Chapter XVII: Sweet sorghum ethanol value chain: Issues and the way forward

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I Introduction

The ICRISAT-NAIP-ICAR sub-project on 'Value Chain Model for Bioethanol Production from Sweet Sorghum in Rainfed Areas through Collective Action and Partnership' focused on developing and establishing sustanable bioethanol value chain models by addressing issues involved along the value chain components. The sweet sorghum value chain encompasses sweet sorghum production and transportation of stalks distillery or crushing unit, crushing stalks for juice extraction, syrup production from juice, ethanol production from juice and or syrup, ethanol blending with gasoline and utilization of the by-products, bagasse, vinasse, etc. For successful implementation of the value chain models, based on the core competencies, a consortium of partners involving public sector research and development organizations (ICRISAT, DSR, IICT, CRIDA, ILRI and SVVU) and private sector ethanol distillery (Rusni Distilleries Ltd.) was formed with ICRISAT as consortium lead. Aakruthi Agricultural Associates of India (AAI), an NGO, was engaged to assist in implementation of the project activities that relate to mobilization of farmers and their capacity building in cluster villages. This unique consortium of private-public-people-partnership (PPPP) was in place to help reach the goals by harnessing the synergies of the partners. The information presented in the previous sections is based on the results obtained from implementation of the project work plans from 2008 to 2012. This chapter describes major issues encountered during implementation of the work plans, the issues related to sustaining the sweet sorghum based ethanol value chain in the state of Andhra Pradesh, India, and the way forward.

II. Issues

1. Consortium building and management

The work culture and administrative practices of the public sector are different from the private sector. The public sector is bound by the agreements and

procedures and therefore the partnership is more durable. On the other hand, the private sector is more influenced by the financial aspects of the enterprise and also by the nature and composition of its partners, working or otherwise. Therefore, private sector partnership is loosely bounded in consortium by virtue of its objectives and profitability motive. The private sector partner, Rusni Distiller could not sustain its operations through the project period under the centralized model for several reasons. Lack of experience in backward linkages with farmers supplying stalk to the distillery is one of the factors that had a bearing on the success of the value chain. However, factors like inadequate working capital, disharmonious relationships among company partners, and unfavorable government ethanol pricing policy were important ones that determined the economic viability of the distillery leading to its closure. As a result, ethanol production from the juice or syrup in the value chain on a commercial scale was hampered during 3rd and 4th year of the project period.

2. Value chain

Value chain describes the chain of value addition activities from production to final consumption. The chain encompasses inputs-processing-outputs-utilization, and the actors involved in these activities. The innovations in sweet sorghum (SS) based ethanol value chain developed in the project can be successfully commercialized only if all the stakeholders in the value chain are benefitted, ie, the farmers, input suppliers, the Decentralized Crushing Unit (DCU) Cooperative and the industry. We assessed the viability to all stallholders in value chain as given below.

A) Viability for farmers: During the rainy seasons (kharif) of 2008-09, the average net income realized by farmers from sweet sorghum cultivation Rs 6490 ha^{-1} excluding family labor. However, during 2009- 2010 and 2010-2011, the net returns were negative due to adverse climatic conditions that affected all crops in the project sites. The negative net returns from sweet sorghum were the lowest among the rainfed competing crops such as grain sorghum, sole maize and maize and pigeonpea intercrops in Ibrahimbad cluster villages (project location), in the Medak district of Andhra Pradesh. During the project period sweet sorghum average stalk yields with minimum 14.6 t ha^{-1} (centralized area) has increased to maximum of 20 t ha^{-1} (decentralized area) and grain yields ranged from 0.2 to 0.9 t ha^{-1} (Table 1). However, to sustain the farmers' interest in sweet sorghum, the current sweet sorghum productivity

should increase from 20 t ha^{-1} to 30 t ha^{-1} and grain from 0.9 t ha^{-1} to 2.0 t ha^{-1} with a higher realization price of Rs 900 t^{-1} for stalk and Rs 12000 t^{-1} for grain. It is not difficult to achieve the proposed yields of stalk and grain as the farmers who adopted fully the improved technologies have realized the set targets.

B) Viability of the Decentralized Crushing Unit (DCU): Sustainability of any rural agro-industry depends on economic and operational feasibility and market linkages and the DCU is no exception. There are several factors that influence the cost of syrup production. These are: juice extraction efficiency (of the machine), sugar content (Brix %) in the juice, conversion of juice in to syrup, and labor and staff employed in managing the crushing unit.

In the course of project implementation, juice recovery increased from 26% in 2008-09 to 30% in 2010-211, reflecting an increase of 15% in juice extraction efficiency. The same sweet sorghum hybrid (CSH 22SS) was used in all the years and it performed well in the farmers' fields, However, there is a need for developing cultivars that give an increased Brix% by at least 6% (from 15% Brix to 16%) that will contribute to increasing the viability of the unit. It is not difficult to achieve the target in the next five years as there is significant variability for Brix% and juice volume in the breeding populations that are being handled.

The labor cost in sweet sorghum syrup production was high (29% of total cost) in 2008-2009 but there is scope for improving labor efficiency through mechanization. There is also scope for improving crushing efficiency by modifying the crushers. Over the three year period, the labor cost has been brought down by 10%. The modifications effected in the crusher helped increase the juice recovery from 260 l to 300 l t^{-1} of stalks (efficiency increased by 15%). Further, the by-product, bagasse feed-chain could contribute to the revenue by the sale of up to 50% of the bagasse to help bring down the operating cost of DCU. The bagasse was sold as fodder at Rs 0.5 kg^{-1} in 2008-2009. In subsequent years, it fetched Rs 1.0 kg^{-1} with minimal processing (chopping). The above factors helped in reducing the cost of syrup production from Rs 32 kg^{-1} (first year of crushing) to Rs 22.5 kg^{-1} in the last year of its operations; the average production cost of syrup during the four year period, 2008-09 to 2010-2012 being Rs 27.2 kg^{-1}. Further, there is a scope for exploring value addition for syrup for use in food industry and demand for bagasse from alternative industries like fuel and paper industry, strengthening the viability of DCU.

During the project period, the distillery offered a maximum of Rs 10 kg^{-1} of syrup on the basis that three kgs of syrup (70% Brix) is required to produce one liter of ethanol (which was then priced at Rs 27 l^{-1}). In such a scenario (selling syrup at Rs 10 kg^{-1} when the production cost is Rs 27.2 kg^{-1}), DCU therefore should look for alternative markets for syrup, such as food/pharmaceutical/ feed industry which give higher price. A part of the syrup produced in the DCU was sold for instance at Rs 22.5 kg^{-1} to the dairy farms.

C) Viability for industry (Centralized area)

i) Productivity: Productivity of ethanol per ton of sweet sorghum stalk was 40 l by Rusni Distilleries, which needs to be improved to 55 l t^{-1} of stalk through 1) efficient crushing to increase juice recovery from the present 300 l t^{-1} to 500 l t^{-1} of stalk; 2) using feedstock with increased Brix% (at least 16%); and 3) increasing the fermentation efficiency by 3% from the present level. Thus, it is hoped that changes if effected as above would help enhance ethanol yield.

ii) Marketing: Ethanol recovery at 55 l t^{-1} at the sale price of Rs 27 l^{-1} will fetch for the industry Rs 1485 t^{-1} of stalk crushed. This leaves Rs 485 towards production cost of ethanol after meeting raw material cost at Rs 1000^{-t} as is the case in the project. However, the present ethanol market price (Rs 27 l^{-1}) needs to be increased to Rs 32 l^{-1} (under the current price structures) to make the industry viable. The industry should also explore the markets for vinasse, the by-product from ethanol production that would further contribute towards the viability of the industry, apart from the bagasse.

iii) Supply chain management: Currently the operating window for industry is only for two months with the available sweet sorghum cultivars which are productive only in the rainy season. Feedstock supply window needs to be increased to at least four months. Further, the industry should be able to utilize other feedstocks, such as broken/molded grain, spoiled potato, cassava tubers, etc., for ethanol production when sweet sorghum is not available. The extension of sweet sorghum feedstock supply is possible provided staggered plantings are possible and also cultivars of different maturities are made available to farmers for cultivation in the rainy season. Thirdly, sweet sorghums that have potentially high stalk sugar yields in postrainy season and in summer (where irrigation is available) should be developed through appropriate breeding methods. Fourthly, adopting and linking DCUs with distilleries will help provide syrup to distillery for use as feedstock at will to

run it for several months in an year because syrup can be stored for several months unlike juice which gets fermented within two hours after crushing.

3. Other issues in commercialization

Labor cost is a major factor that contributes to nearly 55% of the cost of production of sweet sorghum, with harvesting operations being the most labor intensive. The sugarcane crushers used initially in the project did not show good recovery of juice. So, crushers need to be specifically designed for sweet sorghum. Attempts made by the project to develop and improve the harvesters and crusher rollers yielded partial success. There is further scope for bringing in further refinements with harvesters and crushers with the prospects for commercialization.

The Government of India has come out with a policy for minimum blending (10%) of ethanol with gasoline but the ground level regulations for implementation are lacking. To augment ethanol production and achieve the mandated blending target, the Government should come up with a clear policy road map to promote alternative feedstocks like sweet sorghum since ethanol from sugarcane molasses alone will not be able to meet the blending requirements as demanded by the policy.

Strong measures are required in terms of capital subsidy for industry on the basis of sops provided for infant industry status. Government should also take measures to strengthen entrepreneurial skills of farmers and recognize DCU as a small-scale agro-industry enhancing business opportunities for local entrepreneurs.

III. The way forward

The bottom line of any enterprise is to ensure economic benefits to all the stakeholders and in this case the farmers, DCU cooperatives and distillery enterprise apart from sustaining the environment where it is targeted. In this value chain, apart from ethanol, there are other by-products like bagasse for animal feed or bio compost both at DCU as well as at the distillery. The efforts should be directed to further enhance the efficiency in all the operational issues raised above in a way to ensure benefits to all the players in both DCU and centralized areas.

1. Crop production

- Emphasizing on strict adoption of recommended cultivation practices by all the farmers so as to achieve the targeted stalk productivity (30 t ha^{-1}).
- Developing improved sweet sorghum harvesters to reduce the cost of cultivation.
- Streamlining further the stalk supply chain innovation to reduce the time lag between harvesting and crushing and reducing the relative cost of harvesting and transportation.

2. Sweet stalk development

- Genetically improving stalk sugar content and resistance to shoot fly to make the cultivars adaptable to different sowing dates and seasons.
- Identifying appropriate staggered sowings and sweet sorghum genotypes with different maturity durations and the genotypes suitable for postrainy season to increase the harvest window and make the feedstock available for longer periods in the given target region.

3. Juice recovery and fermentation efficiency

- Designing a crusher specifically for sweet sorghum to enhance the juice recovery from present level of 32% to 50% both at DCU and distillery.
- Setting up enough crushers to handle the targeted feedstock on a daily basis to enhance juice recovery
- Reducing time lag between juice extraction and conversion in to syrup to enhance syrup recovery.
- Increasing juice storability and fermentation efficiency for higher ethanol recovery by identifying appropriate fermentation inhibitors yeast strains and enzymes to convert starch and sugars in to ethanol.

4. By-product utilization

- Setting up a feed processing plant for studying the economics of different feed processing methods to add value to bagasse.
- Developing value chain for bagasse utilization to enhance the price of bagasse
- Setting up studies to determine vinasse value and marketability

5. Markets for syrup, ethanol and by-products

- Even if the cost of syrup production is reduced to Rs 20 kg^{-1}, it is difficult to sustain the DCU when the syrup is sold at the rate of Rs 10 kg^{-1} to the distillery. So arrangements ought to be made to sell a portion of syrup to food/pharma/feed industries.
- To enhance bagasse value for use as animal feed (after meeting the fuel needs at DCU), working with fodder traders and dairy farmers to get higher price for bagasse is essential for improving the bagasse value chain.
- Attempts should be made at distillery to explore the use of vinasse as fertilizer.
- Also attempts must be made at distillery to utilize bagasse for second generation ethanol production apart from using bagasse for cogeneration.

The Government should take measures to implement strictly the policy of 10% blending of petrol with ethanol. It is likely that if the distilleries get higher support price for ethanol they may offer higher price for syrup as well as stalks.

The distillery should have facility to use multi-feedstocks to enable it to operate for optimum capacity utilization. Capacity utilization would be sub-optimal with a single feedstock that would increase capital costs. Further, the distillery should have good Research and Development support equipped with appropriate technical staff with skills in the production of ethanol from various feedstocks and in input and supply chain management assets.

We are confident that with the leads obtained from implementation of the sub-project and the measures suggested above will render sweet sorghum ethanol value chain sustainable both economically and environmentally. This can be made possible by the collective action of researchers, farmer cooperatives, ethanol industry and policymakers.