Chapter I: Sweet sorghum for ethanol: A new beginning

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I. Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is an important dryland cereal grown in India (7.8 million ha) and around the world (45.8 million ha) for food, feed, fodder, bioenergy and fiber. Sweet sorghum is similar to grain sorghum and are generally tall (3.0-4.0 m), late maturing (20-30 days) and relatively photoperiod-sensitive; produce 2-3 t ha^{-1} grain yield with higher stalk yields (50-60 t ha^{-1} of fresh biomass).

Sweet sorghum is a new generation bioenergy crop that has potential to accumulate sugar (10-15%) in its stalk similar to sugarcane, apart from producing grains. The bagasse, remnant stalk after extraction of juice, can be used as animal feed or for vermicomposting to generate power. The crop has the ability to adapt to various agro-climatic conditions and reasonably tolerates drought and saline-alkaline conditions. The crop is raised from seed and is of shorter duration (115-120 days) than sugarcane (12-18 months) making it amenable for multiple cropping systems. Water use or seasonal evapotranspiration (ET) for sorghum is 508 mm while it is 1257 mm for sugarcane. Water requirement of this crop is one-third that of sugarcane on a comparable time scale. Also, sweet sorghum requires about 22% less water than maize. With these advantages, sweet sorghum is a good bioenergy crop and can complement the available feedstocks for biofuel production.

For use as a biofuel feedstock, it is important to choose appropriate cultivars of sweet sorghum and follow improved crop management practices to achieve higher yields. The distillery/industry should develop a command area for supply of raw material. Sweet sorghum cultivation on a commercial scale is yet to pick up speed in India and other countries.

The uncertainty of the fossil fuel supplies, sharp escalation of international crude oil prices, and the need to protect the environment has forced several countries to look for renewable energy, especially for transportation fuels. Ethanol is the most popular biofuel used either directly or blended with

gasoline for fueling automobile engines. Use of sugarcane, corn, sugar beet and cassava for large-scale ethanol production is a common practice. There are, however, concerns about the future of the biofuel program since there is an apprehension that these feedstock intensive programs will reduce the availability of grains for human consumption or take up land that could be used for food production in the face of policy induced demand for biofuels, leading to food and feed insecurity. Sweet sorghum is a crop of great potential that can overcome some of these concerns related to food, fuel and fodder security and rising grain prices since it produces sugar-rich stalks for ethanol production without sacrificing grain production. Sweet sorghum produces food/feed, fodder and fuel, without significant tradeoffs in any of these uses in the production cycle. Under NAIP Component 2, an innovative Ethanol Value Chain Model involving sweet sorghum development for ethanol production was undertaken with collective action, of public–private sectors partnership and involvement of farmers' groups in the value chain.

II. Project objectives

- Assess economic and environmental viability, enabling policies and institutions for promoting cultivation of sweet sorghum for bioethanol production and its impact on environment, rural incomes, livelihoods and social capital development.
- Develop and establish pilot-scale Public-Private-People-Partnerships (PPPPs) value chain bioethanol enterprise models through 'Seed-to-Tank' approach encompassing sweet sorghum production, processing, value addition, marketing and protecting the environment.
- 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.
- Fine-tuning a package of practices for increased harvest window, mechanization and development of protocols for by-product utilization.
- Capacity building and skill development of all the stakeholders including rural communities in the enhanced sweet sorghum production and value chain for bioethanol production.

III. Project rationale

The available energy sources fail to meet the energy needs of the world's poor with 2.4 billion people relying on traditional biomass for energy and 1.6 billion people not having any access to electricity. At the same time, awareness has grown across the world about the impact of human energy consumption and land-use changes on our environment through increased release of greenhouse gases (GHG).

With the growing economy and improved living standards, India needs annually about 175 million metric tons (MMT) of petrol, and 60% of it is imported. Increasing fossil fuel consumption and associated contribution to increasing of GHGs concentration by developing countries like China, India and Brazil has become a point of contention during the G8 discussions on putting a mechanism in place for GHG emission-reduction plans by 2012, when the Kyoto protocol expires.

Globally there are efforts to develop a sustainable bio-energy framework, and international agencies such as UN-Energy7 have identified a framework for addressing sustainability issues. UN-Energy uses the definition of sustainable development adopted by the UN Commission on Sustainable Development (SD) ie, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". UN-Energy has identified nine key sustainability issues facing bio-energy development:

- The ability of modern bioenergy to provide energy services for the poor;
- Implications for agro-industrial development and job creation;
- Health and gender implications;
- Implications for the structure of agriculture;
- Implications for food security;
- Implications for government budget;
- Implications for trade, foreign exchange balances, and energy security;
- Impacts on biodiversity and natural resource management; and
- Implications for climate change.

The proposed project has all elements to make it a sustainable bio-energy option to increase the incomes of the rural poor without sacrificing food and fodder security while protecting the environment. When the project is implemented it is expected to bring about the following outcomes.

- The ethanol produced from sweet sorghum can be used for blending with petrol and will contribute to energy security.
- The commercialization of technology will lead to establishment of large scale agro-industries particularly the ethanol distilleries, refineries and micro-entrepreneurship in villages.
- It will improve general health by reducing the pollution both during processing and utilization, and will empower women by involving them in production and processing.
- Incomes from agriculture will increase through strong crop-livestock integration.
- There will be enhanced food production with the better availability of superior genotypes, better management, seeds and other inputs.
- The government's import bills on fossil fuels will be reduced.
- There will be an increase of the area under sorghum; many new sweet sorghum cultivars will be used in feedstock production thereby increasing biodiversity. Being a C_4 crop with high water use efficiency, sweet sorghum can be cultivated without a drain on natural resources.
- Sweet sorghum being a CO_2 neutral crop (also during production, processing and utilization), its cultivation protects the environment without adding any extra CO_2 through ethanol combustion than the CO_2, it sequesters during photosynthesis. Thus the crop and the proposed value chain development will contribute to overall improvement of incomes, employment generation, food and energy availability and environmental protection.

The Government of India's (GOI) policy calls for mandatory blending of petrol with ethanol @ 5% by 2006 and 10% by 2008. This has already created huge demand for ethanol and the demand is likely to increase with the increased percentage of blending and increase in usage of fuels. The vast demand for biofuels accompanied by the enabling policies has triggered the industries to undertake bioethanol production. ICRISAT pioneered the Public-Private-People Partnership (PPPP) initiative with bioethanol and biodiesel producing companies in Andhra Pradesh (AP). For bioethanol, sorghum researchers at ICRISAT in collaboration with partners in India have identified a number of lines of sweet sorghum with high brix content varying from 16-23% and high biomass production.

The new cultivars bred by Indian partners, eg, SSV 84, SSV 74 and NSSH 104 have already been released for sweet sorghum cultivation. ICRISAT in partnership with national agricultural research services (NARS) is already testing sweet sorghum lines with high sugar content and juice yield in India, the Philippines and Uganda.

ICRISAT has incubated sweet sorghum ethanol production with Rusni Distilleries through its Agri-Business Incubator. Rusni is a 40 kilo liters per day (KLPD) unit located in Medak district of Andhra Pradesh (25 km from ICRISAT). It is the world's first sweet sorghum based ethanol production distillery. It is a multi-feedstock processing unit and can use other feedstocks like broken/damaged grain, cassava, sugarcane, cashew-apple and mahua. The ethanol production process is patented. Commercial ethanol production commenced at Rusni during June 2007.

IV. The approach

Strategic interventions were jointly made by ICRISAT and the consortium partners to train the farmers, build their technical capabilities and further provide them with information on improved crop production practices to enhance the yields per unit area. Institutional linkages with various actors in supply and market chains helped the farmers in reducing the overall production and postharvest handling costs. However, it is a well-known phenomenon that the farmers in the absence of sufficient funds for crop production and technology fail to enhance overall productivity and improve their livelihoods.

Traditional approaches to agricultural research and technology development assumed a flow of science-based knowledge transfer from researchers to farmers. This approach did not capture the complex relationships among researchers, farmers, government, civil society, extension workers, donors, universities and private sectors, nor the factors that condition successful development and utilization of research outputs. Integrated market oriented development and innovation system concepts are now gaining popularity as a framework for analysis on how knowledge is generated and used. The stakeholders in an innovation system seek relationship to improve their knowledge and make changes in their practices, resulting in development of new methods and materials, or adaptation of ideas and practices.

1. Project implementation through the consortium approach

- The project adopted an innovation consortium approach between sorghum scientists, economists, fodder scientists, feed manufactures, agro engineering scientists, seed industry, sorghum growing farmers, NGOs and other community-based organizations (Fig. 1).
- Farmers were trained in the use of improved crop production technologies, for enhancing productivity of stalks for ethanol production and grain for food and bagasse for fodder, meeting all requirements of small-scale farmers.
- The Farmers' Associations were formed and linked with input and credit agencies.

2. Consortium approach imperatives and sustainability

Under this arrangement the joint efforts of all the partners were synchronized to meet the overall goal of raising the incomes of small-scale sweet sorghum producers. The sustainability of the project is being ensured by institutionalizing the linkages created under the project:

- Institutionalizing the Farmers' Associations
- Strengthening infrastructure facilities

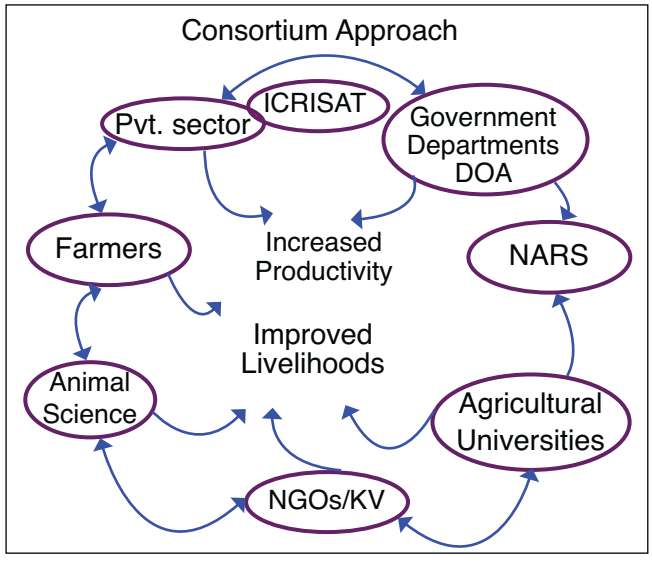

Fig. 1. Consortium approach flow diagram.

- Further training of farmer representatives on production technologies and operation and management of decentralized crushing units (DCU)
- Strengthening marketing linkages through agreements with distillery for supply of stalks and for syrup

3. Essential elements to maintain strong coherence

Promoting strong coherence among the consortium partners involves adoption of principles and practices of give and take between the partners for the overall benefit of the target community. The approach used was decentralization of responsibilities for implementation.

The following elements were promoted in the consortium to maintain a strong coherence among the stakeholders:

- There was a common trust among stakeholders that institutions working with them (ICRISAT & partners) have a credible commitment to the livelihood improvement of small-scale farmers in the SAT region.
- Although stakeholders (consortium partners) came from different backgrounds, they evened out the differences in language, orientation, culture and ideology.
- Clearly stated work plans designed and delineated responsibilities with budgetary allocations and timeline.

The approach involves investigating and strengthening the institutional context of the research undertaken, with a view to building human capital and local innovation system capacity. The focus of the consortium type project is specified in broad development terms (rather than narrow scientific terms) so as to articulate the identified problem in a way that includes the interests of both non-scientific as well as scientific stakeholders.

V. Partnerships

1. Multi-stakeholder consortium partnership

The multi-stakeholder consortium partnership (Fig. 1) initiative was taken up from its inception to building public-private-people-partnerships (PPPP) to help reach the goals by better harnessing the capacities, capabilities and

technologies available with partner organizations, towards making sweet sorghum a commercially viable supplement feedstock for ethanol production.

Many institutions (Table 1) have been partners in this project. The institutions involved in the multi-stakeholder consortium include farmers associations, NGOs, private sector companies (crusher manufacturers and seed companies), public sector organizations – national research institutions, agricultural and veterinary universities, along with ICRISAT as Project Executing Agency.

Table 1. Consortium partners

S. No.	Consortium Partners	Name of the CoPIs	Designation	Full address with Phone Fax and Email
1	ICRISAT	Dr Belum VS Reddy, Consortium Principal Investigator	Principal Scientist (Breeding)	ICRISAT, Patancheru, 502 324, Andhra Pradesh Ph: 040-30713487 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: 040-24015225; Fax: 040-24016378 ssrao@nrcsorghum.res.in
3	CRIDA	Dr Venkateswarulu	Director	CRIDA, Santoshnagar, Hyderabad 500 059 Ph: 040-24530161; Fax: 040-24531802. isvas@crida.ernet.in grkorwar@crida.ernet.in
4	IICT	Dr Ahmed Kamal	Scientist	Indian Institute of Chemical Technology, Hyderabad - 500 007 Ph: 040-27160123; Fax: 040-27193370. ahmedkamal@iict.res.in cgkumar@iictnet.org

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Table 1. Consortium partners

S. No.	Consortium Partners	Name of the CoPIs	Designation	Full address with Phone Fax and Email
5	ILRI	Dr Michael Blummel	Principal Scientist, Animal Nutrition	ILRI, C/o ICRISAT, Patancheru PO 502 324 (AP) Ph: 040-30713653; Fax: 040-30713074. m.blummel@cgiar.org
6	SVVU	Dr Y Ramana Reddy	Associate Professor	Department of Animal Nutrition College of Veterinary Science Rajendranagar; Hyderabad 500 030, AP Ph: 23746032; Mobile: 98850-51280 Email: ramanayr19@yahoo.co.in
7	Rusni Distilleries Pvt. Ltd.	Dr AR Palaniswamy	Managing Director	Rusni Distilleries Pvt Ltd., 411 HIG, BHEL, RC Puram Hyderabad 502 032 Ph: 040-23025310 Email: rusnispirit@rediffmail.com
8	NGO	Mr Subba Rao	CEO	Aakruthi Agricultural Associate of India 6-3-903/A/3, Suryanagar Colony, Raj Bhavan Road, Somajiguda, Hyderabad-500 082 Ph: 040 40038381 Email: aai_aakruthi@yahoo.com

VI. Project implementation

For continuous production of ethanol by the distillery, sweet sorghum feedstock is required on a regular and continuous basis. The farmers can take advantage of the new market opportunity and supply the feedstocks in large quantities on regular basis to the industry through an innovative Value Chain Model that provides linkages between farmers, input dealers and processors. The model

involves collective action and partnership through the production of sweet sorghum and establishment of DCUs in a cluster of villages. Two models developed for centralized and decentralized areas encompassing various project activities such as supply of inputs, technical backstopping and capacity building of stakeholders in various crop production activities, DCU operations and linking farmers to the industry/distillery. The responsibilities of project implementation process have been designated to consortium partners based on the outputs of the project (Table 2).

Table 2. Responsibilities of consortium partners.

Partner	Major responsibilities
ICRISAT	ICRISAT is the consortium leader. The major responsibility of project planning, implementation and reporting lies with it: 1. Baseline characterization, assessment of economic competitiveness of sweet sorghum for bioethanol, documentation and analysis of existing policies 2. Establishment of decentralized crushing units (DCU), 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 feedstocks 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, community-based organizations (CBOs), development personnel and distillers 10. Development of training and information, education and communication (IEC) materials and providing access to self-help groups (SHGs) for these materials.
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

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Table 2. Responsibilities of consortium partners.

Partner	Major responsibilities
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.
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
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
Rusni Distilleries Pvt. Ltd.	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 back stopping 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
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
NGO	1. Selection of farmers in the cluster villages 2. Participation in the selection of cluster villages 3. Facilitate in training programs to farmers and other stakeholders 4. Identification of farmers and supply of seed and fertilizers 5. Facilitation in harvesting and transportation and crushing the stalks at DCU 6. Helping the farmers' associations in book keeping and records of crushing and syrup production.

VII. Project operation area

The criteria behind selecting Medak district in Andhra Pradesh for implementing this project and establishment of DCUs 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 in this area because traditionally sorghum is a popular crop during the rainy and postrainy seasons. 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 provides additional income to the farmers without compromising the food/feed security. Based on the above criteria the Ibrahimbad cluster comprising of seven villages was selected (Table 3) ofter conducting Group discussions with farmers, local leaders and village administration. (Fig. 2 & 3).

Fig. 2. Group discussions with farmers, local leaders and village administration.

Fig. 3. Target Area – Ibrahimbad village, Narsapur Mandal, Medak district in Andhra Pradesh.

Table 3. Details of villages in the Ibrahimbad cluster.	
Village	No. of households
Ibrahimbad	192
Errakuntla Thanda	67
Seethya Thanda	21
Durgam Thanda	20
Umla Thanda	19
Sikindlapur Thanda	123
Lasman Thanda	54
Total	514

VIII. Value chain model for bioethanol production

1. Methodologies

To develop the value chain model (VCM), the methodology is to adopt 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. 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, capacity enhancement of stakeholders are the major innovations aimed in the project. The strategy will be people-centric and environment-friendly.

2. Innovations

These 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 information and communication technology (ICT) to enhance 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, industrialist, government departments, development agencies and farmers to harness the benefits from 'Genes to Engines' through value chain of ethanol produced from sweet sorghum
- Decentralized crushing approach to reach the scale of operations, so as to have decentralized micro-entrepreneurship development in villages and ensuring stable feedstock supply to the distillery

3. Holistic approach for whole plant utilization of sweet sorghum

The project aims at the utilization of the whole sweet sorghum plant according to the demand of its raw materials and by-products. Introduction of decentralized models of extracting juice at the community level leaves large quantities of by-products like leaves and bagasse. The by-products can be utilized either for making feed for 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 lower rate, beside benefits to community and the environment. 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 bio-energy through biogas production or by directly using it as fuel.

4. 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 (Fig. 4).

The seed-to-tank approach is a core component of the project. It encompasses: 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 inputs 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.

The project aims to demonstrate a successful model for up- and out-scaling sweet sorghum cultivation for ethanol production to increase farmers' incomes, reduce

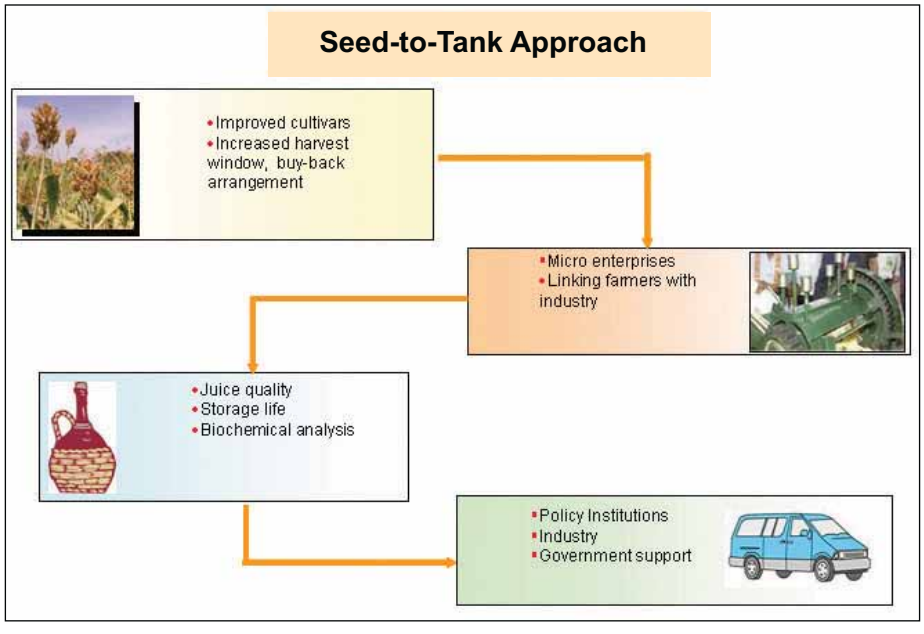

Fig. 4. Line diagram showing sweet sorghum crop from sowing to ethanol production.

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 up to 5000 acres by the end of the project directly benefiting at least 2000 farmers.

IX. Project monitoring and evaluation

Monitoring indicators

Output No.	Outputs/Activity	Monitoring indicator
1.1	***Economic and environmental assessment of sweet sorghum for ethanol completed*** 1.1.1 Baseline characterization (bio-physical and socio-economic) of the target areas (ICRISAT)	Database and survey report
	1.1.2 Assess economic competitiveness of sweet sorghum as a feedstock for bioethanol with other crops like maize, sugarcane and cassava, and the economics of sweet sorghum cultivation vis-à-vis crops replaced (ICRISAT, NRCS)	Database and reports
1.2	***Enabling policy and institutional mechanisms for sweet sorghum ethanol model documented*** 1.2.1 Documentation and analysis of the existing policies and institutional mechanisms in sweet sorghum ethanol technology (ICRISAT, NRCS)	Policy briefs and reports
2.1	***Pilot model of decentralized crushing cum syrup making unit encompassing*** 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
	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
	2.1.3 Linking farmers to decentralized units and processing industry (ICRISAT)	No. of farmers linked to decentralized units and distillery

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Output No.	Outputs/Activity	Monitoring indicator
2.2	***Learnings from the innovative and pilot value-chain model of bioethanol production from sweet sorghum documented***	Documentation reports
	2.2.1 Process documentation built-in in the pilot model system to identify strengths, weaknesses, opportunities and threats of the model (ICRISAT)	
	2.2.2 Content development of the model to be used as inputs for outputs 1.2 and 5.2 (ICRISAT)	Content development manual
3.1	***Promising sweet sorghum cultivars for target region identified***	Number of varieties and hybrids identified
	3.1.1 Identification of varieties, hybrid parents and hybrids through multi-location on-farm testing and farmers' participatory cultivar selection (ICRISAT, NRCS)	
	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
3.2	***Seed and other inputs supply systems for large scale sweet sorghum cultivation established***	No. of institutional mechanisms identified and no. of farmers benefited
	3.2.1 Developing institutional mechanisms for supply of inputs like seed, fertilisers, machinery etc. (ICRISAT)	
	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
4.1	***Production package for increasing the harvest window developed***	Mapping of the area for different planting dates; Enhanced period of feedstock availability
	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)	

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Output No.	Outputs/Activity	Monitoring indicator
	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)	Data base and model validated for sweet sorghum; mapping of potential areas in AP for sweet sorghum
4.2	***Mechanized crop production methods and protocols for by-product utilization developed***	Refined harvesting and leaf stripping machines available for use on the field
	4.2.1 Evaluation and refinement of suitable machines for harvesting leaf/sheath stripping and crushing (CRIDA, Rusni)	
	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.
5.1	***Enhanced capacities of various stakeholders to maximize the productivity and profitability of value chain achieved***	Number of training programs conducted and number of farmer groups and CBOs trained
	5.1.1Training of farmer groups and CBOs for micro-entrepreneurship and management practices to increase the harvest window (ICRISAT, NRCS, Rusni, CRIDA)	
	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
5.2	***Training material (manuals, protocols and audio video material) on sweet sorghum ethanol production made available***	Number of training materials developed and popularized according to users
	5.2.1 Development and popularization of training materials to suit various interest groups (ICRISAT, NRCS, CRIDA)	
5.2.2	Provision of access to these materials to SHGs and other interest groups (ICRISAT)	Number of farmers using training material

2. Consortium Advisory Committee (CAC)

S. No.	Name of the Chairman/Member	Address	Contact
1	Dr ST Borikar Chairman	102, Saraswatinagar, Parbhani 431 401, Maharashtra	stborikar@rediffmail.com; Tel: 02452-223920; 09422177432
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3	Dr RV Vidyabhushanam Member (Scientist)	74, Sriramnagar Colony, SR Nagar, Hyderabad 500 038, AP	Tel: 040-23817590; 09989069010
4	Mr B Kimlal Member (Farmer)	House No. 4-13, Thanda/ Village: Gongular, Mandal: Pulkal, District: Medak, AP	
5	Mr B Narsimhulu, S/o Mr Istari Member (Farmer)	House No. 1-87, Village: Gunthapally, Mandal: Kondapur 502 295, District: Medak, AP	
6	Mr P Balakrishna Reddy Member (Farmer)	House No. 1-78, Village: Gunthapally, Mandal: Kondapur, District: Medak, AP	
7	Mr Manne Narasimlu Member (Farmer)	House No. 1-47/2, Village: Posanpally, Post: Choutakur, Mandal: Pulkar, District: Medak, AP	
8	Ms K Nagamani Member (Farmer)	House No. 3-96, Village: Danampally, Mandal: Andoi, District: Medak, AP	09347353125
9	Prof. Jitendra Mittal member	National Coordinator National Agricultural Innovation Project (NAIP) Project Implementation Unit 515 KAB-II, IARI Campus, Pusa, New Delhi 110 012	jpm@naip@hotmail.com; Tel: 011-25848709, -25848772; Fax: 011-25848709, -25843403

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10	Dr CLL Gowda Member	Leader–Global Theme on Crop Improvement, ICRISAT Patancheru 502 324, AP	c.gowda@cgiar.org; Tel: 040-30713354 Fax: 040-30713074, -30713075; 09849053475
11	Dr Belum VS Reddy Member Secretary	Principal Scientist (Breeding) Global Theme on Crop Improvemenet ICRISAT, Patancheru 502 324, AP	b.reddy@cgiar.org; Tel: 040-30713487 Fax: 040-30713074; 30713075; 09989057535

3. Consortium Implementing Committee (CIC)

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