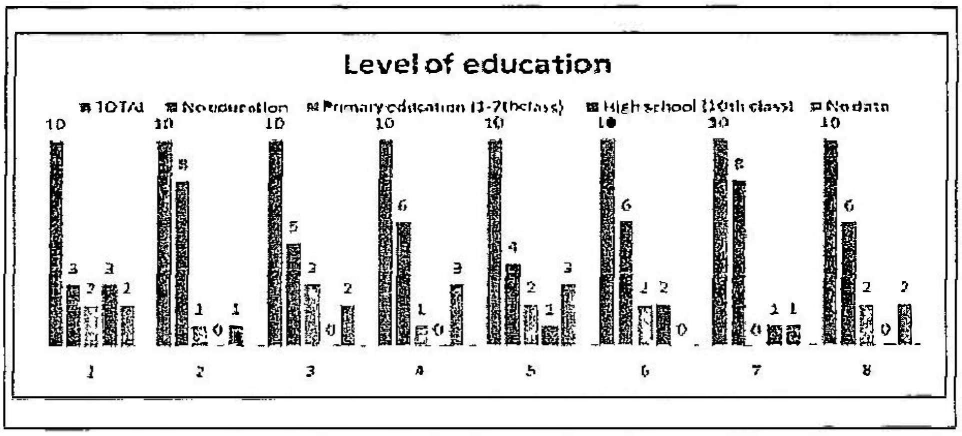


Figure 5. Education level in biofuel social groups at Velchal village, Ranga Reddy district, Andhra Pradesh

Analysis of Source of Livelihood

Analysis of the SHGs' livelihood sources revealed that more than 44 % of the labourers are landless without any assets such as agricultural land. They largely depend on casual labour work such as agricultural labour or construction labour. They often migrate to nearby cities for work, where more than 70% live in slums because they can't afford to pay rent for the accommodation in the cities. The remaining 56% of the SHGs are marginal farmers with less than 2 ha rainfed agricultural land and work as agricultural labourers for their livelihood (Figure 6).

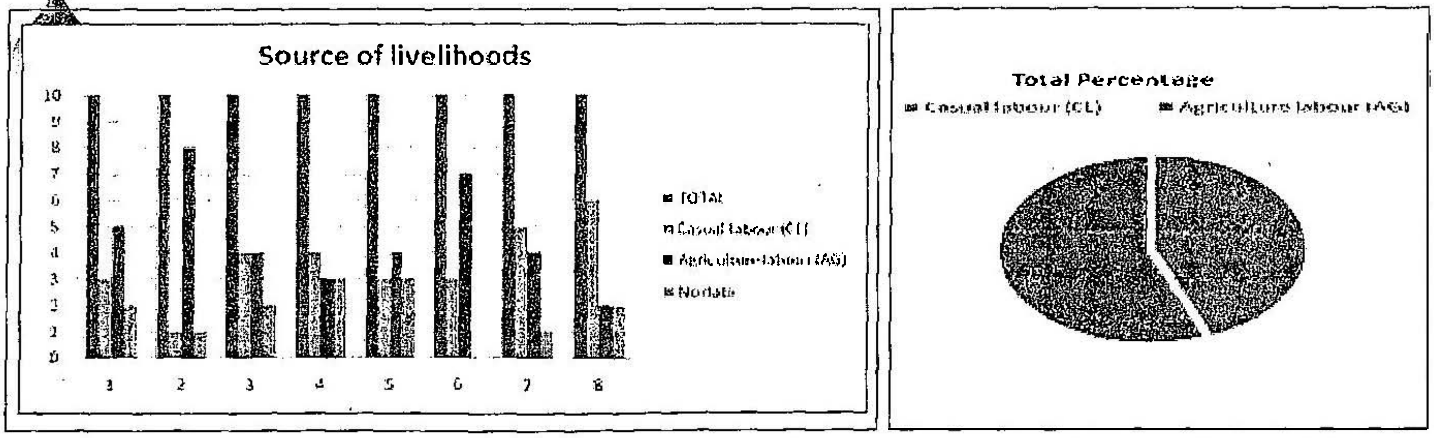


Figure 6. Source of livelihood of biofuel self-help groups at Velchal village, Ranga Reddy district, Andhra Pradesh

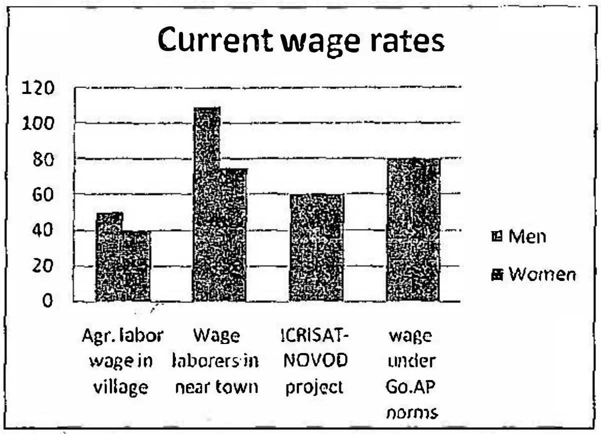


Figure7. Labour wage rates for men and women in Velchal village, Ranga Reddy district, Andhra Pradesh during 2006

Labour Wages

As reported above, in this project men and women receive equal wages as against the practice of differential wages for men and women in vogue in the region (Figure 7). There was quite a lot resistance from the villagers, mainly men, for paying equal wages for men and women. Secondly as against the minimum wage of Rs 80 per day ,as per the norm, SHGs agreed to take wages of Rs 60 per day in 2005. During the Grama Sabha (village meeting) in 2005, many villagers negotiated the wage rates because many marginal farmers cannot afford to pay INR 80 per day to agricultural labourers working in their fields. In Velchal village, the existing wage rates were comparably low. In most cases, men got not more than INR 50 per person per day and women got less than INR 40 per day. Labourers who are working outside the village (within 25 km distance) get INR 100 to 110 per person per day whereas women get INR 60 to 75 per person per day.

Growth of Jatropha

Under full rainfed situation not only Jatropha plants survived up to 2008 i.e. three years after plantation but grew well, reaching a height of upto 114 cm ,with an average height of 86 cm at the end of two years at Velchal. The stem girth of the plants at Velchal varied from 9.2 to 20.3 cm with an average of 15.6 cm; the number of branches varied from 2.4 to 6.8 with an average of 4.7 branches per plant (Table 4). At Kothlapur, in spite of the hilly and challenging terrain for plant growth, Jatropha plants grew well reaching an average height of 90 cm at the end of two years with 16 cm average stem girth and average 9 branches per plant (Table 5). The marginal differences in plant growth at both the locations do suggest that although plants at Kothlapur lagged behind in the first year as compared to the plants grown at Velchal, they caught up in growth during the second year.

Table 4. Growth parameters of *Jatropha* plants after two years in Velchal village under rainfed condition

Group name	12 months after planting			24 months after planting		
	Plant height (cm)	Number of branches	Stem girth (cm)	Plant height (cm)	Number of branches	Stem girth (cm)
Chaitanya group	56.8	3.0	12.0	90.6	4.8	16.0
Swayamkrushi group	52.8	1.7	11.2	84.8	3.8	15.6
Mallikarjuna group	70.7	2.4	15.3	107.6	6.4	18.5
Dhanalaxmi group	65.4	3.4	15.5	104.8	5.1	20.3
Vasundhara group	23.8	1.0	7.8	27.8	1.1	9.2
Laxmi Narasimha group	77.6	3.1	15.5	102.2	6.8	17.4
Sri Sairam group	51.4	2.3	8.3	55.2	2.4	10.5
Vasantha group	73.4	3.7	13.0	114.8	6.8	17.5
Mean	**59.0**	**2.6**	**12.3**	**86.0**	**4.7**	**15.6**

Table 5. Growth parameters of *Jatropha* plants after two years in Kothlapur village under rainfed condition

Group name	12 months after planting			24 months after planting		
	Plant height (cm)	Number of branches	Stem girth (cm)	Plant height (cm)	Number of branches	Stem girth (cm)
Paparaju biodiesel group	71 8	3 8	7 0	116 7	11 8	19 9
Sri Venkateshwara biodiesel group	61 2	3 3	6 3	116 8	18 6	20 4
Saibaba biodiesel group	46 5	2 7	5 1	178 0	18 8	24 0
Raghavendraswamy biodiesel group	45 5	3 4	5 3	48 9	4 2	10 9
Laxmi biodiesel group	47 5	4 3	5 7	86 7	6 4	15 0
Jai Sriram biodiesel group	44 0	1 5	4 1	52 0	4 4	11 9
Sri Balaji biodiesel group	40 0	1 3	3 9	39 4	2 5	10 0
Mean	**50 9**	**2.9**	**5.3**	**91.2**	**9.5**	**16.0**

Jatropha Seed Yield

Jatropha started yielding from the third year onwards and dunng the first year we harvested about 100 kg seed per ha in the plot In other areas becaouse of untimely rains, fruits had fallen on the ground, which were not harvested for economic reasons The yield estimate that we have is from 2008, 100 kg per ha reaching to 1000 kg per ha by 2011 i e , sixth year onwards These results clearly show that Jatropha seed yield of one t ha^{-1} when grown on degraded land, under rainfed conditions, from year sixth onwards is feasible The economic gain from the seed yield as indicated in Table 6 will be Rs 1000 per ha from 2008, and increasing upto Rs 10,000/- per ha 2011 onwards As each SHG member has about 1 8

Table 6. Biofuel income expectations with 90% survival rate in Velchal village

Year	Quantity of seeds (kg/ha)	Seed cost in AP 2007 (INR)	Total income/ ha (INR)	Total income for 140 ha (INR)
2008	100	10	1000	1,40,000
2009	300	10	3000	4,20,000
2010	500	10	5000	7,00,000
2011	1000	10	10000	14,00,000
2012	1000	10	10000	14,00,000
2013	1000	10	10000	14,00,000

Table 7. Intercrop yields in Velchal biodiesel plantation, Rainy season 2006

Number of samples	Pearl millet Grain yield (kg/ha)	Stalk yield (kg/ha)	Castor Grain yield (kg/ha)	Stalk yield (kg/ha)
1	130	408	200	140
2	110	660	180	–
3	180	510	120	–
4	140	450	230	–
5	140	360	–	–
Mean	**140**	**480**	**180**	**140**

ha land usufruct rights, it works out to be additional income of Rs 1800/- in 2008 increasing up to Rs 18,000/- from 2011 onwards (Table 6)

Grass et al (2008) have worked out the economic feasibility of growing Jatropha on wastelands under rainfed conditions using fossil diesel prices They observed that using pure Jatropha plant oil or esterified oil converted to biodiesel is economically viable with the average productivity of 1 t ha^{-1} seed yield when crude oil prices are US$ 75 per barrel

Yield of Intercrops

In these degraded lands during the rainy season of 2006, pearl millet and castor crops were grown as intercrops in 20 ha where soil depth was about 30 cm The SHGs harvested 140 kg ha^{-1} of pearl millet grains and 180 kg ha^{-1} of castor bean seeds (Table 7) In addition 480 kg per ha fodder was also produced In economic terms farmers could earn additional income* of Rs 480 per ha with pearl millet and Rs 2300 per ha with castor bean crops from grains

Impact

As the plants started fruiting during the third year and farmers could grow intercrops on degraded CPRs, one can look back and take stock of the impacts of such rainfed plantations on degraded lands Such impacts are not only in terms of economic returns from the plantations

Table 8. Employment generation and cost of cultivation of *Jatropha* in Velchal village, Mominpet Mandal, Ranga Reddy district based on 140 ha plantation

Particulars	Year 1		Year 2		Year 3 onwards	
	Person days/ha	Rs/ha	Person days/ha	Rs/ha	Person days/ha	Rs/ha
Land clearing	5	300	–		–	
Cost of seedlings	–	4250	–		–	
Cost of seedlings' transport	–	800	–	400	–	
Pitting and planting	50	3000	–		–	
Weeding and basin making	30	1800	40	2400	40	2400
Cost of fertilizers	–	1500	–	2500	–	2500
Fertilizers application	30	1800	30	1800	30	1800
Clearing dried weeds	20	1200	20	1200	20	1200
Staggered trenching (soil & water conservation)	20	1200	–		–	
Plant protection and Hormone spray	–	1250	–	1250	–	1250
Pruning	10	600	15	900	20	1200
Cost of seedlings for gap filling	–		–	1500	–	
Gap filling	–		10	600	–	
Total cost per hectare	165	17700	115	12550	110	10350

but also through employment generation, development of social capital, building community-based organizations, collective action, leveraging credit from the financial institutions taking advantage of their thrift savings in addition to the environmental services provided through C replacement, C sequestration, increased soil moisture resulting in enhanced rainwater use efficiency, and recycling of plant nutrients through use of seed cake as a source of plant nutrients and organic matter.

Employment Generation

One of the important objectives of the national mission on biodiesel in India is the generation of employment in rural areas. During the 1st year of plantation, the ICRISAT-NOVOD project provided employment for 165 person days per hectare; during the 2nd year ,115 person days per hectare ; and 3rd year onwards 110 person days per hectare (Table 8). It is estimated that one hectare of Jatropha plantation will generate 313 person days in the first year itself (Planning Commission, 2003). Another study (Francis, 2005) estimates around 200 person days of employment generation per hectare during the first year and about 50 person days of employment thereafter for 29 years. Our results indicated that on a large scale rainfed plantation, without digging the pits for planting trees, 165 person days employment was created, which was lower by almost 50 per cent of the estimate of the planning commission. From the second year onwards, our results demonstrated that 115 person days as against the estimate of 50 person days per ha (Francis, 2005), which is almost two folds more.

Figure 8. Nurseries of *Pongamia and Jatropha* managed by women self-help groups at Adilabad District and Rango Reddy District of Andhra Pradesh (source: ICRISAT, 2006)

Income Generation for Women

The collectors model, which is implemented in Velchal village provides opportunities for seed collection processes which will add value to the income status of the village. The potential for engaging women in raising nurseries and in collection of tree-borne oils as part of the biofuel initiative could lead to an enhanced participation in the village economy. This is indicated by some of the pilot projects in which the active participation of women was encouraged.

For example, saplings were procured from nurseries raised by women self-help groups (SHGs) in the on-going watershed programmes at Adarsha watershed, Kothapally and from ICRISAT and forest nurseries. Women SHGs were trained for raising Jatropha and Pongamia nurseries in Ranga Reddy district, Andhra Pradesh, to provide them income during off-season (Figure 8). These groups successfully raised nurseries and supplied quality seedlings to establish model plantations in Ranga Reddy district. Another example is Powerguda village in Adilabad District ofAndhra Pradesh, which initiated a new income-generating activity in biofuel nurseries. The women's SHGs of Vana Samarakshaka Samithi (forest protection committee) raised 20,000 seedlings of Pongamia and Jatropha in the year 2004 and 2005. While half of the seedlings were sold to the forest department at 3 INR/seedling, the rest were planted on the field boundaries, farm bunds and community owned lands (D'Silva et al., 2004).

Microfinance

Self-help groups (SHGs) form the basic constituent unit of the microfinance movement in India. A SHG is a group of a few individuals, usually poor and often women, who pool their savings into a fund from which they can borrow if necessary. Such a group is linked with a rural co-operative or commercial bank and they maintain a group account. Over time, the bank begins to lend to the group as a unit, without collateral, relying on self-monitoring and equal pressure within the group for repayment of these loans.

In the ICRISAT-NOVOD biofuel promotion project at Velchal village, the agriculturol labourers were encouraged and fostered to form small groups and initiate thrift and credit activity to bind together into SHGs. This was necessary to develop a stake of the wage earners into the development of the government lands, and inculcate a sense of ownership of the process.

Eight self-help groups were formed with a total of 80 labourers in Velchal village and bank accounts were opened in Deccan Grameena Bank, Velchal branch. In every group, two persons are responsible for handling all bank activities, acting as convener and co-convener of the group. All social groups decided to start by saving Rs 5 per person on each working day in their group bank accounts. Till the middle of 2008, all groups together saved INR 65,155. They further passed a resolution for making use of the savings amount as a revolving fund (among the group members) for internal lending, with a nominal rate of interest (12% per annum).

- Chaitanya group with 10 persons (A/c # 4004), saved Rs. 9002/- as on date 12-04-08
- Swayam Krushi group with 10 persons (A/c # 2227), Rs. 8779/- as on date 12-08-08
- Sri Sai Ram group with 10 persons (A/c # 2228), Rs. 7500/- as on date 12-05-2008
- Sri Mallikarjuna group with 10 persons (A/c # 2226), Rs. 7300/- as on date 12-05-08
- Vasantha group with 10 persons (A/c # 2229), Rs. 7600/- as on date 14-03-08
- Laxmi Narasimha group with 10 persons (A/c # 2239), Rs. 8700/- as on date 13-02-2008
- Dhana Laxmi group with 10 persons (A/c # 2240), Rs. 8872/- as on date 20-04-2008
- Vasundhara group with 10 persons (A/c # 2238), Rs. 7402/- as on date 12-09-2008

Enhanced Rainwater Use Efficiency

Degraded uplands in a watershed are sources for generating large runoff causing further soil erosion in the uplands and other parts of a given watershed. Through the development of degraded uplands more rainwater can be stored in the soil, resulting in reduced runoff generation, increasing groundwater recharge, supporting vegetation and minimizing degradation of natural resources.

Soil tillage for intercropping as well as staggered trenching in biodiesel plantations has influenced moisture conservation in Velchal and Kothlapur villages. Soil tillage helped in conserving 13% more moisture compared to the non-tilled area in Velchal whereas staggered trenching enhanced moisture conservation by 51% in Velchal and 39% in Kothlapur villages in 0-15 cm soil depth (Table 9).

Table 9. Effect of staggered trenching and intercropping on soil moisture conservation on 22 Sep. 2006

Village	Place of collection	Mean soil moisture (g/100g soil)	
		0-15 cm depth	15-30 cm depth
Velchal	Intercrop	17.5	17.0
	Non intercrop	15.5	14.7
	1 m above trench	11.4	12.0
	In the trench	17.4	15.4
	1 m below trench	17.2	16.2
Kothlapur	1 m above trench	13.8	15.1
	In the trench	24.0	25.1
	1 m below trench	19.2	19.6

Table 10. Spear grass production from Velchal plantation during rainy season 2008

Sample #	Spear grass yield from biodiesel plantation (t/ha)		Spear grass yield from non-plantation area (t/ha)	
	Air dry	Oven dry	Air dry	Oven dry
1	1.80	1.74	1.00	0.97
2	2.08	2.01	0.90	0.87
3	1.62	1.56	0.70	0.68
4	2.00	1.93	0.40	0.39
5	1.46	1.41		
6	4.80	4.63		
7	3.00	2.90		
8	3.20	3.09		
9	5.00	4.83		
10	3.40	3.28		
Mean	**2.84**	**2.74**	**0.75**	**0.72**

Biomass Production and Carbon Addition

A lot of spear grass grows in the biodiesel plantations in both the villages and after maturity it is not palatable to cattle, and becomes a hazard for fire accidents in summer. Every year grass can be cut and incorporated in staggered trenches and plant basins to add organic carbon to the soil. About 2 tons of additional grass produced from biodiesel plantation compared to non-planted area (Table 10), which will be adding 800 kg of organic carbon to the soil. This 800 kg organic carbon sequestered from the atmosphere is in addition to the C replacement occurring through use of biodiesel. Additional carbon is added back to the soil through fallen leaves and pruned plant material. Wani et al. (2009a) reported that carbon is added to the soil through organic recycling of 1000 kg of fallen leaves and pruned plant material.

Biodiversity

Microbial diversity in soil

There are a lot of unsubstantiated claims about the impact of Jatropha on soil biodiversity. Our results have shown that bacterial populations (CFU g^{-1} soil) were two folds higher (112 x 10^5) in rhizosphere soil of Jatropha plants grown with urea and SSP, than in the control plant soils (51 x 10^5). Similarly, high fungal populations (CFU g^{-1} soil) (33 x 10^4) in rhizosphere soils were recorded. Fungal population increased by 32% in treated soils than in the control soils; also, actinomycetes (CFU g^{-1} soil) ranged from 5 - 45x 10^4. Diversity studies of bacteria recorded more variation of isolates from ICRISAT soils than Velchal soils.

The number of bacterial isolates from rhizosphere soil of Jatropha varied for various biochemical parameters, for the soil samples collected from the research site at ICRISAT, Patancheru and degraded CPR at Velchal (Table 11). These results demonstrated that diverse microbial flora proliferated in soil planted with Jatropha.

Power Generation using SVOs

Based on the yield potential of Jatropha from 300 ha plantations in these villages that are completely dependent on rainfed conditions, and through a GTZ supported Public-Private Partnership with Kirlosker Engineering Pvt Ltd and ICRISAT, the use of straight vegetable oils (SVOs) has been taken up in the villages itself. Decentralized oil extraction by the Bio-energy committee will ensure that seeds will be procured from the SHGs and oil will be extracted and power will be directly produced.

The Velchal Village Bio-Energy Committee (VVBEC) was registered with the number 1034 of 2008, under the Andhra Pradesh Societies Registration Act., 2001 (Act No. 35 of 2001), on 7th August 2008, in the office of the Registrar of Societies, Ranga Reddy District, for establishing Bio-energy plant by using straight vegetable oils (SVOs) of Jatropha and Pongamia in power generators. This project is funded by GTZ, India, Generators and other technical help is provided by Kirloskar Company, India and the project is implemented by ICRISAT and READ NGO. Under this project, the seeds will be collected by labourers from biodiesel plantations and power will be directly produced by using Jatropha and Pongamia oil and supplied to commercial units like 2 flourmills in the village and also to the community tubewell for village water supply on charge basis. The Bio-Energy committee will collect the charges and maintain it on a sustainable basis. The Bio-Energy Committee consists of a total of 8 members, which includes the village Sarpanch, NGO, ICRISAT staff, women members from SHG, 2 labour group members, one farmer and one flour mill owner. Place for constructing the building was provided by the village gram panchayat and the committee opened a bank account in Deccan Grameena Bank, Velchal branch, Mominpet Mandal, Ranga Reddy District, with the Account No. 20197269 to do financial transactions. Building plans are finalized and construction is in progress.

Table 11. Results of biochemical analysis of bacterial isolates from ICRISAT and Velchal (% of positive isolates)

Locations	Grams stain	H2S utilization	Motility	Indole	Voges Proskauer	Citrate Utilization	Methyl red test	Oxidase Test	Starch Hydro-lysis
Velchal	22	22	44	7	30	44	52	88	52
ICRISAT	43	9	74	4	30	35	13	87	26

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REFERENCES

1. D'Silva E, Wani SP and Nagnath B 2004. The making of new Powerguda : community empowerment and new technologies transform a problem village in Andhra Pradesh Global Theme on Agroecosystems Report No. 11, Patancheru 502 324, Andhra Pradesh, India : International Crops Research Institute for the Semi-Arid Tropics 28 pp
2. Falkenmark M. 1986. Fresh water - Time for a modified approach. Ambio, 15(4),192-200.
3. Francis G, Dinger R and Becker. 2005. A concept for simultaneous wasteland reclamation, fuel production and socioeconomic development in degraded areas of India: Need, potential and perspectives of Jatropha plantations. Natural Resources Forum, 29:12-24.
4. Government of India 2001 Census of India, New Delhi.
5. Grass Martin, Zeller Manfred, Wani SP. 2008. Economic Viability for Jatropha Production at India's Wastelands: A Scenario Analysis. Paper submitted to International Research on Food Security, Natural Resource Management and Rural Development - Tropentag 2008
6 ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) 2006. ICRISAT Archival Report 2006. The seedlings of success in the semi-arid tropics nurtured Patancheru, Andhra Pradesh, India ICRISAT. 417 pp.
7. Planning Commission 2003. Information from Planning Commission, Government of India Available at http://planningcommission nic.in/news/neaug.htm
8. Reddy AM and Panigrahi SK. 2004. Energy Security, Environmental Benefits and Carbon Trading Potential of Bio-fuels in India, A case study of 1st biodiesel project for CDM International Conference on Bio-fuels Perspective and Prospects. Book of presentations, 16-17 September 2004.
9. Rockström J, Nuhu Hatibu, Theib Oweis and Suhas P Wani. 2007. Managing Water in Rain-fed Agriculture. Pages 315-348 in Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture (ed David Molden). London, UK: Earthscan and Colombo, Sri Lanka. International Water Management Institute.
10. Ryan JG and Spencer DC. 2001 Challenges and Opportunities Shaping the Future of the Semi-Arid Tropics and their Implications International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India, 83 p.
11. SEI (Stockholm Environment Institute) 2005. Sustainable pathways to attain the millennium development goals - assessing the role of water, energy and sanitation Document prepared for the UN World Summit, Sept 14, 2005, New York, USA SEI, Stockholm, Sweden. (http://www.sei se/mdg.htm).
12. UNStat 2005. www.unstat com. Last accessed in 2005.
13. Wani SP, Pathak P, Jangawad LS, Eswaran H, Singh P. 2003a. Improved management of Vertisols in the semi-arid tropics for increased productivity and soil carbon sequestration. Soil Use and Management, 19, 217-222.
14. Wani SP, Pathak P, Sreedevi TK, Singh HP and Singh P. 2003b. Efficient management of rainwater for increased crop productivity and groundwater recharge in Asia In· Water Productivity in Agriculture Limits and Opportunities for Improvement. (Kijne, J.W, Barker, R and Molden, D. Eds,), pp. 199-215. CAB International, Wallingford, UK; International Water Management Institute (IWMI), Colombo, Sri Lanka.

15. Wani SP, Osman M, Emmanuel D'Silva and Sreedevi TK. 2006. Improved Livelihoods and Environmental Protection through Biodiesel Plantations in Asia. Asian Biotechnology and Development Review. Vol. 8. No. 2, pp.11-29.
16. Wani SP, Sreedevi TK, Rockström Johan and Ramakrishna YS. 2009. Raifned Agriculture – Past trends and future prospects. In: Rain-fed agriculture: Unlocking the Potential. (Wani, S.P., John Rockström and Theib Oweis Eds.). Comprehensive Assessment of Water Management in Agriculture Series, CABI Publication, pp 1-36.
17. Wani SP, Sreedevi TK, Marimuthu S, Kesava Rao AVR and Vineela C. 2009a. Harnessing Potential of Jatropha and Pongomia plantations for improving Livelihoods and Rehabilitating Degraded Lands. Paper submitted to 6th International Biofuels Conference, NewDelhi.