The New Oil Economy of the Rural Poor:
*Biofuel Plantations for Power, Water, Transport, and Carbon Credits*
A Case Study from Adilabad District, Andhra Pradesh, India

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## I. Introduction

The high price for international crude oil has generated a lot of interest in renewable energy, including oil extracted from tree-borne seeds. There are an estimated 300 tree species from whose seeds oil can be obtained, but only four or five have been tested. This case study focuses on the various value additions from one tree species that is native to South Asia—*Pongamia pinnata.* Raw oils from this species have been used to produce electricity, pump up groundwater, and run farm equipment. The tree has been grown on degraded land rather than good agriculture land. Several community-level enterprises have come up. The local, state, and federal governments have begun to take interest because of the potential for creating rural employment, increasing income, improving the environment and displacing oil imports.

## II. Country & Regional Background

Indian forests cover almost one-fifth of the national land area, but at least 42% of this forested land is patchy or degraded. Apart from small community and privately-owned areas, most of the forest land is the country is state-owned. The livelihoods of about 200 million Indians are wholly or partially dependent on forest resources. Forestry contributes about one percent to India's GDP (Khare *et al*, 2000); this figure does not include subsistence use, local market transactions, and the value of environmental services.

In the early 1990s, the federal government in India began to push the 27 states to follow a new approach to manage public lands; it was called 'joint forest management.' JFM was a radical departure from past management practices in that it gave people living in the vicinity of forests a voice in the management of these forests through their hamlet-level forest protection committees (D'Silva, 2003). JFM was viewed as a partnership between citizens and the state to protect and manage forests jointly. Financial incentives were introduced for the first time to share a part of the government revenue in return for citizens' participation. The state of Andhra Pradesh is one of the early pioneers in JFM. In 2000, 6,271 local forest communities protected over 1.5 million hectares, or about 32% of the total forest area in the state (D'Silva, 2003). .

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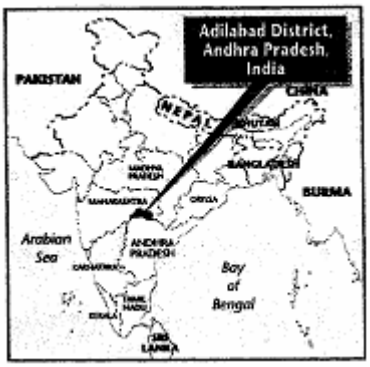
Despite its status as a 'progressive state,' about one-fourth of the rural population in Andhra Pradesh lives in poverty, with limited access to basic services, such as health, education, and electricity. Past development programs have been plagued by poor planning and implementation, misappropriation of funds, and corruption of intermediaries in the government and business sectors. Since the new millennium, development strategies of the state government, with support from international donors, have increasingly focused on channeling public funds directly to women and other user groups in selected areas (D'Silva, Pingle, and Poffenberger 2004). The two dominant user groups in Andhra Pradesh are 500,000 women's self-help groups (SHGs) and some 6,000 forest protection committees (VSS).

Andhra Pradesh is a leader in forming and developing women's self-help groups. Half of India's SHGs are found in this state. These groups take on roles in their communities as contractors, natural resource managers, and primary sources of capital. In 2003, the 500,000 SHGs had a membership of 5 million women and assets worth Rs. 11,195 million or $238 million (D'Silva, Pingle, and Poffenberger 2004). If these funds are properly leveraged with local financial institutions, these groups could have access to a line of credit worth $ 1 billion. In addition, the 6,271 forest protection committees (VSS) protect 1.5 million hectares of forest assets worth an estimated $ 5 billion in timber and non-timber values.

Adilabad is one of the poorest districts in Andhra Pradesh with more than half the population of 2.2 million living in poverty. Most of the poor comprise lower castes and indigenous people—the most prominent among the latter being Gonds and Kolams. In tribal communities, women enjoy relatively equal status to men. Thus in 2003, Adilabad had 19,500 SHGs with about 200,000 women and assets of Rs. 200 million ($4.25 million). In addition, 42% of the land area (700,000 hectares), with an estimated timber value of $2 billion, is forested (D'Silva, Pingle, and Poffenberger 2004).




Resource depletion in the past has been severe in Adilabad. Logging has been banned for decades in response to the severe deforestation, but some illegal logging of teak continues, at a rate of about 1,000 truck loads per year. Due to severe forest degradation, collection of non-timber forest products (NTFP) has declined considerably.

However, a recent series of innovative projects by local government and development practitioners is finding new sources of income and livelihoods for forest-dependent communities. The use of biofuel plantations, based primarily on *Pongamia pinnata*—a local tree species—for generating electricity, pumping groundwater, running transport vehicles, and mitigating climate change has created a lot of excitement, both locally and internationally. The case study highlights the key features of the innovations.

## III. Overview of Country Case Study

*Pongamia pinnata,* a type of Indian beech, is native to South Asia and is found in abundance in Adilabad forests and along roadsides. The tree can grow in many different terrains with very little care and moisture. Seed pods begin to emerge from the fifth year; at maturity (15-20 years)

they can yield between 30-60 kg/tree/year. Some trees are known to yield as much as 300 kgs. of seeds, as in Aliguda village. Roughly, 25 % of the seed is oil; the residue can serve as a substitute for chemical fertilizer.

In the 1930s, the British Institute of Standards in Calcutta investigated pongamia as a potential fuel source, but the post-World War II boom in petroleum production and low oil prices made pongamia an expensive diesel substitute. However, small local producers used pongamia oil in soap-making and lubricant industries, and rural villages routinely burned this in lamps in religious worship. (Good News India, Jan 2003).

In the summer of 1999, I was having animated discussions with the elders of Kishtapur village on alternative sources of energy. Like most villages in India, Kishtapur received irregular electricity from the state-run power grid, particularly in May when temperatures often touched 47 degrees Celsius. The search for an alternative source led me to the Indian Institute of Science and to Professor Udipi Shrinivasa who had begun experimenting with pongamia oil to run power generators in Kagganhalli, Karnataka state. After a visit to Kagganhalli, I persuaded the Integrated Tribal Development Agency (ITDA) in Adilabad to make the first investment in Chalpadi, a Gond tribal community located deep in the forest, about four hours by foot from the nearest road. The experiment was a runaway success. We have not looked back since then.

Raw pongamia is used to fuel power generators to produce electricity locally; pump up groundwater for drinking and irrigation; and run farm equipment, including tractors. Women have been in the forefront of these efforts. They collect pongamia seeds, crush these seeds into oil through specially-installed oil extractors, and market both the oil and the residue. The success of women-run enterprises has spread beyond Adilabad district to other areas in Andhra Pradesh and India and beyond. The experiment is now being replicated in Niger, West Africa.

The overall objective of this new biofuel-based initiative is to provide a source of livelihood to the rural poor—in particular, indigenous women—increase employment and income, while also supporting reforestation and improving the environment. The strategy adopted is to plant pongamia trees as part of reforestation, watershed management, and other programs. To avoid monoculture, mixed tree species are planted alongside pongamia. During the gestation period of five years it takes for pongamia trees to bear seed, a number of income-generating activities are taken up; these include, vermicomposting, bee-keeping, tree nurseries, and value addition to bamboo. Carbon income is an additional incentive.

## IV. The Enterprises

***Power system.*** Generating electricity locally is a powerful idea. It is like giving sight to the blind.. In the village of Chalpadi, where this experiment was first begun, two power generators (one served as a back-up in case of malfunction) each with a capacity of 7.5 KVa were installed. The generator ran on pongamia oil. It took about 2 liters of oil (equivalent to 8 kgs of seeds) to fuel the generator for an hour. The village generated 10-12 KW of power to light 12 family homes and public areas. Each household supplied 1 kg of seed per day, or 300 kgs per year. Marubai and other women of the village ran the decentralized energy system built at a cost of $ 6,000. The local government paid this capital cost so it could serve as a demonstration project,

but the costs of operation and maintenance were met by the women's group. To ensure future oil supply, the villagers planted 30,000 pongamia saplings over three years, equivalent to about 75 hectares. Based on current consumption, just a hectare of pongamia would have been sufficient. However, the surplus seeds should ensure a sustainable income in the future.

***Water system.*** In Kishtapur village, a new water system has been put in place which provides groundwater to the local community for drinking and irrigation. The water system is presently powered by a blend of pongamia oil (20%) and petroleum diesel (80%), but in five years—when the 20,000 pongamia trees begin to yield oilseeds—it will be run purely on pongamia oil. A 300-feet deep borewell pumps up water for distribution to 25 farmers. Each farmer gets water sufficient to irrigate one acre. Water supply is metered. Farmers pay for the water in cash in advance in multiples of Rs 1,000. A participatory hydrological monitoring system installed ensures water is not over-extracted. The water system is run by a village-level committee comprising representatives of participating farmers and the seven women's groups active in the village. The water system was installed at a cost of about $ 7,000. The local community contributed 10% of the capital cost, while the rest came from the USAID project. Farmers hope to use the water to grow second and third crops—mainly vegetables—which will have a positive impact on their incomes. However, since the system was installed in June, just before the onset of monsoon, it is a bit too early to pass judgment.

***Oil mill.*** The women of Powerguda are the proud owners of the first community-owned mill that crushes pongamia seeds into oil. The machine has a capacity to crush 50 kgs of seeds per hour, though this capacity has not been fully reached as yet. Residents of nearby Kommuguda and faraway Ravenpalli bring their pongamia seeds here to be converted into oil for use in their power generators. The women of Powerguda have a good business sense. They buy pongamia seeds and sell pongamia oil and the oilcake. They also extract oil for a fee. The women's group keeps track of diesel oil price at the local gas station and adjusts its price for pongamia oil accordingly. The mill cost of $5,600 was paid for by the local government, but Powerguda's women bear the costs of operation and maintenance. The machine runs on pongamia oil instead of electricity. The mill should reach its full potential in 2007 by which time the thousands of newly planted pongamia trees will begin to yield oilseeds.

***Oilcake.*** The residue from oil extraction—roughly 75% of the pongamia seed by weight—can serve as a good substitute for chemical fertilizer. The N:P:K content of pongamia oilcake is better than farmyard manure. Field studies conducted by the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) in Adilabad indicate that pongamia cake increases yields by at least 25% when compared with farmer's practices. However, the optimum solution is a 50:50 mix of pongamia cake and inorganic fertilizer (see Table 1).

Table 1. Impact of Pongamia Fertilizer on Cotton, Powerguda Village, 2004

| Fertilizer treatment | Average cotton yield (g/sq m | Increase over farmers' practice (%) |
|---|---|---|
| Farmers' practice: 1 bag DAP | 125 | -- |
| Inorganic fertilizer: 120 kg N/ha | 174 | 39 |
| Pongamia oilcake: 300 kg/ha | 156 | 25 |
| 50:50 mix: Inorganic fertilizer (60 kg N/ha) + | 179 | 43 |

| | | |
|---|---|---|
| Pongamia cake (150 kg/ha) | | |

Note: 1 bag of Di-Ammonia Phosphate (DAP) contains 9 kg of N and 23 kg of P2O5
Source: D'Silva, Wani, and Nagnath 2004.

As a result, pongamia oilcake has become a good byproduct for sale to farmers. The women of Powerguda have no problems selling the cake at Rs 4/kg. Thus, 4 kgs of pongamia seeds yield 1 kg of oil and 3 kgs of cake for a total value of Rs 42 (90 US cents). The nutritional and financial values of pongamia cake are just beginning to be known.

***Vermi-composting and bee-keeping.*** During the five years it takes for the pongamia plants to produce seeds, it is important to ensure a steady flow of income to sustain community interest in biofuel plantations. Vermicomposting and, to a lesser extent, bee-keeping can help generate income in the interim. Vermicomposting helps to recycle a village's organic waste, such as leaf litter and agriculture residue, while generating a sustained income. A 10 ft x 5 ft x 5 ft pit can generate Rs 10,000 to Rs 12,000 per year; this activity alone is sufficient to lift a family out of poverty. As the compost residue is high in organic content, it is in great demand for use in vegetable gardens. Bee-keeping has been introduced as a forest protection measure. Communities that keep bee hives next to forests are more likely to protect such forests as income is earned from the honey derived from forest nectar. In several villages in Kagazhnagar forest division, women have begun to market their honey with support from the local forest department.

***Carbon income.*** The provisions of the Clean Development Mechanism (CDM) of the Kyoto Protocol provide an incentive—albeit a limited one—to local communities to take up biofuel plantations. When the provisions for carbon sequestration and fuel switch are combined, the gains can be meaningful. However, the transaction costs involved in putting together a CDM project can be substantial—ranging from $50,000 to $250,000 or more depending on the size and activities of the project (Poffenberger *et al* 2002). Even though the CDM Executive Board has developed simplified methodologies for small projects, the transaction costs are still prohibitively expensive for small communities unless subsidized by rich countries.

The voluntary emission reduction (VER) market in which some NGOs and small buyers look for community-driven projects offers better scope than the more official certified emission reduction (CER) market operating under the guidelines of the United Nations Framework Convention for Climate Change. For the forest-based enterprises in Adilabad interested in selling carbon, we have been able to find a variety of buyers, both Indian and international. The carbon income has served as seed money to local communities to continue reforestation and other sustainable development activities.

Chalpadi, which pioneered electricity generation from pongamia oil, became the first village to sell carbon credits in March 2003. The equivalent of 900 tons of carbon dioxide worth $4,000 was sold to Germany in verified emission reduction. The verification was done by 500PPM. In October 2003, Powerguda sold 147 tCO2e to the World Bank. In February 2004, 42 individuals from five countries decided to offset emissions of their private cars by buying the equivalent of 160 tCO2 from Kommuguda. Single villages have now given way to clusters of villages selling carbon. Foreign buyers are being followed by Indians. Even though Indian companies are under no obligation to offset or reduce their emissions, some of them do it as part of their corporate

social responsibility or community outreach. In a new development, the Bio-Carbon Fund of the World Bank has shown interested in buying carbon from 100 villages in Adilabad. Detailed studies in carbon sequestration are under way.

***Biodiesel.*** The most valuable end of the biofuel value chain is biodiesel production. Biodiesel is the name given to a variety of ester-based oxygenated fuels made from vegetable oils, fatty acids, used cooking oils, and other raw material. In Europe, biodiesel is produced mainly from rape seed and in the United States from soybeans. Most of the raw material in the production of biodiesel in India will come from *Pongamia pinnata* and *Jatropha curcas* grown mainly on degraded lands. India's first commercial-sized biodiesel plant with a capacity of 10,000 tons of oil coming up in Nalgonda district, Andhra Pradesh is a public-private partnership. Small farmers, women's groups, and forest communities are important stakeholders—they will be the main suppliers of raw materials for the plant. Some of them have already signed raw material purchase agreements with the company—Southern Online Bio Technologies Limited—while a few VSS and SHGs have also obtained share equity. Considering India's energy needs, and its dependence on oil imports, domestic biodiesel production from a forest-based resource has important implications for the forest sector.

## V. Economics of the Enterprise

The economics of operating individual enterprises has been described above. However, a key underpinning of these enterprises is the cost-benefit analysis of a pongamia plantation, the main resource of most of these enterprises. Because the discovery of the commercial potential of pongamia is relatively new, and there are virtually no long-standing pongamia plantations in the country, long-term yields are difficult to predict. Nevertheless, I have made a conservative estimate of the net returns to a local community growing pongamia trees on degraded public land where the opportunity cost of the land is assumed to be zero. The net present value of a 40-year plantation is Rs 118,144 ($ 2,715) per hectare; the internal rate of return is 36% based on a discount rate of 10%. The biggest benefit to the community from the plantation is oil from the seeds for which there is presently an enormous demand (see Table 2). This is followed by oilcake, a byproduct of oil extraction, which has demand among large farmers. Carbon income is a small portion of the benefit (about 3%).[1]

Table 2. Sources of Income from A Pongamia Plantation

| Income source | Percentage |
|---|---|
| Raw oil | 58.6 |
| Oil cake | 38.5 |
| Carbon | 2.9 |
| Total | 100 |

Note: The value of raw pongamia oil has been calculated at Rs 16 per liter; it may be higher in some villages. Oilcake has been assumed at Rs 3.5/kg.

**1.** Only carbon income from fuel switch is calculated as there is no available data on carbon sequestration from pongamia.

Biofuel plantations have caught the imagination of the rural poor in Adilabad district. Forest-dependent communities have begun to plant pongamia trees on degraded public and private land on a large scale. The state forest department has also begun to support the effort. During the last two years, over 1 million pongamia saplings have been planted in the district with the help of the forest department. Throughout the state, a target of 15 million pongamia trees has been set. About a third of the plants in forest department nurseries are now of the pongamia variety. Recognizing the employment, income, environmental, and other benefits of a biofuel plantation, the Andhra Pradesh government has created a new department to support this effort in the five arid districts of the state. Both pongamia and jatropha plants are encouraged. The government is also offering financial incentives for setting up biodiesel enterprises. The state wants to be a leader in the production of biodiesel. The Andhra Pradesh State Road Transport Corporation has successfully tested a "biodiesel bus." The corporation has a fleet of 28,000 buses—arguably the largest in India—of which 3,000 are run in Hyderabad City. The hope is that city buses will be run on biodiesel to reduce vehicular pollution once India's first biodiesel plant begins commercial production in August 2006. This will also be good news for the small farmers and women's groups that are involved in tree planting, seed collection, and oil extraction.

There is no estimate of the number of biofuel enterprises operating in Adilabad district, or for that matter in Andhra Pradesh state, or India. However, K. Subadrabai, leader of the women's group in Powerguda, reports that her village has a regular stream of visitors interested in discussing the business potential of pongamia. Among the visitors was a parliamentary delegation from Delhi who had come to review the potential of renewable energy. One indication of the biofuel potential is this simple observation. In 2000, when I was involved with the Chalpadi power generation experiment, virtually no one collected pongamia seeds even though this tree is found in abundance in Adilabad forests. In 2004, a government seed collection agency reported that 2 tons of pongamia seeds were available in its warehouse. In 2005, several women's groups began to trade in these seeds. This is likely to become better organized once the commercial biodiesel plant begins to acquire seeds for its operation.

## VI. Enterprise Organization, Management, Governance

### *SHGs*

The SHG, in many ways, is the starting point of a group-run enterprise. The SHGs were initially modeled on the lines of the Grameen Bank in Bangladesh with savings mobilization serving as its main function. Several groups began with a savings target of one rupee per person per day, or Rs 30 ($ 0.68) per month, corresponding to a day's wage. A large number of SHGs were formed under various government-operated rural programs—in particular, joint forest management and watershed management. While all SHGs mobilized savings, a few attempted to deliver services previously rendered by government—for example, tree nurseries, building check-dams, and generating electricity (D'Silva, Pingle, and Poffenberger 2004). The failure of a weak local government system—known in India as *Panchayati Raj*—to deliver local services led to the strengthening of these groups, say government officials who acknowledge that women are better managers of money and businesses than men. My personal field experience has shown that women are generally more transparent in their financial dealings and in decision-making than men.

There were two key drivers of SHG growth in Adilabad district. The first was a watershed management program begun in tribal villages with funding from the International Fund for Agricultural Development (IFAD), Rome, Italy. Two government officials[2] determined that tribal women, with some training, could replace private contractors in building and managing the local construction of water harvesting structures. This decision had tremendous financial, organizational, and governance implications. This meant that the profit margin in the contract now went to the SHG. It also meant that local politicians and petty bureaucrats who were bribed by the contractors no longer received this largesse. Predictably, there was considerable opposition from the lower order bureaucracy and the local political elite, but the two officials stuck to their decision.

The financial impact of this decision can be seen in the bank accounts of two villages: Pittabangaram and its neighbor Bhattaguda. The former undertook watershed works while the latter did not. The Jangubai group in Pittabangaram—one of the four SHGs in the village—had a total savings of Rs 45,893 ($ 1,055) at the end of the three-year watershed contract in 2003 whereas in Bhattaguda village, the Maruti group's total savings during the period was a meager Rs 7,440 ($ 171). Savings from the soil and moisture conservation projects accounted for the big difference (see Table 3).

Table 3. Savings With and Without Watersheds: A Comparison of Two SHGs

| Pittabangaram Watershed Village *Jangubai Group* | | | | Bhattaguda Non-watershed Village *Maruti Group* | | |
|---|---|---|---|---|---|---|
| Year | Personal Savings | Soil Conserv. Savings | Total Savings | Personal Savings | Soil Conserv. Savings | Total Savings |
| 2000 | 8,400 | - | 8,400 | 1,200[a] | - | 1,200 |
| 2001 | 5,200 | 10,035 | 15,235 | 2,880 | - | 2,880 |
| 2002 | 4,800 | 14,537 | 19,337 | 2,880 | - | 2,880 |
| 2003[b] | 1,200 | 1,721 | 2,921 | 480 | - | 480 |
| Total | 19,600 | 26,293 | 45,893 | 7,440 | - | 7,440 |

Note: **a.** From October 2000 onward **b.** For the period January-March 2003
Source: D'Silva, Pingle, and Poffenberger 2004.

The second driver of growth was a community-driven project, known in Andhra Pradesh as *Velugu,* financed by the World Bank. This project has provided a management structure by federating the large number of SHGs into management units to help run and expand micro-enterprises. The first level of federation is at the village. The various SHGs in the village (some have 8 to 10) form a Village Organization (VO). The VOs are federated at the level of a *mandal*—an administrative unit below the district. About 25-30 VOs form a Mahila Mandal Samakhya (MMS).

**2.** Navin Mittal, Project Officer, and B. Nagnath, Assistant Project Officer, Integrated Tribal Development Agency, Utnoor, Adilabad district.

Two examples will help to illustrate how the VOs and MMS work in the business world. The Pittabangaram village has four SHGs federated into a village organization. The VO decided to form a soybean association to secure better prices for farmers. Soon 240 members from 24 villages joined the association. In 2002, the first year, 47.8 tons of soybean were procured directly from farmers who were paid on the spot. In 2003, the association hoped to increase the membership to 500 members and purchase 500 tons of the crop. At least two levels of middlemen were eliminated. The association has plans for processing soybeans into soy milk in the future. The Kerimeri MMS covers some 50 hamlets in an area of about 150 square kms representing 16 VOs and 120 SHGs. The MMS meets twice a month to discuss important social and financial issues. At the meeting I attended, the key issue of the day was the procurement, sale, and processing of *red gram* pulse. The MMS wanted to borrow Rs 1.3 million ($ 29,885) to open six procurement centers for the commodity. The 90 women and 15 men who attended the meeting deliberated on the proposal.

The SHG federations formed in Adilabad serve at least four useful functions (D'Silva, Pingle, and Poffenberger 2004). First, they provide a forum for women to discuss common problems. SHG members consider the unity and solidarity among women to be one of the most important benefits of SHG membership. Second, by providing guarantees to member SHGs, the federations help SHGs to borrow from financial institutions at lower interest rates. Third, the federations take over the responsibility for book-keeping and training functions of SHGs. Book-keeping is a serious problem, according to local bankers, one that often thwarts the ability of SHGs to use their funds effectively. Fourth, the federations invest in cluster-level economic activities such as agricultural commodities marketing and other value-added services, including the collection and processing of oilseeds for biofuel.

The financial success of SHGs is now having secondary effects on health, education, and poverty. Government officials and NGOs report increases in household expenditures on the education of children and on the health of families (D'Silva, Pingle, and Poffenberger 2004). Government data from Adilabad indicate that 47% of women who belong to SHGs practice family planning more than twice the district average.[3] According to one program evaluation, 23% of the loans from SHGs were used in human capital formation (Galab and Rao 2003). Literacy level among SHGs is increasing gradually as women first learn to sign their names and then begin to attend literacy classes. The poverty level among SHGs is also dropping. A survey of 83 SHGs formed under the SPAP model revealed that poverty declined among 69% of members and the proportion of 'very poor' declined from 48% to 18% (Galab and Rao 2003).

However, there is also the downside to the rapid expansion of SHGs. The reduction in poverty was less pronounced in the tribal population, lower castes, and female-headed households. The numerical expansion of SHGs has not been matched by improvements in the quality of their activities. Most SHGs have not diversified beyond thrift because of low literacy levels and lack of skills. Some enterprises—particularly those in vegetable and fruit vending—have failed because of excessive competition (D'Silva, Pingle, and Poffenberger 2004). The formation of SHG clusters and federations could help overcome some of these problems.

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**3.** "Self-Help Groups in Adilabad District: A Status Report." Circa 2000. District Development Agency, Adilabad Dsitrict.

### *VSS*

The successful functioning of the SHG federation model has led the Forest Department to think of extending it to some of the 6,000 forest protection committees (VSS) as a way to help the forest-dependent people to move toward value-addition of the forest resources. Adilabad is among the three districts selected for experimentation. Some 100 VSS protecting 89,000 hectares of forest land will be federated at cluster and division levels in Kagazhnagar forest division. Common enterprise groups (CEGs) are to be formed initially for five to six activities—vermicomposting, oil extraction, bamboo products, etc. In some cases, the common enterprise groups will be the existing women's self-help groups. The focus of the VSS federation will be the conservation of the forest resource. The business plan will be to add financial value to the resource to provide employment and incomes to the local population. The federation will be headed by a Chief Executive Officer. Elected representatives of the VSS and the CEGs will be on the Board of Directors. With a resource base of $ 2 billion in timber assets and 1 million pongamia trees planted in the last two years, the VSS federation can leverage these assets to benefit the forest-dependent community who are among the poorest people in the district.

The key driver for the VSS federation appears to be the possibilities of carbon income. A proposal sent to the Bio-Carbon Fund of the World Bank identified the possibility of 1.75 million tCO2e over 30 years from carbon sequestration activities in 100 villages in Kagazhnagar forest division, Adilabad district.[4] To move this proposal forward requires the setting up of an institutional mechanism to receive carbon funds and also meet the requirements of the Clean Development Mechanism. A federation of the VSS involved would be the appropriate institution for this purpose as it would reduce transaction costs and foster entrepreneurship among the VSS since incomes from raw oils and other businesses rather than carbon would sustain longer-term development. Discussions on the modalities of the new federation are in progress between the Forest Department, NGOs, and other stakeholders. The federation is expected to be registered as a legal entity by the March 2006.

### *Convergence*

The formation of federations for both SHGs and VSS has raised concerns over possible duplication of functions between SHGs and VSS and their links to the *Panchayati Raj* institutions that are mandated by the Constitution. Some efforts have been made by the Forest Department and the Rural Development Department to attain "convergence" in functions at the village level, but without much success. The formation of VSS federation will require even more efforts to bring this about.

The relationship between SHGs and the panchayats is still not clear. SHGs and VSS were created, in part, because the panchayats were regarded as too weak to deliver public services. Panchayats lack fiscal autonomy and, therefore, do not have sufficient funds to deliver services. In contrast, the SHGs and VSS relatively have access to considerable resources from World Bank-financed projects. Not surprisingly, elected panchayats leaders believe SHGs and VSS

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**4.** Adilabad Reforestation and Biofuel Production Project, Andhra Pradesh. India. Project Idea Note prepared for the Bio-Carbon Fund of the World Bank under the direction of Emmanuel D'Silva. May 28, 2005.

undermine their authority. To overcome any potential antagonism, Velugu staff has tried to involve panchayat leaders in important decisions. VSS leaders and the Forest Department will have to follow suit to keep the peace.

## VII. Environmental Benefits: Conservation Values, Impact on Biodiversity

Because of their nitrogen-fixing properties and deep roots, pongamia saplings make an ideal choice in tree planting along the slopes of watersheds. In Adilabad, pongamia plantations are generally accompanied, or followed, by watershed management practices. The building of watershed structures has helped to recharge aquifers and raise the water table in many villages. Though no formal study has been done to estimate the increase in groundwater availability as a result of watershed development, local officials and residents of Powerguda estimate the water levels in the four village wells rose by an average of 2 meters. Similarly, the planting of over 40,000 trees—one-fourth of them pongamia—to serve as vegetative barriers has helped to contain soil erosion along the slopes. ICRISAT has estimated that 20% of the rainwater run-off was stored in the watershed structures built in Powerguda as part of soil and water moisture conservation (D'Silva, Wani, and Nagnath 2004).

To prevent monoculture, pongamia saplings are often planted with other native tree species that have value to the local community. Bamboo, in particular, is cherished by the indigenous people because of its multiple uses. Teak (*Tectona grandis)* has been an item of choice for timber smugglers in the past. It is quite likely that pongamia and bamboo have begun to supplant teak in terms of their commercial value to local communities. Most of the large teak trees have disappeared from the forests of Adilabad and are slowly being replaced by other species that have little or no timber value. The growth of non-timber miscellaneous forest is actually a boon for local communities because it reduces the importance of timber and undercuts the power of the timber mafia. It is possible that pongamia plantations reduce the biotic pressure, help conservation, and preserve biodiversity, but this needs to be verified.

There are at least three environmental benefits flowing from the pongamia tree: emission reduction from the use of pongamia oil, the substitution of inorganic fertilizer by pongamia oilcake, and carbon sequestration by pongamia trees. The pongamia cake is rich in nitrogen when compared with farm yard or chicken manure. The phosphorus content ranged between 0.52% and 0.54% and the potassium content was 0.42% to 0.56% (see Table 4). As a result of these

Table 4. Chemical Composition of Pongamia Oilcake and Other Fertilizers

| Type of fertilizer | Nitrogen | Phosphorus | Potassium |
|---|---|---|---|
| Pongamia oilcake | 3.95 | 0.52 | 0.42 |
| Jatropha oilcake | 4.44 | 2.09 | 1.68 |
| Neem | 5.00 | 1.00 | 1.50 |
| Castor | 4.37 | 1.85 | 1.39 |
| Cow manure | 0.97 | 0.69 | 1.66 |
| Chicken manure | 3.04 | 6.27 | 2.08 |
| Di-Ammonium phosphate (DA) | 18.00 | 20.00 | 0 |
| Urea | 46.00 | 0 | 0 |

Source: D'Silva, Wani, and Nagnath 2004

findings, local communities have begun to use pongamia cake in their agriculture field with substantial increase in their crop yields (see Table 1). Pongamia oil, when it is used as a replacement for petroleum diesel—as in the case of power generators—helps to lower carbon emission. The basis for Powerguda's sale of 147 tCo2e to the World Bank in 2003 lay in this fuel-switch option.

The use of biodiesel is expected to reduce carbon dioxide emissions by as much as 80% when compared with conventional diesel (TERI 2004). Several studies have shown there is a substantial reduction in unburnt hydrocarbons, carbon monoxide, and particulate matter with the use of biodiesel (see Table 5). The 10,000-ton commercial biodiesel plant being put up outside Hyderabad by Southern Online Bio Technologies Limited is expected to avoid 27,000 tCo2e per year once it begins production.[5]

Table 5. A Comparison of Emissions: Biodiesel vs. Petro-diesel

| Emissions | Pure: 100% biodiesel | Blend: 20% biodiesel, 80% petro-diesel |
|---|---|---|
| Total unburnt hydrocarbons | -93% | -30% |
| Carbon monoxide | -50% | -20% |
| Particulate matter | -30% | -22% |
| Nitrous oxide ($No_x$) | +13% | +2% |

Source: Planning Commission, 2003

In addition, there is the carbon sequestration option. Though detailed studies remain to be done, preliminary data indicate that one hectare of pongamia trees can sequester, on average, 5 tons of carbon dioxide incrementally. If other rules of the Clean Development Mechanism are met, carbon sequestration can be an additional source of funds for local communities, though not as important as revenues from the oil and oilcake.

Table 6. Awareness of environmental services in Powerguda Village

| Environmental factors | Public awareness |
|---|---|
| Hydrological functions | Substantial awareness as watershed management has increased the water table in village wells |
| Soil erosion | Some knowledge because of contour bunding along slopes to minimize soil erosion |
| Medicinal properties of trees | Most people are aware of the medicinal uses of *Pongamia pinnata* and neem |
| Biodiversity | Limited knowledge of the importance of multiple tree species |
| Reducing chemical fertilizer and pesticide use | Public awareness increasing with the introduction of integrated pest management and the use of pongamia oilcake |

**5.** Project Design Document for "30 TPD Biodiesel Project in Andhra Pradesh, India." Southern Online Biotechnologies Limited, Hyderabad, February 2004.

| | |
|---|---|
| Mitigating climate change | Increased awareness of carbon sequestration and carbon emission reduction since the sale of carbon to the World Bank |

Source: D'Silva, Wani, and Nagnath 2004.

Many of the VSS involved in forest protection and SHGs in value addition appear to understand the potential environmental benefits from biofuel plantations and watershed management. Table 6 highlights the level of environmental awareness in Powerguda.village.

## VIII. Intersection with Government Regulations and Policies

The small, village-level experiments in biofuel production and use are having a big impact on state and federal governments in India. Both governments have recognized the enormous potential of biofuels production in generating rural employment and incomes, rehabilitating degraded public lands, and displacing petroleum imports. The Andhra Pradesh state government has created a new department to promote biofuel plantations and value additions in mainly arid districts. At the federal level, a National Biodiesel Board has been proposed for this purpose. A national task force on biofuel, which covers both ethanol and biodiesel, has proposed a series of actions, regulations, and policies to promote the use of biofuel in the transport sector (Planning Commission 2003).

The task force report states that up to 40 million hectares of wastelands is suitable for jatropha plantations. Of the 14 million hectares of forest land under joint forest management, 3 million hectares could be covered by jatropha. Another 3 million hectares of agricultural land could be covered by such plants as hedgerows. The Planning Commission has allocated Rs 14,960 million ($ 340 million) over five years to promote biofuel plantations, seed collection, oil extraction, and testing in various states. Very little of this money has reached Adilabad district.

The report notes that the use of biodiesel has become "compelling" because of tightening in automobile emission standards and judicial interventions to reduce air pollution. However, it has recommended a "minimalist approach" in terms of regulations and laws arguing that a comprehensive legislation will deal with too many issues which are in the process of evolution and may prove counterproductive. A basic framework for development and suitable amendments to existing laws has been preferred to enacting a separate law.

Among the changes suggested in regulations, two are noteworthy. One relates to blending jatropha and pongamia oil in edible oil and adding alcohol to biodiesel (TERI 2004). Since jatropha and pongamia oils are inedible because of the presence of some toxins, there is a risk of adulteration of edible oils. The addition of alcohol to biodiesel could drastically reduce its flashpoint thereby affecting engine performance and emissions (TERI 2004). The second change relates to setting fuel standards for meeting quality and environmental norms. The Bureau of Indian Standards has already set standards for biodiesel.

A key policy recommendation of the task force is that the federal government should set a goal of 20% blend of biodiesel in conventional diesel by 2012 beginning with 5% in 2006. The implementation of such a recommendation would have serious implications on the country's

economy. This would require between 3 million and 13 million hectares of land being planted to jatropha and pongamia over the next five years (see Table 7).

Table 7. Diesel and Biodiesel Demand and Land Area Required for Biofuel Plantations

| Year | Diesel demand MMT | Biodiesel @ 5% MMT | Area for 5% biodiesel Mha | Biodiesel @ 10% MMT | Area for 10% biodiesel Mha | Biodiesel @ 20% MMT | Area for 20% biodiesel Mha |
|---|---|---|---|---|---|---|---|
| 2001-02 | 39.81 | 1.99 | NA | 3.98 | NA | 7.96 | NA |
| 2006-07 | 52.33 | 2.62 | 2.19 | 5.23 | 4.38 | 10.47 | 8.76 |
| 2011-12 | 66.90 | 3.35 | 2.79 | 6.69 | 5.58 | 13.38 | 11.19 |

Note: These figures are calculated for jatropha on the basis of plantation density of 2,500 plants/ha, 1.5 kg/tree, or 3.75 MT of seed per hectare corresponding to 1.2 MT of oil/ha. Because of difference in the density of planting, the area under pongamia is likely to be slightly higher than under jatropha, as follows: 3.3 mha under the 5% scenario, 6.7 mha under 10%, and 13.4 mha under the 20% scenario.
MMT refers to million metric tons; Mha is million hectares; and NA means not applicable.

That biofuel plantations offer good employment and income opportunities under joint forest management (JFM) is beyond doubt. However, there are dangers in pursuing excessive monoculture practices because of risk of pest and disease destroying the plantations. Moreover, jatropha is an exotic species with origins in Latin America. In some parts of southern Mexico and Guatemala, jatropha has been almost wiped out. This should serve as a warning to the Indian government which is pushing jatropha without regard to concerns over lack of biodiversity. In Adilabad, local people have little interest in jatropha, but are very excited about planting pongamia, which is found in nearby forests. The 1 million plus pongamia trees planted in the district, along with other tree species, have been under the auspices of Community Forest Management, a successor to JFM in the state. Women's groups are actively involved in the planting.

## IX. Ways Forward and Opportunities

The unprecedented rise in global oil prices has created new opportunities for ushering in alternative fuel sources. Since biodiesel is a natural, renewable source of energy it has a bright future. For a fast-growing developing economy, such as India, which imports 78% of its crude oil needs, a little known native tree (*Pongamia pinnata)* and an exotic bush *(Jatropha curcas)* are helping to lay the foundation for a new oil economy in which the rural poor have an important role as oil producers.

The availability of 40 million hectares of degraded land, large numbers of underemployed rural poor, and successful experiments in biofuel production provide the basis for a large rural program in the future. Fortunately, the state and federal governments in India have recognized the biofuel potential to create employment, increase incomes, and rehabilitate public and private lands of poor quality. A good start has been made by allocating about $300 million of federal public funds to promote biofuels. A number of Indian research centers are at work developing improved varieties of pongamia and jatropha, testing various combinations of oils in engines for

maximum advantage, and modifying existing technologies to increase value additions to benefit the rural poor.

In the future, small-scale biodiesel units producing about 10 tons of biodiesel per day may dot the landscape. Investments in such decentralized units may come from small farmers, women's groups, forest protection groups as well as local private entrepreneurs working together in the form of a public-private partnership. The Southern Online Biotechnologies Limited, soon-to-be the first commercial biodiesel producer, has provided the basis for such a partnership. However, large Indian corporate interests and foreign multinational companies will also step in to build large biodiesel processing plants (100,000 tons/year capacity) considering India's huge oil needs. These corporate interests will probably use the plantation model for meeting their raw material needs; the rural poor will probably have the role of wage labor.

Despite the great enthusiasm for biodiesel, there are at least four areas of concern. First, the government policies on biodiesel are not clearly spelled out. A draft biodiesel policy has been in discussion for several years, but no decision has been taken. A clear policy will help to increase investment in this new field. Second, there remains skepticism about the financial viability of biodiesel, particularly if the company producing biodiesel has to invest in biofuel plantations. Third, the availability of sufficient raw materials is an issue. The availability of rice bran oil, acid oils, used cooking oils, in addition to pongamia and jatropha oils can provide some cushion for the time being. However, for the long term, massive investment in biofuel plantations would be required if the government goal of achieving a 20% biodiesel blend is to be achieved by 2012. Finally, concerns over excessive monoculture are being largely ignored. The risk of pest and disease wiping out a jatropha or pongamia plantation can be only ignored at the nation's peril.

Nevertheless, there is a lot the government—particularly at the state level—can do to promote biofuel production through supportive policies and incentives:

- *For the farmer:* State agencies can provide technical packages in growing biofuel plantations. Tree nurseries can be supported at the village level by making use of some of the 50,000 women's self-help groups and 6,000 forest protection committees.
- *For the village entrepreneurs:* Individual and groups can be encouraged to set up a network for seed collection and oil extraction by providing appropriate linkages with financial institutions.
- *For the biodiesel industry:* The government could take steps to exempt the biodiesel industry from sales, excise, and other taxes that fall within the purview of the state as has been done in Europe.
- *For the consumer:* An education campaign can create public awareness and support the use of biodiesel in transport.

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