ICRISAT-NAIP sub-project on

Value Chain Model for bioethanol production from sweet sorghum

ICRISAT

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

Science with a human face

Citation: ICRISAT. 2008. ICRISAT-NAIP sub-project on Value Chain Model for bioethanol production from sweet sorghum. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 36 Pages.

ICRISAT-NAIP sub-project on

Value Chain Model for bioethanol production from sweet sorghum in rainfed areas through collective action and partnership

Project Implementing Agency (PIA):
ICRISAT Global Theme on Crop Improvement

International Crops Research Institute for the Semi- Arid Tropics (ICRISAT)
Patancheru – 502 324, Andhra Pradesh, India
2008

CONTENTS

Consortium Team

Dr Belum VS Reddy: Principal Scientist (Sorghum Breeding), Global Theme on Crop Improvement, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

Dr SS Rao: Principal Scientist, National Research Centre for Sorghum (NRCS), Rajendranagar, Hyderabad 500 030, Andhra Pradesh, India

Dr B Venkateswarlu: Director, Central Research Institute for Dryland Agriculture (CRIDA), Santoshnagar, Hyderabad 500 059, India

Dr Ahmed Kamal: Scientist F, Indian Institute of Chemical Technology, Tarnaka, Hyderabad-500 007, India

Dr Michael Blümmel: Principal Scientist, International Livestock Research Institute (ILRI), C/o ICRISAT, Patancheru 502 324, Andhra Pradesh, India

Dr Y Ramana Reddy: Associate Professor, Department of Animal Nutrition, College of Veterinary Science, Sri Venkateshwara Veterinary University, Rajendranagar, Hyderabad 500 030, Andhra Pradesh, India

Mr AR Palaniswami: Managing Director, Sweet Sorghum Ethanol projects, Rusni Distilleries Pvt Ltd., 411 HIG, BHEL, RC Puram, Hyderabad 502 032, India

Project Implementing Agency - ICRISAT

CLL Gowda: Global Theme Leader, Global Theme on Crop Improvement, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

Belum VS Reddy: Principal Scientist (Sorghum Breeding), Global Theme on Crop Improvement, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

SP Wani: Principal Scientist (Watersheds), Regional Theme Coordinator for Agroecosystems, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

P Parthasarathy Rao: Principal Scientist (Economics), Global Theme on Markets, Institutions and Impacts, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

KK Sharma: Head, Agri-Business Incubator, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

A Ashok Kumar: Scientist, Global Theme on Crop Improvement, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

Ch Ravinder Reddy: Visiting Scientist, Global Theme on Crop Improvement, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

1. Project at a Glance

Title of Proposal:	Value Chain Model for bioethanol production from sweet sorghum in rainfed areas through collective action and partnership
Component Code:	2
Name of Consortium Principal Investigator:	Dr Belum VS Reddy
Co-Principal Investigator:	Dr SP Wani
Institution:	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru – 502 324, Andhra Pradesh, India
Mailing Address:	Principal Scientist (Breeding), Global Theme on Crop Improvement, ICRISAT, Patancheru, India 502 324.
Telephone Number:	040-3071-3487
Fax No:	040-3071-3074/75
Email:	b.reddy@cgiar.org
Consortium Partners:	NRCS, CRIDA, IICT, ILRI, SVVU, Rusni Distilleries Pvt. Ltd.
Associate Partners:	ANGRAU, CIAE, IIT (Chennai).(Based on need, more members will be added)
Date of Start:	20 December 2007
Planned Duration:	4 years 6 months
Funds from NAIP:	Rs 913.32 lakhs
Funds available from other sources:	NIL
Expected Resource Generation/year:	Rs 0.4 lakhs

2. BioPower – a holistic strategy for food and energy security of poor people

ICRISAT has broadened its thinking beyond biofuels into a holistic, pro-poor bio-energy approach, represented by the term BioPower. All aspects of the energy cycle relevant to the poor needs attention, including bioenergy generation for rural needs, the recycling of bio-wastes, social, institutional and economic dimensions of bioenergy, environmental impacts, sustainability and other important issues.

The BioPower strategy focuses on feedstock sources and approaches that do not compete with food production but rather produce food as well as fuel, and may even enhance food production by stimulating increased input use and crop management intensity.

Processors need a reliable stream of quality feedstock at a predictable price and in high volumes; small-scale farmers need a fair and reliable share of the benefits, and technical and credit assistance. Sweet sorghum has some inherently pro-poor characteristics relative to other major feedstocks (described later). Research to increase the production system efficiency will enhance its competitive positioning vis-à-vis other feedstocks, which in any case will not be able to meet the demand alone. By providing competitive, remunerative options beneficial to the culture and livelihoods of poor dryland farmers, sweet sorghum research-for-development can help ensure that the biofuels revolution aids the sustainable development of drylands, rather than bypassing or marginalizing them.

Increased production system efficiency, while important, is not enough. It will need to be coupled with institutional and policy research to find socially-acceptable ways to efficiently engage thousands of poor as feedstock suppliers so that the revenues accrued to biofuels benefit them rather than pushing them aside in favor of massive-scale industrial farms. This is a major global concern and particularly important for the poorest developing countries that are the target of ICRISAT's mandate.

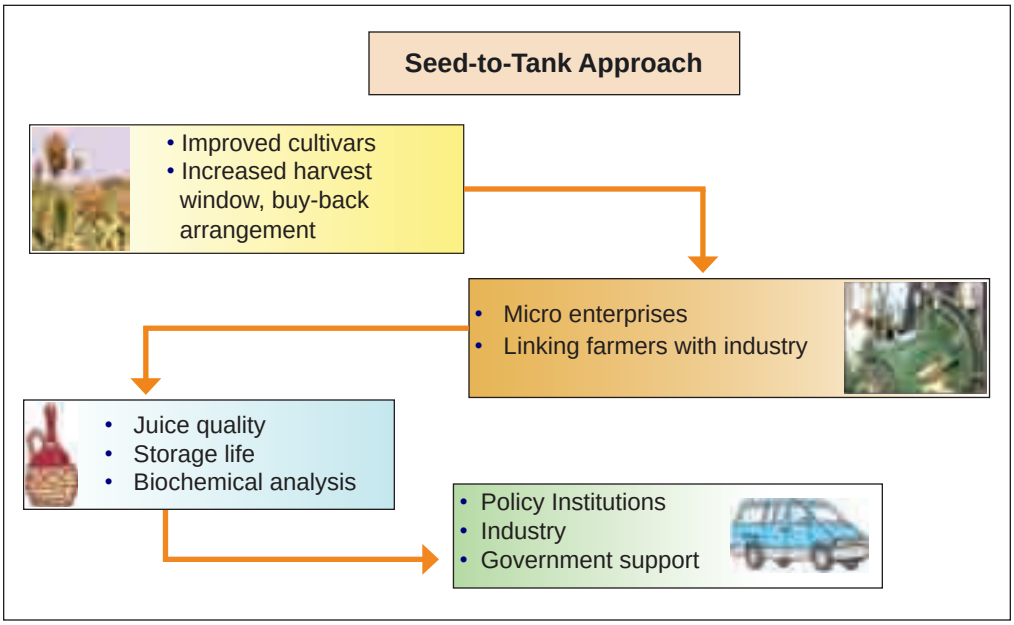
Sweet sorghum cultivation can be a boon for farmers and they can become its most vocal advocates, if they are engaged in the enterprise. Positive, mutually-beneficial arrangements that favor food security, production system stability and predictability, risk management, and environmental sustainability while providing a cost-effective supply of feedstock to the industry, will generate support and benefit both industry and poor nations.

Multiple-use crops (food/feed/fodder/fuel) adapted to dryland conditions that provide flexibility and food security to the resource-poor farmers is the key to maintaining the balance between all the needs-food and fuel, water demands and environmental sustainability drivers.

3. Objectives

1. Assess economic and environmental viability, enabling policies and institutions to promote cultivation of sweet sorghum for bioethanol production and its impact on environment, rural incomes, livelihoods and social capital development.
2. Develop and establish pilot-scale Public Private People Partnership (PPPPs) value chain bioethanol enterprise models through "Seed-to-Tank" approach encompassing sweet sorghum production, processing, value addition, marketing and environmental protection.

3. Farmers' participatory multilocation testing of the improved biomass (stalks and grain) and juice yielding sweet sorghum cultivars under on-farm situations and development of production and seed systems in the targeted area.
4. Fine-tuning of package of practices for increased harvest window, mechanization and development of protocols for by-product utilization.
5. Capacity building and skill development of all the stakeholders including rural communities in the enhanced sweet sorghum production and value chain for bioethanol production.



4. Sorghum improvement research at ICRISAT

a. Genetic enhancement for high productivity and adaptation: Sorghum [*Sorghum bicolor* (L.) Moench] is the world's fifth major cereal crop in terms of area and production. It is the major source of food, feed and fodder/forage since time immemorial. It is mostly grown in the semi-arid tropics (SAT) of the world as a subsistence dryland crop by resource-limited farmers under traditional management conditions, thereby recording low productivity compared to other major cereals. The yield and quality of sorghum produced worldwide is influenced by a wide array of biotic and abiotic constraints. The shootfly and grain mold among the biotic constraints and drought, soil salinity and soil acidity associated with Al^{3+} toxicity among abiotic constraints pose major threat to sorghum yields. In addition, the parasitic weed *Striga* is prevalent in many regions of Africa and significantly impacts sorghum production.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has developed a large number of improved cytoplasmic-nuclear male sterility (CMS)-based hybrid parents, and varieties and genetic male-sterility-based populations by exploiting large number of diverse genetic resources for use either as direct cultivars or in further breeding programs in various parts of the world. As many as 804 seed parents, 883 restorer lines/varieties and 17 populations were developed for high yield and bold grain; shoot fly and grain mold tolerance, *Striga* resistance (system priority 2a) and tolerance to salinity and Al^{3+} toxicity in different maturity backgrounds (priority 2b). Of late, major emphasis is on improving sorghum for postrainy season adaptation, increasing the grain micronutrient density (Fe and Zn) and sweet stalk traits, keeping in mind the three major issues ie, drought (priority 2b), nutrition (priority 2c) and energy (priority 2d), while diversifying nuclear genetic and CMS bases.

The sorghum improvement program is focusing on use of modern biotechnological tools in genetic diversity assessment and QTL mapping of important traits, large scale involvement of farmers and NARS in the research programs, and building up of public-private partnerships for quick dissemination of the research products, in turn, tapping unconventional funds for research with the ultimate aim of creating a win-win situation through innovative linkages.

b. Partnership with private sector for grain sorghum hybrid parents research: The enhanced research and development capabilities of private sector (PS) seed companies over time and their emergence as a major channel for delivering ICRISAT's seed-based technologies to sorghum farmers and producers especially in India, and other developing countries (eg, Indonesia and Egypt), prompted ICRISAT to recognize that the Institute's traditional relationship with public sector breeding programs, though important, was no longer the sole route to farm-level adoption of the hybrids developed based on ICRISAT-bred research products. This realization was all the more pertinent following the succession of funding shocks in ICRISAT and other CGIAR Centers.

This led to conceptualization and initiation of the Sorghum and Pearl millet Hybrid Parents Research Consortia during 2000 at ICRISAT, Patancheru, the first of its kind in the entire CGIAR system to provide complementary expertise in the area of hybrid development, seed production and dissemination to the clientele and partial funding support to ICRISAT's hybrid parents research with an explicit understanding that the research products from this research will still remain in the public domain and ICRISAT will retain the exclusive rights on its research products. This consortium was later restructured in 2004 with expanded participation of the private sector companies and higher levels of funding support

from each company. The new structure still enables to keep the research products in the public domain with free access to the public sector as well. The number of members in the consortium increased from seven in 2000 to 17 in 2005, reflecting the value and relevance of ICRISAT's research to farmers.

c. Sweet sorghum research and development: As sweet sorghum is relished by livestock and digestibility is high compared to other stovers, sweet sorghum research at ICRISAT, Patancheru was initiated mainly for forage/fodder purpose way back in 1980. Keeping in view the potential of sweet sorghum for ethanol production, research has been intensified in sweet sorghum since 2002. With the Government of India's decision in 2006 to blend gasoline with ethanol up to 5 per cent, the demand for fuel grade ethanol shot up, creating a huge demand for ethanol feedstocks including sweet sorghum in India.

ICRISAT, Patancheru in collaboration with national programs developed several improved sweet sorghum lines with high stalk sugar content (18-24% Brix) that are currently being tested in pilot studies for sweet sorghum-based ethanol production in India, the Philippines and Uganda. A few of these cultivars such as SSV 84, SSV 74 and CSH 22 SS have already been released in India. Some of the varieties or restorer lines developed at ICRISAT with Brix value greater than 19% are ICSR 93034, ICSV 700, ICSV 93046 E36-1, SPV 422, NTJ 2, Seredo and Entry#64 DTN. The promising female lines for combining ability for high Brix are ICSA/B 38, ICSB 264, ICSA/B 474, 321, 480, 479, 453, 73, 271 and 487. A total of 30 hybrids developed by ICRISAT are under different stages of evaluation. The varieties/hybrids developed at ICRISAT are doing well in India and other countries too.

Research experience at ICRISAT and elsewhere has shown that hybrids produce relatively higher biomass, besides being early and more photo-insensitive compared to the varieties under normal as well as abiotic stress conditions including water-limited environments. Requirement of photo- and thermo-insensitiveness is essential to facilitate plantings at different dates for extended supply of sweet sorghum stalks to distilleries for ethanol production. Therefore, development of sweet sorghum hybrids is receiving high priority to produce more feedstock and grain yield per drop of water and unit of energy invested.

It is generally debated that sweet sorghum cultivars do not produce grain yield and if they do, the grain yield is less. At ICRISAT, however, the comparison of sweet sorghum and non-sweet sorghum hybrids in the rainy season showed that they produce higher sugar yield (21%) and higher grain yield (15%) than non-sweet sorghum hybrids, indicating that there is no trade off in hybrids. On the other hand, in the varieties during the rainy season, there is some trade off between

grain yield and sugar yield, but the loss in grain yield is far less than the gain in sugar yield. Similar trends are noted for both varieties and hybrids during the postrainy season.

d. Public Private Partnership for sweet sorghum ethanol research: ICRISAT's mission is to reduce poverty, enhance food and nutritional security and protect the environment of the semi-arid tropics by empowering the poor through *science with a human face*. ICRISAT firmly believes in building public-private partnerships to help reach the goals by better harnessing of technology for commercialization. Towards making sweet sorghum a viable supplement feedstock for ethanol production to meet the demand, ICRISAT is actively working with the national agricultural research systems (NARS) partners in India, the Philippines, Uganda and Nigeria. Its tie up with Rusni Distilleries Pvt Ltd., Medak District, Andhra Pradesh through the Agri-Business Incubator (ABI) for the purpose of incubating the sweet sorghum based ethanol technology, commissioned by the Director General of ICRISAT in 2006 amply demonstrated the commercial viability of this technology. It is the world's first sweet sorghum based ethanol production distillery, and has become a model for the establishment of such industries the world over. Further, ICRISAT is working with distilleries for promotion of sweet sorghum by establishing sweet sorghum ethanol research consortia (SSERC) all over the world.

5. Economics of sweet sorghum production

Components	Sweet sorghum	Grain sorghum
Grain yield (t ha^{-1})	1.6	2.5
Stalk yield (t ha^{-1})	20	4 (dry)
Grain value (US$ $season^{-1}$)	234	365
Stalk value (US$ $season^{-1}$)	293	50
Total value (US$ $season^{-1}$)	527	415
Leaf stripping (US$ $season^{-1}$)	15	-
Net value (US$ $season^{-1}$)	512	415
Gain from sweet sorghum (US$ $season^{-1}$ ha^{-1})	97 (23%)	

Adapted from Rajasekhar (2007), UAS, Dharwad
Sweet sorghum is more profitable (23%) to the farmer than grain sorghum.

6. Consortium partners

S. No.	Consortium Partners	Name of the CoPIs	Designation	Full address with phone, fax and e-mail
1	ICRISAT	Dr Belum VS Reddy, Consortium Principal Investigator	Principal Scientist (Breeding)	ICRISAT, Patancheru, 502 324, Andhra Pradesh Ph: 040-3071-3487 Fax: 040-3071-3074/3075 b.reddy@cgiar.org a.ashokkumar@cgiar.org
2	NRCS	Dr SS Rao	Principal Scientist	National Research Centre for Sorghum (NRCS), Rajendranagar, Hyderabad 500 030. AP, India Ph: 040-2401-5225, 2401-5349, Fax: 040-2401-6378 ssrao@nrcsorghum.res.in
3	CRIDA	Dr YS Ramakrishna	Director	CRIDA, Santoshnagar, Hyderabad 500 059, Phone: 040-2453-0161 Fax: 040-2453-1802 ramakrishna.ys@crida.ernet.in isvas@crida.ernet.in bsreddy@crida.ernet.in aravikant@crida.ernet.in grkorwar@crida.ernet.in
4	IICT	Dr Ahmed Kamal	Scientist F	Indian Institute of Chemical Technology, Hyderabad - 500 007 Ph: 040-2716-0123, Fax: 040-27193370 ahmedkamal@iict.res.in cgkumar@iictnet.org
5	ILRI	Dr Michael Blümmel	Principal Scientist, Animal Nutrition	ILRI, C/o ICRISAT, Patancheru PO 502 324, Andhra Pradesh Phone: 040-3071-3653 Fax: 040-3071-3074 m.blummel@cgiar.org
6	SVVU	Dr Y Ramana Reddy	Associate Professor	Department of Animal Nutrition, College of Veterinary Sciences, Rajendranagar, Hyderabad 500 030, Andhra Pradesh Tel: 2374-6032, Cell: 98850-51280 Email: dvgkmohan@rediffmail.com ramanayr19@yahoo.co.in
7	Rusni	Mr AR Palaniswamy	Managing Director, Sweet Sorghum Ethanol projects	Rusni Distilleries Pvt Ltd., 411 HIG, BHEL, RC Puram, Hyderabad 502 032, Phone: 040-2302-5310 Email: rusnispirit@rediffmail.com

Partner-wise work-distribution in the consortium

S .No	Partner	Major responsibilities
1	ICRISAT	ICRISAT is the consortium leader and has the major responsibility of project planning, implementation and reporting. 1. Baseline characterization, assessment of economic competitiveness of sweet sorghum for bioethanol, documentation and analysis of existing policies. 2. Establishment of decentralized crushing units, their maintenance and operation and process documentation for SWOT analysis. 3. Linking the farmers with decentralized units and distillery and technical back stopping for increased productivity. 4. Identification of promising sweet sorghum cultivars for the target region through farmer participatory multilocation on-farm evaluation. 5. Development of institutional mechanisms for input supply. 6. Seed multiplication and distribution for large scale cultivation. 7. Increasing the harvest window to supply feed stocks for longer times and simulation studies. 8. Development and evaluation of protocols for use of sweet sorghum stillage as organic matter. 9. Capacity enhancement of farmers, CBOs, development personnel and distillers. 10. Development of training and IEC materials and providing access to SHGs for these materials.
2	CRIDA	1. Providing technical support to farmers for enhanced crop productivity. 2. Evaluation and refinement of suitable machines for harvesting, leaf/ sheath stripping and crushing of stalks. 3. Training of various stakeholders
3	NRCS	1. Assessment of economic competitiveness of sweet sorghum for bioethanol, documentation and analysis of existing policies. 2. Providing technical support to farmers for enhanced crop productivity. 3. Identification of promising sweet sorghum cultivars through farmer participatory multilocation on-farm evaluation. 4. Taking part in development and assessment of biochemical quality parameters of sweet sorghum juice for optimizing recovery, minimizing storage losses and improved fermentation efficiency. 5. Refinement of agronomy for increased harvest window. 6. Training of various stakeholders.
4	ILRI	1. Development and evaluation of protocols for production of animal feed, organic matter and fuel from the sweet sorghum stillage. 2. Standardizing the ratios and methods of making feed blocks from sweet sorghum stillage. 3. Comparison of stillage feed blocks as animal feed with other common raw material in the feed blocks.

Continued

Continued.

S .No	Partner	Major responsibilities
5	IICT	1. Development and assessment of biochemical quality parameters of sweet sorghum juice for optimizing recovery, minimizing storage losses and improved fermentation efficiency. 2. Capacity enhancement of distillers and other stakeholders for minimizing the storage losses.
6	Rusni	1. Assessment of biochemical quality parameters of sweet sorghum juice for optimizing recovery, minimizing storage losses and improved fermentation efficiency. 2. Seed multiplication and distribution and technical backstopping for increased productivity. 3. Mechanization aspects of sweet sorghum cultivation in centralized growers model. 4. Protocols for utilization of stillage as fuel. 5. Training of farmers, CBOs and development personnel.
7	SVVU	1. Comparison of stillage feed blocks as animal feed with other common raw material in the feed blocks. 2. Capacity enhancement of farmers, CBOs, development personnel and distillers.

7. Project operation area

Selection of target region

Traditionally, sorghum is a popular crop in Andhra Pradesh during the rainy and postrainy seasons. The criteria behind selection of Medak district in Andhra Pradesh for establishment of decentralized crushing units as part of the project is based on the sorghum acreage and suitability of agro-ecology in addition to the location of Rusni Distilleries. There is good scope for area expansion under sweet sorghum. Grain quality of rainy season sorghum is generally affected by the grain mold at maturity stage, which makes it unsuitable for human consumption. Ethanol production from such grains and sweet sorghum stalks gives additional income to the farmers without compromising the food/feed value. Based on the above criteria, Ibrahimbad cluster, comprising seven villages (given in Table 1) was selected.

Participatory site selection.

Participatory site selection.

Target Area – Ibrahimbad village, Narsapur Mandal, Medak district in Andhra Pradesh.

Table 1. Number of villages and households in Ibrahimbad cluster

S No.	Village Name	Total no. of households
1	Ibrahimbad	192
2	Errakuntla Thanda	67
3	Seethya Thanda	21
4	Durgam Thanda	20
5	Umla Thanda	19
6	Sikindlapur Thanda	123
7	Laxman Thanda	54
	Total	514

8. Outputs, Activities and Work programs

Outputs

1.1 Economic and environmental assessment of sweet sorghum for ethanol completed (AP)

1.2 Enabling policy and institutional mechanisms for sweet sorghum ethanol model documented

2.1 Pilot model of decentralized crushing cum syrup making unit encompassing sweet sorghum bioethanol value chain established and operationalized

2.2 Learnings from the innovative and pilot value-chain model of bioethanol production from sweet sorghum documented

3.1 Promising sweet sorghum cultivars for target region identified

3.2 Seed and other input supply systems for large scale sweet sorghum cultivation established

4.1 Production package for increasing the harvest window developed
4.2 Mechanized crop production methods and protocols for by-product utilization developed
5.1 Enhanced capacities of various stakeholders to maximize the productivity and profitability of value chain achieved
5.2 Training material (manuals, protocols and audio video material) on sweet sorghum ethanol production made available.

Activities

Output 1.1 Economic and environmental assessment of sweet sorghum for ethanol completed (AP)
Activity 1.1.1 Baseline characterization (bio-physical and socio-economic) of the target areas
Activity 1.1.2 Assess economic competitiveness of sweet sorghum as a feedstock for bioethanol with other crops like maize, sugarcane and cassava, and economics of sweet sorghum cultivation vis-à-vis crops replaced

Output 1.2 Enabling policy and institutional mechanisms for sweet sorghum ethanol model documented
Activity 1.2.1 Documentation and analysis of the existing policies and institutional mechanisms in sweet sorghum ethanol technology

Output 2.1 Pilot model of decentralized crushing cum syrup making unit encompassing sweet sorghum bioethanol value chain established and operationalized
Activity 2.1.1 Establishment of decentralized juice extraction and syrup making units for value chain development
Activity 2.1.2 Providing technical support to the farmers for enhanced crop productivity
Activity 2.1.3 Linking farmers to decentralized units and processing industry

Output 2.2 Learning from the innovative and pilot value-chain model of bioethanol production from sweet sorghum documented
Activity 2.2.1 Process documentation built-in in the pilot model system to identify strengths, weaknesses, opportunities and threat of the model
Activity 2.2.2 Content development of the model to be used as inputs for outputs 1.2 and 5.2

Output 3.1 Promising sweet sorghum cultivars for target region identified
Activity 3.1.1 Identification of varieties and hybrids through multi-location on-farm testing and farmers' participatory cultivar selection

Activity 3.1.2 Development and assessment of biochemical quality parameters of sweet sorghum juice for optimizing recovery, minimizing storage losses and improved fermentation efficiency

Output 3.2 Seed and other inputs supply systems for large scale sweet sorghum cultivation established

Activity 3.2.1 Developing institutional mechanisms for supply of inputs like seed, fertilizers, machinery, etc, and also the sale of feedstock

Activity 3.2.2 Seed multiplication and supply in the target region

Output 4.1 Production package for increasing the harvest window developed

Activity 4.1.1 On farm trials for refining agronomic practices for enhancing the productivity and availability of sweet sorghum feedstock to the industry

Activity 4.1.2 Generating data to validate the simulation models for identifying potential areas suitable for prolonged availability of feedstock materials to the industry in AP

Output 4.2 Mechanized crop production methods and protocols for by-product utilization developed

Activity 4.2.1 Evaluation and refinement of suitable machines for harvesting, leaf/sheath stripping and crushing

Activity 4.2.2 Development and evaluation of protocols for production of animal feed, organic matter and fuel from the sweet sorghum stillage

Output 5.1 Enhanced capacities of various stakeholders to maximize the productivity and profitability of value chain achieved

Activity 5.1.1 Training of farmer groups and community based organizations (CBOs) for micro-entrepreneurship and management practices to increase the harvest window, high productivity and by-product utilization.

Activity 5.1.2 Increasing the awareness of various stakeholders through the conduct of field days, training, consultation and provision of Information, Education and Communication (IEC) materials on sweet sorghum cultivation, processing and ethanol production

Output 5.2 Training material (manuals, protocols and audio video material) on sweet sorghum ethanol production made available

Activity 5.2.1 Development and popularization of training materials to suit various interest groups

Activity 5.2.2 Provision of access to these materials to self-help groups (SHGs) and other interest groups.

Work Program log frame: Year-wise

The project starts with the baseline characterization (bio-physical and socio-economic) of the target areas for sweet sorghum ethanol production using the existing genotypes and technology. Enhancement of the production, processing and marketing aspects is attempted though the different activities given below.

Sl. No	Activity No.	Activity	Year				
			I	II	III	IV	V
1	1.1.1	Baseline characterization (bio-physical and socio-economic) of the target areas (ICRISAT)	√				
2	1.1.2	Assess economic competitiveness of sweet sorghum as a feedstock for bioethanol with other crops like maize, sugarcane and cassava, and economics of sweet sorghum cultivation vis-à-vis crops replaced (ICRISAT, NRCS)	√	√			√
3	1.2.1	Documentation and analysis of the existing policies and institutional mechanisms in sweet sorghum ethanol technology (ICRISAT, NRCS)	√	√			√
4	2.1.1	Establishment of decentralized juice extraction and syrup making units for value chain development (ICRISAT)	√	√			
5	2.1.2	Providing technical support to the farmers for enhanced crop productivity (ICRISAT, NRCS, CRIDA, Rusni)	√	√	√	√	
6	2.1.3	Linking farmers to decentralized units and processing industry (ICRISAT)	√	√			
7	2.2.1	Process documentation built-in in the pilot model system to identify strengths, weaknesses, opportunities and threats of the model (ICRISAT)	√	√	√	√	
8	2.2.2	Content development of the model to be used as inputs for outputs 1.2 and 5.2 (ICRISAT)	√	√	√	√	
9	3.1.1	Identification of varieties, hybrid parents and hybrids through multi-location on-farm testing and farmers' participatory cultivar selection (ICRISAT, NRCS)	√	√		√	
10	3.1.2	Development and assessment of biochemical quality parameters of sweet sorghum juice for optimizing recovery, minimizing storage losses and improved fermentation efficiency (IICT, NRCS, Rusni)	√	√	√	√	
11	3.2.1	Developing institutional mechanisms for supply of inputs like seed, fertilizers, machinery, etc (ICRISAT)	√	√	√	√	

Continued

Continued.

Sl. No	Activity No.	Activity	Year				
			I	II	III	IV	V
12	3.2.2	Seed multiplication and supply in the target region (ICRISAT,Rusni)	√	√	√	√	√
13	4.1.1	On farm trials for refining agronomic practices for enhancing the productivity and availability of sweet sorghum feedstock to the industry (ICRISAT, NRCS, Rusni)	√	√	√		
14	4.1.2	Generating data to validate the simulation models for identifying potential areas suitable for prolonged availability of feedstock materials to the industry in AP (ICRISAT)	√	√	√		
15	4.2.1	Evaluation and refinement of suitable machines for harvesting leaf/sheath stripping and crushing (CRIDA, Rusni)	√	√	√	√	
16	4.2.2	Development and evaluation of protocols for production of animal feed, organic matter and fuel from the sweet sorghum stillage (ILRI, SVVU, ICRISAT, Rusni)		√	√	√	
17	5.1.1	Training of farmer groups and CBOs for micro-entrepreneurship and management practices to increase the harvest window (ICRISAT, NRCS, Rusni, CRIDA)	√	√	√	√	√
18	5.1.2	Increasing the awareness of various stakeholders through the conduct of field days, training, consultation and provision of IEC materials on sweet sorghum cultivation, processing and ethanol production (ICRISAT, NRCS, Rusni)	√	√	√	√	√
19	5.2.1	Development and popularization of training materials to suit various interest groups (ICRISAT, NRCS, CRIDA)	√	√	√	√	√
20	5.2.2	Provision of access to these materials to SHGs and other interest groups (ICRISAT)		√	√	√	√

9. Monitoring Indicators

Sl. No	Activity No.	Activity	Monitoring indicator
1	1.1.1	Baseline characterization (bio-physical and socio-economic) of the target areas (ICRISAT)	Database and survey report
2	1.1.2	Assess economic competitiveness of sweet sorghum as a feedstock for bioethanol with other crops like maize, sugarcane and cassava, and economics of sweet sorghum cultivation vis-à-vis crops replaced (ICRISAT, NRCS)	Database and reports
3	1.2.1	Documentation and analysis of the existing policies and institutional mechanisms in sweet sorghum ethanol technology (ICRISAT, NRCS)	Policy briefs and reports
4	2.1.1	Establishment of decentralized juice extraction and syrup making units for value chain development (ICRISAT)	Number of decentralized crushing units operational and running, and quantity of syrup produced
5	2.1.2	Providing technical support to the farmers for enhanced crop productivity (ICRISAT, NRCS, CRIDA, Rusni)	No. of technologies advocated and adopted; no. of farmers benefited
6	2.1.3	Linking farmers to decentralized units and processing industry (ICRISAT)	No. of farmers linked to decentralized units and distillery
7	2.2.1	Process documentation built-in in the pilot model system to identify strengths, weaknesses, opportunities and threats of the model (ICRISAT)	Documentation reports
8	2.2.2	Content development of the model to be used as inputs for outputs 1.2 and 5.2 (ICRISAT)	Content development manual
9	3.1.1	Identification of varieties, hybrid parents and hybrids through multi-location on-farm testing and farmers' participatory cultivar selection (ICRISAT, NRCS)	Number of varieties and hybrids identified
10	3.1.2	Development and assessment of biochemical quality parameters of sweet sorghum juice for optimizing recovery, minimizing storage losses and improved fermentation efficiency (IICT, NRCS, Rusni)	Percent improvement in juice quantity and quality; improved methods of juice shelf-life extension and fermentation efficiency
11	3.2.1	Developing institutional mechanisms for supply of inputs like seed, fertilizers, machinery, etc (ICRISAT)	No. of institutional mechanisms identified and no. of farmers benefited
12	3.2.2	Seed multiplication and supply in the target region (ICRISAT, Rusni)	No. of groups/seed companies organized for seed production; quantity of seed made available to farmers

Continued

Continued.

Sl. No	Activity No.	Activity	Monitoring indicator
13	4.1.1	On farm trials for refining agronomic practices for enhancing the productivity and availability of sweet sorghum feedstock to the industry (ICRISAT, NRCS, Rusni)	Mapping of the area for different planting dates; enhanced period of feedstock availability
14	4.1.2	Generating data to validate the simulation models for identifying potential areas suitable for prolonged availability of feedstock materials to the industry in AP (ICRISAT)	Database and model validated for sweet sorghum; mapping of potential areas in AP for sweet sorghum
15	4.2.1	Evaluation and refinement of suitable machines for harvesting leaf/sheath stripping and crushing (CRIDA, Rusni)	Refined harvesting and leaf stripping machines available for use on the field
16	4.2.2	Development and evaluation of protocols for production of animal feed, organic matter and fuel from the sweet sorghum stillage (ILRI, SVVU, ICRISAT, Rusni)	Value addition as livestock feed, organic manure and fuel
17	5.1.1	Training of farmer groups and CBOs for micro-entrepreneurship and management practices to increase the harvest window (ICRISAT, NRCS, Rusni, CRIDA)	Number of training programs conducted and number of farmer groups and CBOs trained
18	5.1.2	Increasing the awareness of various stakeholders through the conduct of field days, training, consultation and provision of IEC materials on sweet sorghum cultivation, processing and ethanol production (ICRISAT, NRCS, Rusni)	Number of field days conducted and number of different IEC materials made available
19	5.2.1	Development and popularization of training materials to suit various interest groups (ICRISAT, NRCS, CRIDA)	Number of training materials developed and popularized according to users
20	5.2.2	Provision of access to these materials to SHGs and other interest groups (ICRISAT)	Number of farmers using training material

10. Consortium Advisory Committee (CAC)

S No.	Name of the Chairman/Member	Postal Address	E-mail, telephone no.
1	Dr ST Borikar Chairman	102, Saraswatinagar, Parbhani 431 401, Maharashtra, India	stborikar@rediffmail.com Tel: 02452-223920; 094221-77432
2	Dr G Harinarayana Member	Director of Research, Ganga Kaveri Seeds Pvt Ltd, 1406 Babu Khan Estate, Bashir Bagh, Hyderabad 500 001, AP, India	harinarayanag@rediffmail.com Tel: 040-6666-7222 Fax: 040-2323-3418; 098662-28782
3	Dr RV Vidyabhushanam Member	74, Sriramnagar Colony, SR Nagar, Hyderabad 500 038, AP, India	Tel: 040-2381-7590; 099890-69010
4	Mr B Kimlal Member	House No. 4-13, Thanda/Village: Gongular, Mandal: Pulkal, District: Medak, AP, India	
5	Mr B Narsimhulu, Member	House No. 1-87, Village: Gunthapally, Mandal: Kondapur 502 295, District: Medak, AP, India	
6	Mr P Balakrishna Reddy Member	House No. 1-78, Village: Gunthapally, Mandal: Kondapur, District: Medak, AP, India	
7	Mr Manne Narasimlu Member	House No. 1-47/2, Village: Posanpally, Post: Choutakur, Mandal: Pulkar, District: Medak, Andhra Pradehs, India	
8	Ms K Nagamani Member	House No. 3-96, Village: Danampally, Mandal: Andoi, District: Medak, AP, India	093473-53125
9	Prof Jitendra Mittal	National Coordinator, National Agricultural Innovation Project (NAIP) Project Implementation Unit 515 KAB-II, IARI Campus, Pusa, New Delhi 110 012, India	jpm.naip@hotmail.com Tel: 011-2584-8709, -2584-8772; Fax: 011-2584-8709, -2584-3403
10	Dr CLL Gowda Member	Leader—Global Theme on Crop Improvement, ICRISAT Patancheru 502 324, AP, India	c.gowda@cgiar.org Tel: 040-3071-3354 Fax:040-3071-3074, -3071-3075; 098490-53475
11	Dr Belum VS Reddy Member Secretary	Principal Scientist (Breeding) Global Theme on Crop Improvement ICRISAT, Patancheru 502 324, Andhra Pradesh, India	b.reddy@cgiar.org Tel: 040-3071-3487 Fax: 040-3071-3074; 3071-3075;099890-57535

11. Consortium Implementing Committee (CIC)

S. No.	Consortium partners	Name of the committee member	Designation	Full address with phone, fax and e-mail
1	ICRISAT	Dr Belum VS Reddy	Chairman	ICRISAT, Patancheru 502 324, AP, India Ph: 040-3071-3487 Fax: 040-3071-3074/3075 b.reddy@cgiar.org a.ashokkumar@cgiar.org
2	NRCS	Dr SS Rao	Member	National Research Centre for Sorghum (NRCS), Rajendranagar, Hyderabad 500 030, AP, India Phone: 040-2401-5225, -2401-5349, Fax: 040-2401-6378 ssrao@nrcsorghum.res.in
3	CRIDA	Dr B Venkateshwarlu	Member	CRIDA, Santoshnagar, Hyderabad 500 059, Andhra Pradesh, India Ph: 040-2453-0161 Fax: 040-2453-1802 ramakrishna.ys@crida.ernet.in isvas@crida.ernet.in bsreddy@crida.ernet.in aravikant@crida.ernet.in grkorwar@crida.ernet.in
4	IICT	Dr Ahmed Kamal	Member	Indian Institute of Chemical Technology, Hyderabad - 500 007, AP, India Ph: 040-2716-0123 Fax: 040-2719-3370 ahmedkamal@iict.res.in cgkumar@iictnet.org
5	ILRI	Dr Michael Blümmel	Member	ILRI, C/o ICRISAT, Patancheru PO 502 324, AP, India Ph: 040-3071-3653 Fax: 040-3071-3074, m.blummel@cgiar.org
6	SVVU	Dr Y Ramana Reddy	Member	Department of Animal Nutrition, College of Veterinary Sciences, Rajendranagar, Hyderabad 500 030, Andhra Pradesh, India Tel: 2374-6032, Cell: 98850-51280 Email: dvgkmohan@rediffmail.com ramanayr19@yahoo.co.in
7	Rusni	Mr AR Palaniswamy	Member	Rusni Distilleries Pvt Ltd.,411 HIG, BHEL, RC Puram, Hyderabad 502 032, AP, India Phone: 040-2302-5310 Email: rusnispirit@rediffmail.com
8	ICRISAT	Dr SP Wani	Member	GT Agroecosystems ICRISAT, Patancheru 502 324, Andhra Pradesh, India Phone: 040-3071-3466 Fax: 040-3071-3074/3075

12. Consortium Monitoring Unit (CMU)

S. No.	Consortium partners	Name of the committee member	Designation	Full address with phone, fax and e-mail
1	ICRISAT	Dr Belum VS Reddy	Chairman	ICRISAT, Patancheru 502 324, Andhra Pradesh, India Ph: 040-3071-3487 Fax: 040-3071-3074/3075 b.reddy@cgiar.org a.ashokkumar@cgiar.org
2	NRCS	Dr SS Rao	Member	National Research Centre for Sorghum (NRCS), Rajendranagar, Hyderabad 500 030, AP, India Ph: 040-2401-5225, 2401-5349 Fax: 040-2401-6378 ssrao@nrcsorghum.res.in
3	ICRISAT	P Parthasarathy Rao	Member	Principal Scientist (Economics), ICRISAT, Patancheru 502 324, Andhra Pradesh, India Phone: 040-3071-3510 Fax: 040-3071-3074/3075

13. Value chain model for bioethanol production

a. Methodologies

For developing the value chain model, we will be adopting innovative strategies to address all the issues holistically by harnessing the strengths and synergies of consortium partners. The concerns of all the stakeholders will be addressed to ensure that the value chain becomes stronger and successful. The farmers' participation and collective action is the core of the value chain development.

Farmers participatory multilocational testing for identification of suitable high sugar and grain yielding cultivars, increasing the harvest window, organizing the farmers' groups, input (seed and fertilizers) supply, technical backstopping, micro-entrepreneurship development in villages, linking farmers to markets, providing for better utilization of by-products, and capacity enhancement of stakeholders are the major innovations aimed at in the project.The strategy will be people-centric and environment-friendly.

Farmer in sweet sorghum field.

b. Innovations

Following specific innovations form the pillars of the strategy in the value chain development.

- Holistic systems approach encompassing 'seed to tank', to give a sustainable and up scalable 'sweet sorghum ethanol' model
- Use of whole plant for processing and value addition
- Participatory Research and Development (PR&D)
- Training and human resource development by adopting knowledge management and sharing systems
- Use of ICT to enhance the reach
- 4 Cs and 4 Es
  Consortium, Convergence, Collective action and Capacity building
  Equity, Environment protection, Efficiency and Economic benefits
- Research mediated value chain as we will undertake strategic research for identifying new valuable by-products as well as continually strive for increasing efficiency of operations
- Unique partnership of agricultural scientists with basic science scientists, engineers, industries, government departments, development agents and farmers to harness the benefits from "Genes to Engines" through value chain of ethanol produced from sweet sorghum
- Decentralized crushing approach to reach scale of operations to have decentralized micro-entrepreneurship development in villages and ensuring stable feedstock supply to the distillery.

c. Holistic approach for whole plant utilization of sweet sorghum

The project aims at the whole plant utilization of sweet sorghum according to the demand of raw materials and by-products drawn from the plant. Introduction of decentralized model of extracting juice at the community level leaves large quantities of by-products like leaves and bagasse in the village. The by-products can be utilized either for making feed for the animals, compost or co-generation. This ultimately leads to a win-win situation wherein the farmer gets more income from his produce and the industry gets the feedstock at a cheaper rate, in addition to the environmental benefits. The scale of operation will generate large quantities of by-products opening up new vistas for identifying new value added products such as fodder, feed, compost or source of bioenergy through biogas production or directly as fuel.

Crushing stalks to extract juice.

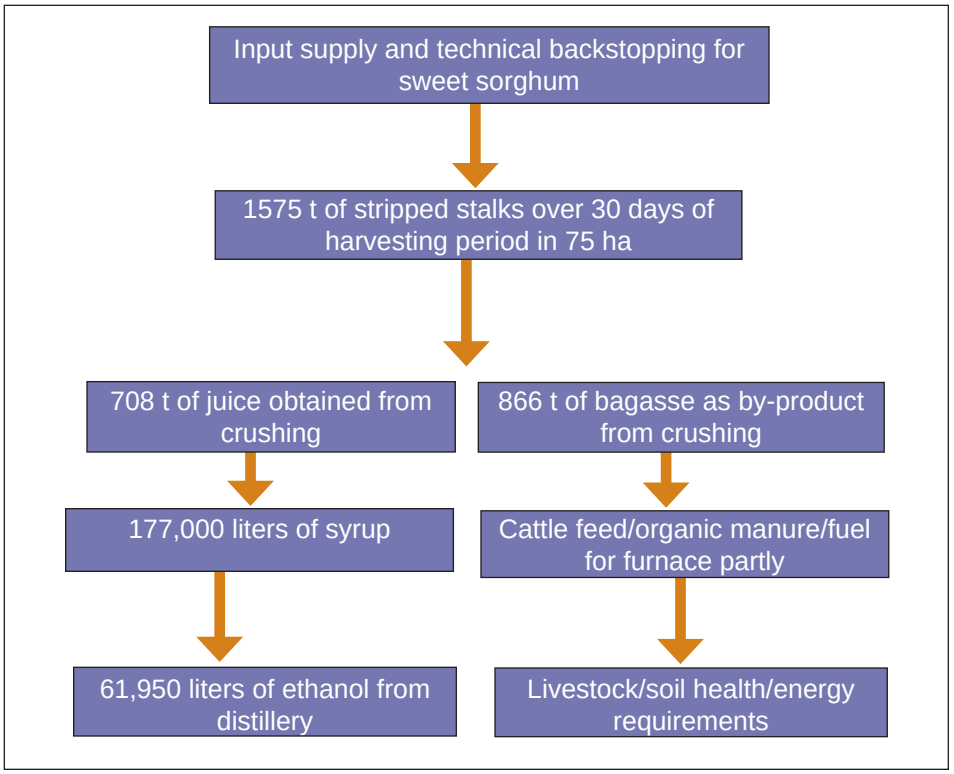
Value chain model: Through the innovative 'seed to tank' approach, value is added to the sweet sorghum bioethanol production process through decentralized crushing units, community seed systems, input supply, technical backstopping, credit and market linkages. The issues and interventions are shown in the flowcharts.

The Seed-to-Tank approach encompassing the identification of areas for sweet sorghum production, suitable cultivars through on-farm trials, increasing the harvest window, establishment of decentralized crushing cum syrup making units, organizing the farmers and linking them to decentralized syrup units and distillery, linking the farmers to input agencies, refinement of machinery for large scale cultivation, increasing the shelf life of juice and efficiency of processing, most economic and efficient utilization of by-products, micro-entrepreneurship development and capacity enhancement form the core components of the project. The project aims at demonstrating a successful model for up and out scaling the sweet sorghum cultivation for ethanol production to increase the farmers' incomes, reduce the environmental pollution without compromising the food or fodder needs of farmers. This paves way for the most efficient whole plant utilization of sorghum, one of the most promising crops for the tropics particularly in the light of climate change. The project intends to increase the area of sweet sorghum cultivation up to 5000 acres by the end of the project, directly benefiting at least 2000 farmers.

14. Establishment of decentralized crushing unit

A group of villages in Medak district, located more than 50 km away from Rusni Distilleries were identified for establishing decentralized syrup units for extracting the juice and making syrup. The syrup will be supplied to Rusni Distilleries for ethanol production and the by-products (mainly bagasse) from the sweet sorghum will be realized by the communities themselves. Setting up of decentralized units enable the farmers located far away from the distillery to benefit from the new market opportunities. It also encourages micro-entrepreneurship among the beneficiaries, linking them to the industry for sustainable livelihoods.

An area of 75 ha is targeted to begin with to demonstrate a viable and up scalable value chain model. Suitable sweet sorghum based cropping systems in the target clusters will be designed for both rainy, postrainy and summer seasons based on the soil type, rainfall and irrigation potential. It is assumed that stripped stalks are produced from 2250 t of green stalks from 75 ha having average productivity of 30 t per ha, spread over 30 days of harvesting period over a single cropping season.



Supply chain management.

Leaf stripping.

Boiling the syrup in a pan.

Centralized growers model linking with distillery

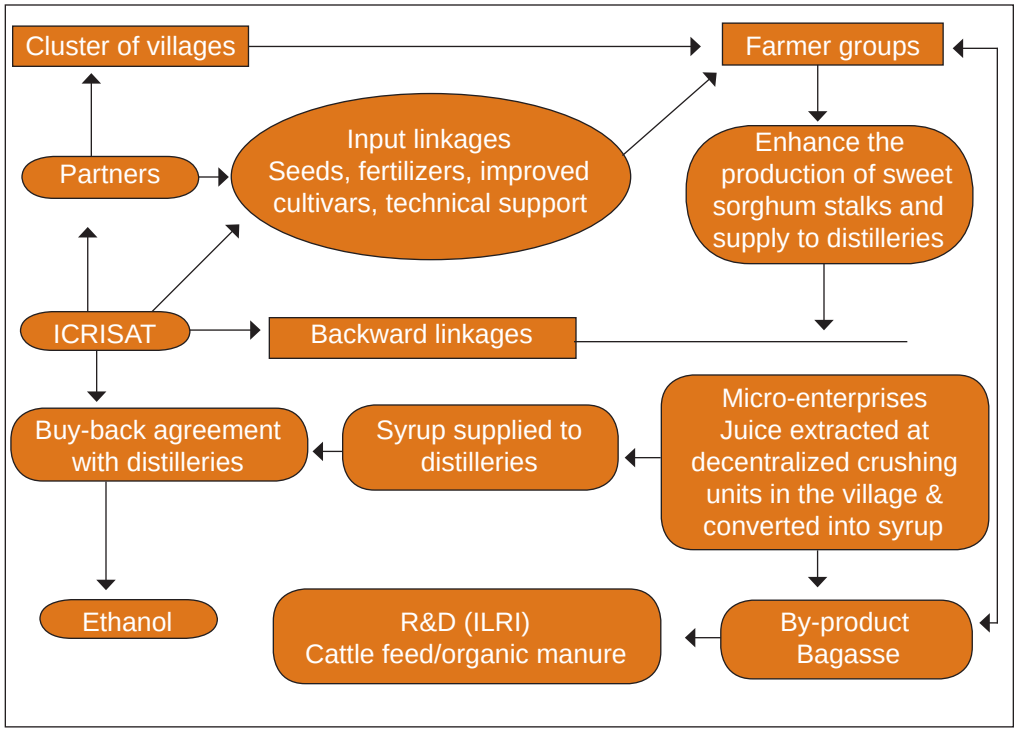
A cluster of villages covering an area of 500 ha under sweet sorghum cultivation will be targeted in the radius of 50 km from the distillery to transfer raw materials (stalks) to the distillery within 24 hours of harvesting to prevent losses in juice recovery and quality. Rusni will enter into a buy-back agreement with farmers to purchase the stalks at an agreed cost (currently it is Rs 600 t^{-1} of green stalk). Technical backstopping and input supply will be carried out to maximize the production. The growers' model will be used for scheduling of feedstock supply to the industry during different crop seasons and multilocational on-farm evaluation for identifying suitable sweet sorghum cultivars and agronomic manipulation to increase the harvest window.

Growers linked to decentralized crushing units and distillery

In the villages with decentralized crushing units, Rusni will enter into buy-back agreement with farmers to purchase the syrup. The crushing units, pans and chulas (fireplaces) for syrup making standardized by the Indian Institute of Sugarcane Research in collaboration with the Indian Institute of Petroleum have been established under this project. The equipment are operated by farmers' groups themselves. Project staff will be placed in the village to take care of the maintenance and operations. Input supply and technical backstopping is also provided to maximize the production. The stalks are harvested at appropriate stage and crushed to extract

the juice. The juice obtained from crushing is boiled in pans for syrup production. Based on the buy-back agreement, Rusni Distilleries will purchase the syrup. The bagasse is handed over to respective farmers for their own use. The syrup will be transported to Rusni for ethanol production. The transport costs are borne by Rusni. The syrup produced in decentralized units is storable for 9 months without any deterioration. The volume of the feedstocks transported to the distillery is considerably reduced in the form of syrup compared to stalks. Each decentralized model provides regular employment to 5-6 people during the crushing season. Small and marginal farmers form the core of the farmer group. Participation of women is ensured in all the operations. Upon the success of the model, efforts will be made to expand the area up to 200 ha per decentralized unit. Similarly, micro-entrepreneurship will be encouraged in villages for establishing such units. The experiences of the model will be shared with the farmers, bankers and policy makers for up and out scaling.

Rusni Distilleries production capacity being 40 KLPD, needs 6500 ha area to supply enough feedstocks for continuous production in a year (300 days as stipulated by law). The centralized model alone cannot meet this requirement. Availability of water in the postrainy and summer season is very important. The decentralized model has all the strengths and advantages to compliment the supply of feedstocks over a longer period of time. Thus, a combination of centralized and decentralized models ensures continuous supply of feedstocks to the distillery leading to a win-win situation wherein both farmers and entrepreneurs are benefited. This ultimately contributes to energy security and environmental protection.



Backward linkages of the NAIP sweet sorghum value chain project.

In both the models, CRIDA and Rusni are working on mechanizing the sweet sorghum cultivation and leaf stripping. Biochemical studies on the juice storability and genotypic differences for fermentation efficiency will be carried out by IICT.

Community seed systems will be promoted to avail quality seeds of sweet sorghum at the right time and affordable prices for the resource poor farmers. The system will reduce the dependence on external seed sources and encourages village level trade, improving village economy. The breeder seeds will be supplied to the communities from the project for seed multiplication and seed bank groups (micro-entrepreneurs) will be trained to assess seed quality, storage, purchase and selling procedures. Farmers will be trained to produce quality seed of sweet sorghum to ensure quality seed supply as well as to earn an additional income. The "Seed-to-Tank" approach will be adopted, which involves production, processing, value chain for main and by-products, and consumption spectrum.

Success of the model

The decentralized model has all the strengths and advantages to supply the feedstocks over a longer period of time. Each decentralized model will provide regular employment to 5-6 people during the crushing season. Small and marginal farmers form the core of the target farmer group and benefit the most, and participation of women is ensured in all the operations encouraging women empowerment. Upon the success of the model, efforts will be made to expand the area under the decentralized syrup unit. Similarly, micro-entrepreneurship will be encouraged in villages for establishing such units. The experiences of the model will be shared with farmers, bankers and policy makers for scaling up and out.

About ICRISAT

ICRISAT
Science with a human face

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).

Company Information

ICRISAT-Patancheru
(Headquarters)
Patancheru 502 324
Andhra Pradesh, India
Tel +91 40 30713071
Fax +91 40 30713074
icrisat@cgiar.org

ICRISAT-Liaison Office
CG Centers Block
NASC Complex
Dev Prakash Shastri Marg
New Delhi 110 012, India
Tel +91 11 32472306 to 08
Fax +91 11 25841294

ICRISAT-Nairobi
(Regional hub ESA)
PO Box 39063, Nairobi, Kenya
Tel +254 20 7224550
Fax +254 20 7224001
icrisat-nairobi@cgiar.org

ICRISAT-Niamey
(Regional hub WCA)
BP 12404, Niamey, Niger (Via Paris)
Tel +227 20722529, 20722725
Fax +227 20734329
icrisatsc@cgiar.org

ICRISAT-Bamako
BP 320
Bamako, Mali
Tel +223 2223375
Fax +223 2228683
icrisat-w-mali@cgiar.org

ICRISAT-Bulawayo
Matopos Research Station
PO Box 776,
Bulawayo, Zimbabwe
Tel +263 83 8311 to 15
Fax +263 83 8253/8307
icrisatzw@cgiar.org

ICRISAT-Lilongwe
Chitedze Agricultural Research Station
PO Box 1096
Lilongwe, Malawi
Tel +265 1 707297/071/067/057
Fax +265 1 707298
icrisat-malawi@cgiar.org

ICRISAT-Maputo
c/o IIAM, Av. das FPLM No 2698
Caixa Postal 1906
Maputo, Mozambique
Tel +258 21 461657
Fax +258 21 461581
icrisatmoz@panintra.com

www.icrisat.org

331-2008