Strategic Assessments and Development Pathways for Agriculture in the Semi-Arid Tropics

Policy Brief No. 12

December 2007

Emerging biofuel industry: A case for pro-poor agenda with special reference to India

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Introduction

Bioenergy is increasingly drawing the attention of policy makers in both developed and developing countries to overcome the rising cost of energy and address environmental concerns, while providing new employment and income generating opportunities for the rural communities. Bioenergy is the energy generated through biofuels that are produced from renewable sources of plant origin.

This policy brief addresses the on-going efforts related to liquid biofuels, ie, bioethanol and biodiesel in the face of rising crude oil prices that increased from US$ 22/barrel in 1990 to US$ 90/barrel in 2007 **(Figure 1)**. This trend of rising prices of fossil fuels is expected to continue in the face of their shrinking supplies and rising demand due to income growth in several developing countries. This is because energy consumption and economic development go hand in hand. Other reasons for the anticipated increase in fuel prices include higher costs of production, increased depletion and instability in exporting countries.

A number of alternatives to natural sources of energy have been explored that include wind

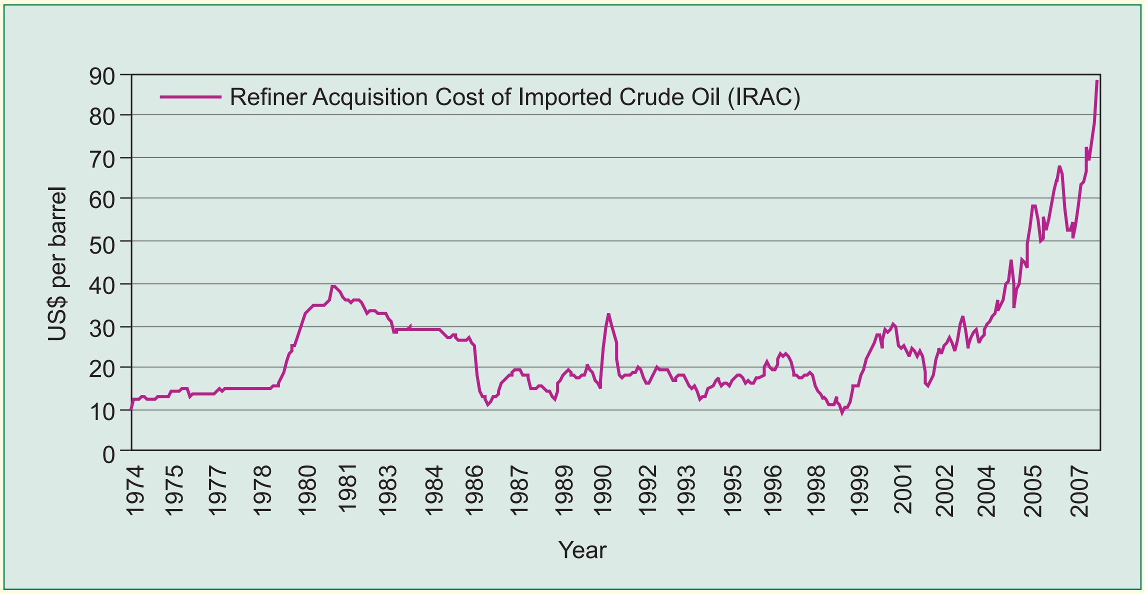

Figure 1.World nominal oil prices (1974-2007).

Source: Energy Information Administration, 2007.

power, solar energy and plants. One such source that is currently gaining in importance is the production of energy from plant biomass or more specifically ethanol from sugar or starch derived from grains/biomass and biodiesel derived from the processing of edible and non-edible vegetable oils. Biofuels are renewable energy sources that contribute to the reduction in greenhouse gases. Additionally, biofuels would have a positive effect on demand for agricultural raw materials, arresting the long-term decline in agricultural prices, thereby, benefiting the agricultural producers. However, there are strong apprehensions that as more and more land is brought under biofuel crops, food prices would increase substantially affecting poor consumers particularly those from low-income net food importing countries.

This policy brief discusses the current and future demand for biofuels, and the apprehensions about food–fuel trade offs, and ultimately goes on to highlight alternative feed stocks that do not compromise on food security and hence are more pro-poor.

Biofuels production

Based on the available data from several sources, it is estimated that ethanol production, which was 12.9 million tons in 1991, leapfrogged to 40.3 million tons by 2006 (Aeck 2005). Brazil and the USA are the dominant producers accounting for nearly 70% of global production. Several other countries such as China, India, France, Russia, South Africa and UK make up the rest.

Biodiesel production that accounts for a smaller proportion of liquid biofuels increased from 0.01 million tons in 1991 to 4.0 million tons by 2006 **(Figure 2).** Germany and France are the major producers of biodiesel with USA, Australia and Brazil emerging as new players.

The growth in both ethanol and biodiesel production has accelerated since early 2000 **(Figure 2)** and this trend is expected to continue since many governments have now made it mandatory to blend petroleum products with 5 to 10% biofuels.

The main raw material sources for bioethanol production is sugarcane in Brazil as also in other Latin American countries, corn in the United States, corn and wheat in China, sugarcane molasses in India, cassava and sugarcane in Thailand and sugar beet and grains in Europe.

Brazil is a successful example of sugarcane based ethanol production from sugarcane juice. Over half of its cane production of nearly 300 million tons is turned into ethanol. Over half of the cars in

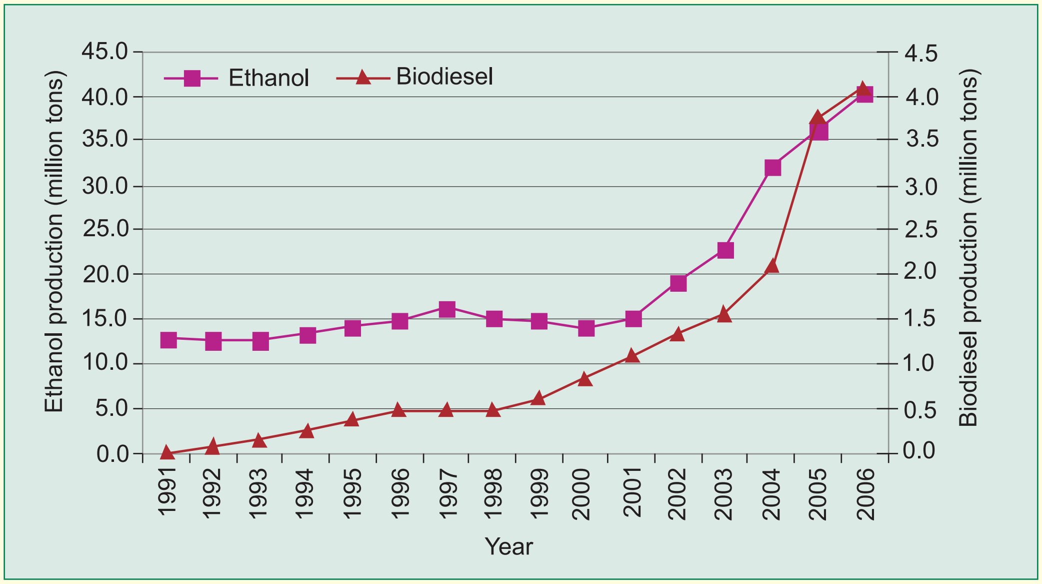

Figure 2.World ethanol and biodiesel production.
Source: 1991-2003 International Energy Agency, 2005. 2004-06 FO Licht, 2007.

the country are flex fuel vehicles that can run on 100% ethanol and any mixture of ethanol–gasoline. Since its inception, Brazil's ethanol program has displaced 40% of gasoline use in the country and saved the country over US$ 120 billion due to reduced oil imports (Asher 2006). Brazil also has a comparative advantage in the production of ethanol largely due to the productivity increases that it has had in sugarcane yields, which have increased by 33%, ethanol production per unit of sucrose, which has increased by 14%, and productivity of the fermentation process, which increased by 130% in the period 1970-2000 (Moreira 2006). In a study on cost of producing ethanol from different sources, the US Department of Agriculture found that Brazil is the cheapest producer of ethanol from sugarcane followed by corn in the US (USDA 2007). The cost of production of ethanol from sugarcane and sugar beets is almost double in the US and EU, respectively (Avery 2006).

For biodiesel production, the main feedstocks are vegetable oils from rapeseed, soybeans, sunflower oil (in southern Europe) and in recent years, palm oil. Rapeseed oil is the preferred vegetable oil in EU since it is produced within the region and accounts for 80% of the feedstock for biodiesel. Rapeseed receives a high level of government support making it competitive for biodiesel production (Thoenes 2006). Used cooking oil and animal fats are also considered as cheap alternatives to rapeseed oil. But there are some technical limitations, for instance, used cooking oil requires a purification process with a mixture of high percentage of rapeseed-based biodiesel for it to meet the quality standards. Animal fat cannot be used as a feedstock for largely the same reason (Ahmed and Thin Sue 2005).

Demand for biofuels

A number of countries are moving towards the blending of biofuels with fossil fuels and governments are stipulating mandatory requirements of 5-10% blending. Based on these mandatory requirements, a number of studies have projected the future demand for biofuels in several countries. For instance, the projected demand for bioethanol in the Philippines in 2007 was estimated at 0.16 million tons at 5% blending with gasoline. This is expected to rise to 0.22 million tons by 2016. In case 10% blending is made mandatory, the demand would be exactly double (ISSASS 2007). In the case of Japan, if the country were to meet its commitment to the Kyoto protocol, its bioethanol demand will increase in a span of 5 years from 1.42 million tons in 2006 to 4.81 million tons in 2010 and the country will have to meet this demand from imports in the world market (ISSAAS 2007). In the EU, approximately 14 million tons of biofuels are needed by 2011 to meet the 5.75% mandatory blending target. Of this, the biodiesel demand is expected to be 7.3 million tons. The EU has a production capacity of 10.3 million tons of biodiesel of which in 2006 it produced 4.8 million tons, up by 54% from 2005 (www.ebb-eu.org).

In the US, the creation of the new Renewable Fuel Standard would involve a substantial increase in the volume of renewable fuels to be blended into gasoline from current levels of about 3% for ethanol and about 1% for biodiesel. China, India, Columbia, Argentina, Indonesia, Thailand and Canada are other countries that are mandating 5 to 10% blending in a phased manner over the next 3 to 4 years.

Brazil and Australia dominate the world trade in ethanol because of superior technological know how and economies of scale in feed stock production and processing. Trade in biofuels like ethanol and biodiesel is limited owing to the protectionist policies adopted by a number of governments to protect their emerging biofuel industry. For example, Brazilian ethanol is kept out of the US through high tariffs and duties.

Food vs fuel debate

There are concerns about the future of the biofuels program since this feedstock-intensive program will reduce the availability of grains and edible oils for human consumption or take up land that could be used for food production in the face of policy induced demand for biofuels. To meet the current and potential demand for biofuels, the use of traditional crops for their production raises the question of diversion of land used for cereal crops and oil crops to energy producing crops or diversion of food crops to biofuel production. This, it is argued, will lead to food and feed insecurity and also removes crop residues that sustain soil productivity and structure. For example, nearly 50% of rapeseed oil production in the EU is going for the non-food energy production (Ahmad and Thin Sue 2005) and to meet the targets for biodiesel in the future it will have to at least double its rapeseed oil production (assuming rapeseed will continue to be the main feedstock). This will divert land away from other food crops. The alternative is to import substantial quantities of rapeseed oil or other vegetable oils such as soybean, sunflower or palm oil.

Similarly, production of ethanol from corn to meet all the US's requirements of 7.5 billion gallons by 2012, implying a near doubling of ethanol production is not feasible due to huge land requirements. It is feared that food costs would soar risking the nutritional security of the world's poor (Avery 2006).

In general, it is feared that the large-scale production of biofuels will increase prices of agricultural commodities. Rising prices would not be restricted to one country, or just the main biofuels producing countries, since the world markets are driven by global supply and demand for agricultural commodities. Higher prices would benefit the exporting countries and producers at the expense of poor consumers and the net importing countries.

Some countries like China and the Philippines have already passed legislations banning the use of corn for ethanol production and have curtailed further expansion of already existing distilleries (Forbes.com September 2007, International Herald Tribune 20 September 2007).

To address the concerns about rising food prices, researchers at IFPRI have carried out modeling exercises using the IMPACT model to address the projected food vs. feed trade off in the coming years in the face of rising biofuel production (Rosegrant et al. 2006). Their findings indicate that aggressive biofuel growth would indeed lead to dramatic increase in world prices for First Generation feedstock crops, like cassava, maize, oilseeds, sugar beet, sugarcane, etc. However, in another scenario that allows for crop technology innovation at the farm level, rising productivity softens the rise in prices to some extent. A third scenario where cellulosic technology will be used for biofuel production, ie, production from cellulosic material such as cornstalks, switch grass, wastes from forest industry, etc, dampens the effect on food prices considerably. However, production of biofuels using cellulosic technologies economically is still a long way away since we still need to overcome several technical constraints that elevate production costs.

To overcome the food security concern, China, for example, is trying to use non-grain feed grain stocks such as sweet potatoes and cassava (USDA 2007). For biodiesel, China is importing palm oil from Malaysia.

Sweet sorghum (*Sorghum bicolor* L. Moench) is a crop of great potential that can overcome some of the above concerns related to food security and rising grain prices since it produces sugar-rich stalks for ethanol production without sacrificing on grain production.

Similarly for biodiesel production non-edible oil plants such as jatropha (*Jatropha curcus)* and pongamia *(Pongamia pinnata)* could be an option since these crops can be grown on marginal lands and hence do not compete with land for food crops. Both the crops' seeds contain 25 to 40% oil that can be used after estreification with diesel. However, as of now the large-scale plantations of these crops are not manufacturing biodiesel and hence more information is required to draw firm conclusions.

Situation/outlook in India

For India, at present, the domestic production of crude oil from fossil fuels meets only 25-30% of national requirements, while the balance is met through imports of nearly 110.9 million metric tons of crude oil and petroleum products that cost the country close to US$ 60 billion in 2006-07 (**Figure 3**). Over the last five years, the

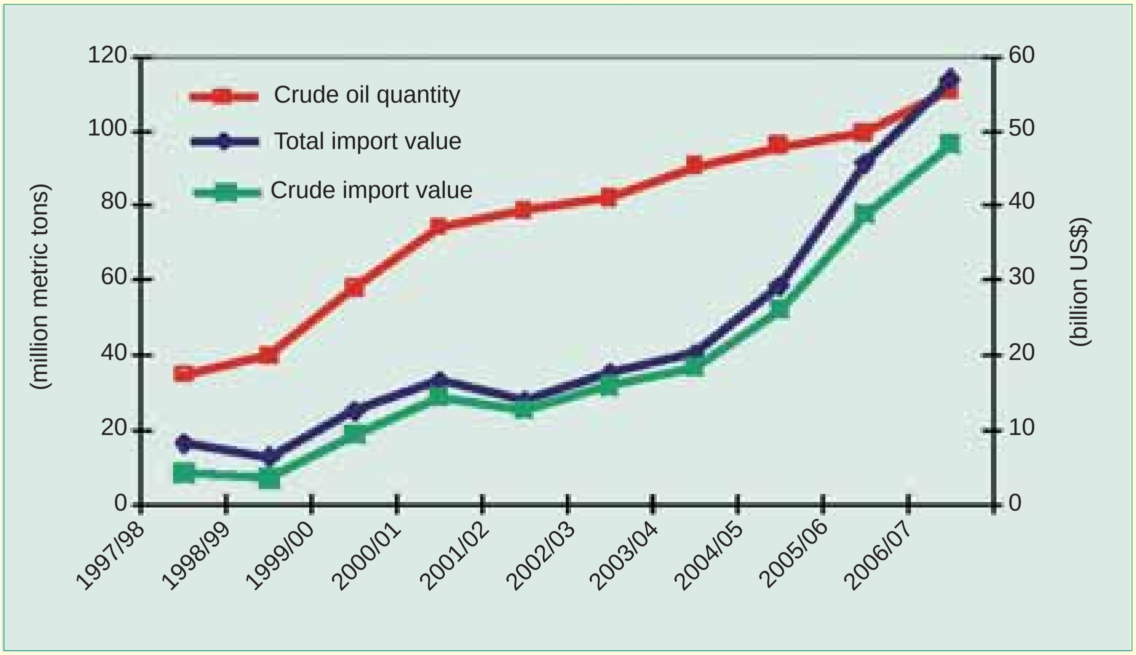

Figure 3. India's import of crude oil and petroleum products.
Source: USDA 2007

consumption of gasoline has grown by 5.2% from 7 million tons in 2001-02 to 8.6 million tons in 2005-06. For High Speed Diesel, the growth was 2.7% from 36.5 million tons to 40.1 million tons (USDA 2006). This growth is expected to continue over the next several years since it is projected that the motor vehicle population in India will grow by 10-12% that would further increase the demand for petroleum products.

Ethanol

The Government of India in 2001 initiated a biofuel policy to lower the country's dependence on crude oil imports, improve the environment by reducing various emissions from fossil fuels and thus conform to stricter emission norms. In the first phase, the Government of India has mandated 5% blending of ethanol that would be raised to 10% by 2007-08. To meet the targets for 5% blending with ethanol in 2006-07, about 0.50 million tons of ethanol was required, while about 1.01 million tons would be required to meet the target of 10% blending **(Table 1).**

Ethanol in India is primarily produced by the fermentation of molasses, a by-product in the manufacture of sugar from sugarcane. Molasses is traditionally used for the production of alcohol for the chemical and potable sectors and thus, the production of ethanol from molasses would be an additional product.

Due to the government policy of mandatory blending of ethanol, several sugar industries have modified their plants to produce ethanol from

Table 1. Projected demand for petrol and diesel, and biofuel requirements, India (million tons)

		Ethanol blending requirement			Diesel blending requirement	
Year	Petrol demand	@5%	@10%	Diesel demand	@5%	@10%
2006-07	10.07	0.50	1.01	52.32	2.62	5.23
2016-17	16.40	0.82	1.64	83.58	4.18	8.36

Source: Planning Commission, Government of India, 2003.

molasses. The availability of molasses depends on sugar production and the price of molasses, which has been fluctuating considerably over the years (Rs 50/ton to Rs 2,000/ton), leading to large variation in ethanol production costs. The availability of molasses in sufficient quantities to meet the projected demand for ethanol depends on cane production and consequently sugar production and government policy on use of molasses etc. For instance, the first phase of the project (5% blending in selected states) was initiated in January 2003 but had to be abandoned due to low sugar production leading to a shortage of molasses. The project was reinstated in September 2006 and from the latest available estimates 0.2 million tons of ethanol was blended against the target of 0.43 million tons in 2006-07 (USDA 2007).

Biodiesel

Demand for biodiesel with similar blending requirements as in the case of ethanol would be 2.62 million tons at 5% and 5.23 million tons at 10% blending **(Table 1)**. Most of this production will have to come from non-edible oilseeds, which would, in turn, promote the utilization of wastelands for cultivation of biofuel feed stocks. However, the biodiesel program is still in a nascent stage in India, although the government has ambitious plans to increase biodiesel production from non-edible oil seeds like jatropha and pongamia. Jatropha plantations are however, slow to take off due to the lack of good quality planting materials, ownership issues of community or government wastelands and other factors. The GOI target is to cover 11.2 million hectares under jatropha but in 2006-07 only about 400,000 hectares is under cultivation and it will take at least another 4-5 years before reliable estimates for production are available (USDA 2007).

Other issues that remain to be resolved are the pricing of seed by companies and pricing of biodiesel. At present, jatropha seeds are mainly crushed for oil at village level or small-scale plants for local use or for sale to the unorganized sector.

ICRISAT's BioPower strategy

To overcome the justifiable concerns that the bio-energy revolution could marginalize the poor, raise food prices and degrade the environment, ICRISAT has launched a global **BioPower** Initiative to find ways to em**power** the dryland poor to benefit from, rather than be marginalized by the **bio**-energy revolution. The Institute's BioPower strategy seeks approaches that forge a path out of poverty for dryland farmers.

Sweet sorghum (*Sorghum bicolor* L. Moench) is a leading crop targeted for ethanol production while jatropha (*Jatropha curcus)*, pongamia *(Pongamia pinnata)* would be targeted for biodiesel production. Central to ICRISAT's **BioPower** Strategy is its commitment to make the bio-energy opportunity work for the poor instead of against them.

Sweet sorghum for ethanol

In the recent years, juice from sweet sorghum stalks is emerging as a viable source for bioethanol production (Rajvanshi 2003, Reddy et al. 2005). Normal grain sorghum is grown on 11.7 million hectares in dryland Asia (28% of global sorghum area) and on 23.4 million hectares in Africa (55% of global sorghum area). Sweet sorghum could fit into many of these areas, producing more biomass and grain if yield-enhancing technologies were stimulated by biofuel market incentives.

A crop of sweet sorghum takes about 4.5 months, and can be followed by a ratoon crop (natural second re-growth from stubble after the first crop is harvested). Together the main and ratoon crops require about 8,000 cubic meters (m^3) of water, whether from rainfall or irrigation (Soltani and Almodares 1994). This is four times less than that required by one crop of sugarcane (12−16 months duration and 36,000 m^3 of water per crop). Sweet sorghum can also be planted from seed, which is less laborious than the stem cuttings used to plant sugarcane, and can be readily mechanized.

Because of water-use efficiency, less fertilizer, labor, and other inputs, the cost of one hectare of sweet sorghum cultivation (main + ratoon crop in 9 months) is 60% lower than that of sugarcane (one crop in 9–12 months). Since poor farmers are less likely to have access to irrigation water and the capital needed to bear the cultivation costs of sugarcane, sweet sorghum is more accessible to poor farmers in less water-endowed areas. Moreover, sweet sorghum has high net energy balance since manual labor is mainly used for its cultivation. Even though the ethanol yield per unit weight of feedstock is lower for sweet sorghum, compared to sugarcane, the much lower per unit production cost for sweet sorghum more than compensates and hence, sweet sorghum still ends up with a competitive cost advantage in the production of ethanol (Rao et al. 2004). These preliminary findings need to be corroborated with more hard data as it becomes available in due course.

The triple-product potential of sweet sorghum-grain, juice for ethanol, stillage or bagasse for livestock feed or generation of electricity is a strong pro-poor advantage compared to sugarcane. Grain yields of 2 to 2.5 t ha^{-1} obtained from sweet sorghum can be used for human food. Based on preliminary animal feeding trials it is found that the stripped leaves and stillage after extraction of juice for ethanol production make excellent fodder for cattle (Blummel et al. 2007). Thus, the concern about the competition between biofuels and food/feed crops for land can be overcome by growing sweet sorghum that has multiple advantages.

Under a pilot project under the initiative of the Agri-Business Incubator (ABI) at ICRISAT, high quality seeds are made available to farmers for production of sweet sorghum with high grain and stover yield and sucrose content in the stalk. The farmers are then integrated by local NGOs with Rusni Distilleries Private Limited for buy back of stover for production of ethanol.

Biodiesel

As part of the bioenergy strategy ICRISAT is also promoting non-edible oilseeds for the production of biodiesel. Jatropha and pongamia plantations are being introduced in watershed programs. As already indicated, jatropha and pongamia have attracted special interest in the tropics since they are inedible and can be grown on areas unsuitable for food crops, eg, wastelands bordering crop lands. Research in biodiesel has been limited to date, it would be worthwhile to investigate a wider range of species in order to maximize options and potential for long-term progress.

Recommendations:

To achieve successful establishment and scaling-up of the pro-poor biofuel program it is recommended that:

- More research be conducted on crops like sweet sorghum for bioethanol and jatropha and pongamia for biodiesel in a participatory mode involving all stakeholders, particularly small–scale farmers
- Available varieties of sweet sorghum/jatropha are adapted into suitable farming systems, ie, establish target domains for these crops by variety/cultivar
- Hard data be collected from the on-farm pilot scale testing sites for a better estimate on returns from these crops to small-scale farmers and processing industry
- Small-scale farmers be grouped into commodity groups or associations and linked with the end users, ie, industry, for better bargaining capacity
- Backward linkage of farmers' association with seed and input suppliers be established for bulk purchases
- Appropriate models of vertical coordination or contract farming or its variants to save on transaction and marketing cost be tested while providing an assured market for the growers.

Thus, empowering the poor and engaging them in the innovation process harnesses the creativity and initiative of the poor. Institutional and policy support to strengthen the pro-poor biofuel initiatives would go a long way in overcoming the initial constraints and sustaining these initiatives in the longer run. Biofuel production models clearly require large economies of scale in order to be cost-effective and competitive with the current fuel sources in the marketplace. Pro-poor models will only succeed if they are intentionally guided in that direction, for example, as was the case with the White Revolution (dairy) in India.

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Acknowledgement

The authors would like to thank Dr. Bekele Shiferew (ICRISAT, Nairobi) and Dr. K K Sharma (ICRISAT, Patancheru) for their comments and suggestions on an earlier draft of the policy brief. The authors also thank Mr Shravan Kumar and Ms Shraavya Bhagavatula for literature search and data analysis.

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Published by

International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

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