Policy Paper for HOPE Project milestone 1.1.5 in South Asia

Policy Brief on Future Outlook and Options for Target Crops: The Sorghum and Pearl millet economy of India

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POLICY BRIEF ON FUTURE OUTLOOK AND OPTIONS FOR TARGET CROPS: The Sorghum and Pearl millet economy of India[1]

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Preamble:

More than 60 percent of the area in India is cultivated under arid and semiarid conditions which provide around 40 percent of the food production. Farmers here are exposed to harsh agro climatic conditions, as they have to cultivate shallow and poor soils, under drought prone conditions receiving low and erratic rainfall below 600 mm. Recurrent drought coupled with frequent dry spells further exacerbate the situation. In the last few decades these regions are facing a shrinking natural resource base and land degradation, resulting in low productivity in crop and livestock sector. This in turn is contributing to poverty, malnutrition and indebtedness of small holder farm families. More than 70 per cent of the land holdings belong to small and marginal farmers (below 2ha), which is further shrinking due to extensive subdivision and fragmentation of holdings constraining mechanization and scale economies. The resulting drudgery and impoverishment of farmers and farm women are apparent.

Excessive dependence on rice and wheat:

Excessive dependence on rice and wheat for food self-sufficiency has not only made food security fragile, but also has shrunken the diversity of food basket. In order to alleviate this problem and to make food more nutritional, healthy and affordable, coarse cereals like pearl millet and sorghum deserve to be promoted in the wake of climate change. Millets (pearl millet , finger millet) are grown on 35.46 million hectares in the world producing 28.52 million tonnes, of which India shares around 60 % of area and output being the largest producer and consumer of millets. Millets are staple diets of farm households in the arid and semi-arid regions and offer food security to humans and livestock

In India, both sorghum and pearl millet are cultivated as dual purpose crops in over 9.3 and 8.3 m ha ranking third and fourth position among total cereals respectively

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(Yadav O P *et al* 2011). Sorghum is widely cultivated both during rainy and post-rainy season in the regions of central and western parts of Maharashtra, Northern regions of Karnataka, Andhra Pradesh and Tamil Nadu, while pearl millet is produced in Rajasthan, Gujarat, Maharashtra, Uttar Pradesh and Haryana. Besides grain, millet and sorghum stover are an important feed for livestock especially when other feed resources are in short supply. The sorghum grain produced during post rainy season is from local and improved land races of superior quality (bold, white in colour and sweeter taste) and hence preferred for consumption. On the contrary, sorghum produced in the kharif is from hybrids with poor grain quality and less preferred for human consumption. About 50 % of kharif produce is utilized for alternative uses like poultry feed, alcohol and animal feed, while post rainy season sorghum is exclusively used as food and not utilized for alternative uses owing to higher prices by 20–40% compared to rainy season sorghum and thus uneconomical for alternative uses (Parthasarathy Rao *et al*, 2010). Pearl millet on the other hand, apart from being used as food, is also used as poultry and animal feed, manufacture of alcohol and health foods.

Limited crop choice in harsh environments:

In marginal environments under arid and semiarid harsh conditions, the cropping choice is restricted due to moisture stress, low soil fertility, poor and saline soils and lack of assured sources of irrigation. Millets like sorghum and pearl millet besides some minor millets are the only hardy crops that thrive in such adverse agro-ecological situations and are less risky for production. Thus, the choice for substitute crops is limited. Hence millets continue to occupy a prime place in small holder systems in arid and semi arid regions providing employment, income and food for human consumption and feed for livestock.

Advantages of growing millets in the dry areas:

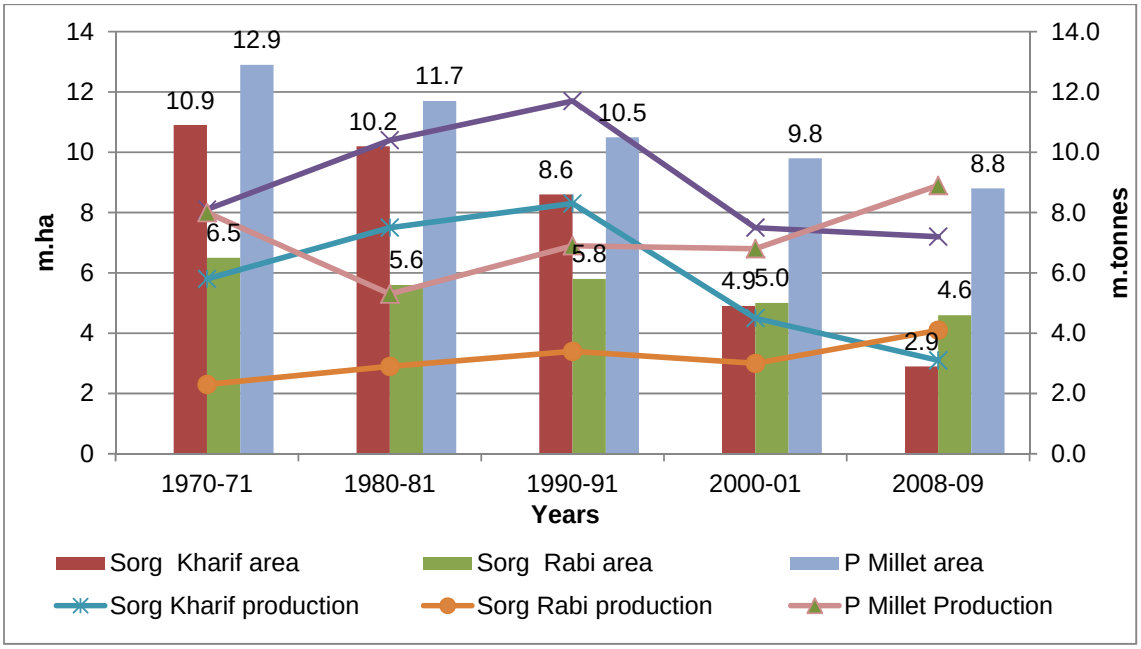
In the rainfed regions of the country, millets form the staple diet of a majority of the poor/ small holders. The advantages of growing millets include: a) They are low external input using, dryland, drought tolerant, sturdy, short duration, low labor utilizing crops resistant to pests and diseases meeting food, nutrition and fodder requirements, b) Millets are C4 crops having carbon fixing properties (climate change compliant).Further, in view of moisture stress, millets are the best alternatives for extreme weather and well suited to the drought

prone regions, c) The most important aspects of millets are its nutritional quality as food for the poor people. They are the richest source of nutrition especially iron, calcium and zinc among cereals and hence can provide all the nutrients at the least cost compared to wheat and rice (Parthasarathy *et al* 2006). d) The crop residue of coarse cereals like sorghum and millet forms an important component of feed for livestock (Parthasarathy and Hall 2003). Despite these advantages, due to lack of economic incentives, millets have been relegated as inferior crops in the country.

Focus:

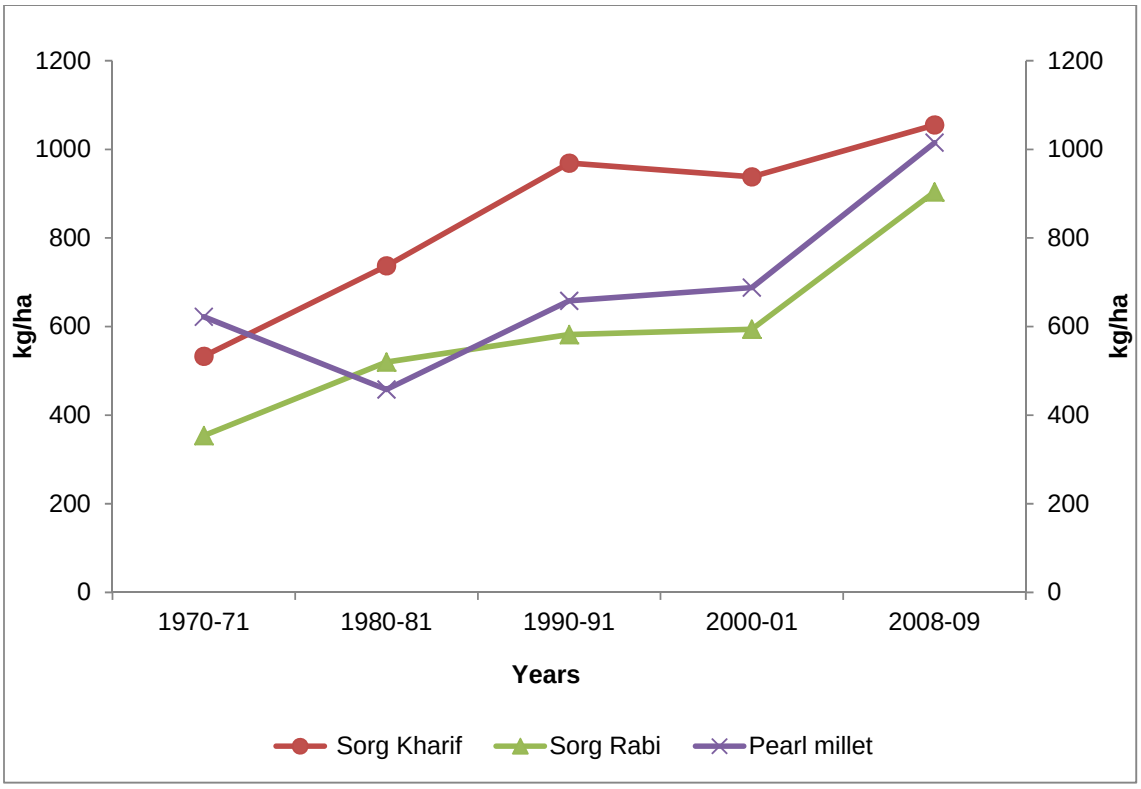
Considering the vital role of millets in the food basket and livestock economy an economic analysis leading to policy steps towards promoting these crops is critical. This policy brief mainly focuses on pearl millet and sorghum economy, analysing the growth trends, consumption trends and identifying the constraints in enhancing productivity growth, identifying potential areas for future investment, markets and policy options.

Figure1: Area and production of Sorghum and Pearl Millet in India, 1970-71 to 2008-2009



Source: Economic Survey, GOI 2010.

Figure3. Productivity trend of Sorghum (in kharif and rabi season) and Pearl millet in India during 1970-71 to 2008-09 (kg/ha)



Area, Production and Productivity trends

Total sorghum area (*kharif* and *rabi* seasons) has shrunk over time by 52 % since India's independence registering a negative growth rate of -1.23. The Kharif area dipped at a faster rate (70 %), than *rabi* area (32 %) between 1970 and 2009 (Figure 1). Despite sharp decrease in the area, the production of sorghum *kharif* increased till 1990, due to use of hybrids and improved cultivars and gradually decreased thereafter owing to area decline without significant impact on production, after 90's the yield increase also slowed down. The overall *rabi* sorghum production increased by 83 % during 1971 to 2009 while Kharif sorghum the production declined by 52 percent. Thus, currently, 55% of the area is under *rabi* sorghum compared to 35% in the 70's. In the case of pearl millet, area and production

increased till 1970's and declined during 80's due to downy mildew menace (Pray and Nagarajan 2010). After 1980's, though there was a marginal decline in area under pearl millet, accelerated productivity enabled production to sustain at a higher level.

Waves of change during different periods

With the onset of green revolution, the productivity of sorghum and pearl millet triggered appreciably. In most of the states in India, the trends of area, production and productivity of sorghum and pearl millet witnessed three waves of change. The 1st wave pertained to pre green revolution period (1950 to 1960's), the 2nd wave was in green revolution period (1970's to 1980's) and the third wave in post green revolution period (after 1990's). During the pre-green revolution period, traditional varieties were grown hence the growth in output was area led. In the green revolution period, there was appreciable increase in productivity due to high yielding varieties and hybrids, intensive use of chemical fertilizers and other improved package of practices. The productivity registered an impressive growth rate of 40% during this period. Thus, in the second wave of change, the growth in output was mainly productivity led due to technical change with access to markets despite policy support. The third period marked by release of varieties with value added attributes like resistant to pests and diseases, drought and heat tolerant. In this period too, area exhibited declining trend but productivity increased in pearl millet at a higher rate compared to sorghum. Nevertheless, the production levels of both grains remained stable.

Though productivity recorded a high compound growth rate of 2.5% per annum in kharif sorghum, there has been wide productivity differential between kharif and *rabi* sorghum by 2-3 times. This is due to non availability of improved cultivars for *rabi* sorghum and cultivation under residual soil moisture. The improved varieties occupy only 25- 30 % of the area under cultivation of *rabi* sorghum. Thus the contributing factors towards improved productivity in case of *rabi* sorghum are management practices like nutrient management, soil and moisture conservation and improved production technology.

Comparative economics of sorghum and millet

The profitability of *rabi* sorghum is relatively higher as compared to *kharif* sorghum. Farmers cultivating *kharif* sorghum realize productivity advantage as the productivity of the sorghum is higher by 2-3 times compared to that of rabi and hence, the cost of production per quintal is lower, while the farmers who produce *rabi* sorghum have price advantage, as the price of rabi sorghum is double that of *kharif* sorghum. In case of pearl millet, the production cost per unit of output is low due to high productivity and the net margin realized per unit is also modest. Considering the current minimum support price of Rs. 880 per 100 kg of pearl millet, Rs. 900 for *rabi* sorghum and Rs 880 per 100 kg of *Kharif* sorghum, farmers are not able to get remunerative returns. Unless the price scenario changes, pearl millet and sorghum will not emerge as commercial crops and the area under these crops is likely to decelerate though the productivity may improve with the availability of improved technology. Area decline can be addressed through appropriate policies promoting these crops both at the farm level and as at consumption level as nutritious cereals for consumers.

Economic Importance of *Rabi* Sorghum:

Bulk of the *rabi* sorghum output produced goes for human consumption, as the grain is of superior quality and highly preferred for consumption. As a result, the *rabi* sorghum commands a premium price in the market compared to *Kharif* sorghum by 20 to 40 %. Similarly, *rabi* sorghum fodder is highly preferred as livestock feed, which is a key complementary activity in dry land agriculture contributing to total farm income. Economic contribution of fodder to the total income from *rabi* sorghum is to the order of 45 to 57 % in varieties and 39 to 47 % in hybrids in Maharashtra and Andhra Pradesh (DSR 2010).

Consumption trends:

The annual per capita consumption of sorghum at all-India level has declined sharply by 68 % (8.5 to 2.7 kg) in urban areas and by 70 % (19.1 to 5.2 kg) in rural areas of India between 1972–73 and 2004–05. Similarly, the pearl millet consumption both in rural and urban areas has fallen very steeply from 11.5 kgs to 4.6 kgs (by 60 %) in rural areas and from 4 kgs to 1.5 kgs (by 62 %) in urban areas (Fig 3 & 4) (Parthasarathy Rao *et al,* 2010 and Basavaraj *et al,* 2010). This is due to increase in per capita income, growing urbanization, changing tastes and preferences (Chand 2007) rendering sorghum and millet as inferior goods with low to

negative income elasticity of demand and positive price elasticity. Apart from decline in consumption, these crops are gradually disappearing in traditional areas due to access to irrigation and markets which have enabled farmers to shift their area under cultivation of high value crops. (Chandrakanth and Akarsha, 2011).

The food security strategy of Government of India of supplying subsidized rice and wheat through Public Distribution System (PDS) has also contributed to the decline in consumption of sorghum and other cereals like pearl millet and finger millet even in rural areas and urban centres. Thus sorghum and pearl millet popularity faded resulting in negative growth in area, production and consumption, as they could not compete with other remunerative crops due to market imperfections and market failure (to recognize nutritive properties), poor policy support and poor consumer awareness. Additionally, access to irrigation gradually replaced millets area by rice, maize and other high value crops. Due to low market price, farmers do not follow improved production practices and hence their cultivation became un-economical.

The PDS system in India is based on the wheat and rice model, which is less relevant in many areas and especially in the dryland farming areas, where millets, sorghum, and pulses are traditionally the staple grains for household consumption (Dayakar Rao, Reddy, and Seetharama 2007). Hence, despite the decline in per capita consumption, sorghum grain is an important staple for the low and middle income consumers in regions where they are grown. For example in rural areas of central Maharashtra, per capita annual consumption of sorghum is around 60 kg, accounting for almost half (48 percent) of per capita consumption of all cereals. Similarly, among the major pearl millet producing regions, per capita consumption was highest (69 kg/year) in rural Rajasthan and in the dry areas of Gujarat (59 kg/year). In those two regions, pearl millet accounts for more than 50 percent of cereal consumption, contributing about 20 to 40 percent of the total energy and protein intake (Parthasarathy Rao *et al*, 2006).

Fig-3. Trends in the annual per capita consumption (PCC) of Sorghum in rural and urban India, 1972 to 2005

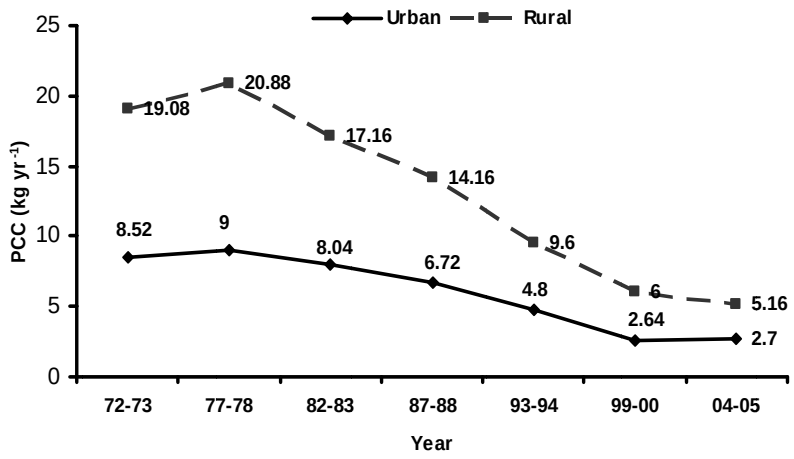
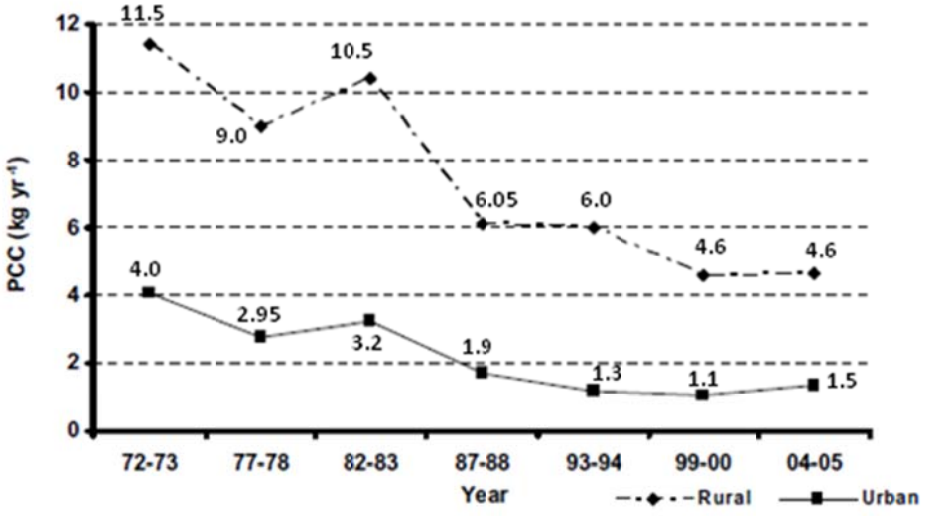


Fig-4, Trends in Annual per capita consumption (PCC) of Pearl Millet in rural and urban India during 1972 to 2005



Non-conventional uses

During the last 1-2 decades the new sources of demand for sorghum and pearl millet have been emerging from different sectors. As evident from the table 1, the share of sorghum and millet alternative uses to availability increased phenomenally, especially after 1990's. The demand for sorghum and pearl millet has potential in the poultry feed (especially as layer feed) and animal feed sector. Dayakar Rao, Reddy, and Seetharama (2007) projected that by the year 2010, the likely demand for sorghum for poultry and cattle feed would be around 3 million metric tons. Additionally, there is a growing demand for the grain of these two crops from alcohol industry for manufacture of potable alcohol. Thus, the demand for sorghum and pearl millet is derived from the demand for feeds both for animals and poultry and other industrial uses. This requires efforts from breeders for development of varieties based on industrial preferences traits.

Table 1: Trends in supply and share of sorghum and millet in alternative uses

Year	Supply (million tons)		Share of alternative uses to availability (%)	
	Sorghum	Pearl Millet	Sorghum	Pearl Millet
1972–73	8.32	5.59	0	0
1977–78	11.47	5.38	0	7
1982–83	11.59	6.13	5	0
1987–88	11.75	5.91	14	30
1993–94	10.99	6.96	30	37
1999–2000	7.92	6.93	33	46
2004–05	7.16	9.19	31	55

Source: Parthsarathy *et al,*2010 and Basavaraj *et a*l, 2010

Market and policies

Market for millets (except maize) is undergoing a sea change from near perfect markets to imperfect markets. This is due to lack of consumer demand for millets including demand from farmers themselves who produce these crops. As these farmers face relatively imperfect markets compared with superior cereals, pulses and oilseeds, the low prices received will lead them to be economically inefficient just covering or even not covering the production costs. Unless policies specifically address these farmers, as they are already in Below the Poverty Line (BPL) category this aggravates the situation by further moving them down on poverty line.

Traditionally, these crops are being grown for food security and not for marketing. Hence,

the market participation was quite low and so also their price response. As a result, these crops never fetched the prices equivalent to the superior cereals. Currently, with increasing importance of alternative uses the producers sell some portion of their production as marketable surplus and are more concerned about the prices received for the crop and they sell. Minimum Support Price (MSP) mechanism has not been effective in this respect as the marketing of the produce is not in bulk and most of the times it is sold in local market. These crops have received unfair treatment on the price front (Deshpande, R. S. and Rao V. M. 2003).

Synergies from the public and private investment on sorghum R and D-Implications

Public sector primarily national and state Governments monopolised investments in agricultural R & D, especially food crops till 1990's. The new technology led interventions were implemented by National and state governments working in collaboration with the International institutes like International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). The ICRISAT contributed genetic material to public and private institutions that helped to breed varieties resistant to biotic and abiotic factors. Using ICRISAT germplasm and breeding materials, 242 sorghum and 163 pearl millet varieties/hybrids have been released by NARS as of December 2010 (http://www.thehindubusinessline.com/industry-and-economy/agri-biz/article2047506.ece).They mainly focused in the areas of: 1) breeding varieties that are resistant to pests and diseases 2) seed production by both public and private sector . Additionally, favorable Government policies also encouraged private investment on seed multiplication and distribution. Currently, 82 % of the total seed supply of pearl millet and 75 % of the sorghum is by private sector companies (Pray and Nagarajan 2009). This has increased seed replacement rate phenomenally and productivity of sorghum and pearl millet have almost doubled benefiting farmers. The increased productivity enabled to allocate less area under millets and diverting the saved land to other cash crops, improving the incomes of the farmers.

Constraints:

The millet based production system in arid and semi arid regions greatly suffer from biotic and abiotic stress like frequent droughts and uncertain rainfall, soil nutrient deficiencies

especially phosphorus, nitrogen, and organic matter**,** major pests such as shootfly, stem borer and earhead bug and major diseases like grain mold and charcoal rot.

Availability of quality inputs like seeds fertilisers and other inputs in right time and place is a major constraint farmers are facing in dry areas. Labor scarcity particularly during the harvesting is yet another critical constraint reducing the profit margin of *rabi* sorghum. Farmers in dry land tend to under-invest on fertilsers due to price risk and uncertainty. Lack of credit, input supply bottlenecks are common factors precluding optimal production. Lack of improved storage facilities at farm level is another constraint. Post harvest processing of millets is in infancy with no policy support, relegating millets. The most common complaint of small farmers in rural India is lack of access to stable markets and market led extension. Unorganized markets, asymmetric information, superfluous middlemen, little vertical coordination between producers, processors and consumers, meager bargaining power, poor transportation links and lack of processing opportunities are making the millets less remunerative.

Future Investment options:

In marginal and harsh environments, the options to shift from millets to other lucrative crops is limited. Hence, farmers demand productivity augmenting technologies which are cost effective and land saving. Though, productivity of *kharif* sorghum is twice that of *rabi* sorghum, enhanced productivity gain is not substantial in *rabi* sorghum due to lack of varieties/hybrids that have grain quality on par with the local variety viz., Maldandi,M35 -1 which has better consumer preference for grain and fodder. In addition, the new sources of demand for sorghum and pearl millet are also emerging. Hence, investments should flow towards breeding varieties incorporating the quality attributes preferred by end users. It goes without saying that breeding efforts for value added characteristics like tolerance to drought, downy mildew, smut, blast, heat and bird loss, should continue as their yield loss due to these factors is to the tune of 30-50 %.

The 2nd priority is to breed varieties to increase the shelf life of grain and reduce the undesirable attributes in the grain like reducing fat content and phenol compounds, followed by improving keeping quality of the flour and exploring health benefits and nutriceutical value for pearl millet.

Industrial demand for grain-based alcohol is also expected to propel a double digit growth rate. There is a huge demand for pearl millet towards extraction of alcohol, provided the starch content in pearl millet is increased from the present level of 55 % to 65 %. Presently, most of the distilleries are using broken rice in the distilleries, as rice has high starch content and the unit cost of starch from rice is cheaper than starch from the pearl millet. Hence, the demand for pearl millet from the distilleries depends on the relative prices of broken rice and pearl millet. Thus private-public partnership and investment is required to breed varieties with high starch content, targeting towards 100% substitution of pearl millet with maize, rice etc in alternative uses.

Investment in research should be directed towards increasing productivity of *rabi* sorghum which would help in bringing down the prices and make it affordable for lower income consumers. In order to improve productivity of *rabi* sorghum, besides targeting improved varieties, targeting on the key recommended technologies, management practices like drilling of fertilizer along with seed, seed treatment, deep sowing, wide row spacing, optimum plant population, Integrated Pest Management (IPM) and Integrated Nutrient Management (INM) is crucial. In addition, moisture use efficiency towards reducing drought risk is also important.

Exploring non-conventional uses and extrusion products is another important area for future investment in these crops. Incentives should be provided to food industry to use *rabi* sorghum for novel processed food products (snacks, bread, biscuits, flakes, papad, rava, etc) and also traditional processed products. Value addition in millets is now crucial to widen markets, consumer acceptance and to render cultivation of these crops remunerative for producers. Though potential exist for bakery, nutrifoods, nutraceuticals, health foods, value addition in millets is in infancy stage with no research and policy support. Enriching nutritional value in pearl millet like zinc and iron content is yet another fertile area for investment. Thus, there is wide scope to invest on nutrition technologies which will have a ripple effect on the improvement in livelihoods of dryland farmers in marginal areas who are dependent on cultivation and consumption of crops like sorghum and pearl millet.

Research and Policy imperatives

In the case of *rabi* sorghum, higher productivity and fodder yield under residual moisture situation are the crucial attributes. Any significant increase in productivity requires the use of crop management technologies and market support for economic incentive. In addition, the biotic and abiotic problems such as resistance to shootfly, aphid, charcoal rot, drought and cold are important for adaptation in *rabi* season. Consumer acceptability is towards bold, round and lustrous grain and higher flour recovery. Thus, research efforts on *rabi* sorghum should address the above problems on priority in order to augment productivity rendering sorghum as a profitable crop benefiting the small and marginal farmers in SAT areas.

Chronic under nourishment especially deficiency of micronutrients , the "hidden hunger" is rampant in India. Hence, millets need to be included in the diets addressing micronutrient deficiency. But urban dwellers view it as "Poor man's crop" and has become an inferior good. The Government must include millets in the PDS as a quid pro quo measure in the National Food Security Mission. For every kilo of rice and wheat allotted to ration card holder, half a kilo of millet purchase must be made mandatory. Millets need also to be integrated with Integrated Child Development Services (ICDS), Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) and School Mid-day Meals programmes wherever these crops are predominantly grown.

Even though Minimum support prices are offered for millets similar to rice and wheat, farmers are not responding to millet cultivation due to (1) absence of procurement operations (2) lack of consumer demand as millets are treated inferior goods (3) poor value addition (4) poor consumer awareness and (5) lopsided policy support compared to rice, wheat and other commercial crops.

The price disadvantage of rainfed farmers due to lack of storage and bargaining capacity is exploited by middlemen who garner the produce during peak arrivals at harvest time and then storage the grain to reap the time utility. The vertical integration capacities of small and marginal farmers are virtually non-existent or poor which puts them at an additional disadvantage.

In order to make a case for millets and raise the demand from the consumers, establishing a link between the health and consumption of traditional food-grains is crucial and this needs initiatives from different stakeholders.

Much of the millets in the rural areas are processed at household level by following a tedious method involving a considerable drudgery. So, there is vast scope to transfer information regarding modern technologies and benefits of value addition to the farmers. Providing backward and forward linkages for value chain using innovative value addition in domestic and international markets is required. Capacity building for social capital formation among farmers and consumers regarding their cooperation for millet cultivation and consumption considering their nutraceutical properties is quintessential.

Field level findings suggests that there is scope to arrest the declining demand for sorghum in urban centers by promoting value added and ready to eat products as they are in much demand in hotels and restaurants. Though consumers are aware of the health benefits of sorghum in their dietary requirement, unavailability of processed products as in the case of wheat have contributed to decline in consumption of sorghum. Hence, keeping in view the potential benefits of sorghum, research efforts should be focused on releasing varieties to cater to needs of processing sector for better value added products and to meet the demands of the growing urban population.

Since sorghum and pearl millet are occupying a prime place in the food basket in Maharashtra, Karnataka, Andhra Pradesh and Rajasthan, Gujarat and Haryana, efforts should be made at policy making level to include sorghum and millet in the Public Distribution System (PDS) in these states. This would in the long run help both the producers and consumers. It would provide incentives to producers to grow sorghum and to consumers by making it available at cheaper price for consumption as that for rice and wheat.

Policy makers should facilitate forward linkages where farmers enter directly in agreement with industrial users through contract farming, bulk marketing, etc. This will enable an assured price to the growers while the industry can expect bulk supplies of the required quality grain.

Market efficiency can be improved by the addition of a processing facility to handle excess produce in times of maximal production and allow for an expansion beyond the fresh market.

The producers, by organizing as a group, will be able to obtain market power, thereby increasing their share of the increased profits in the chain.

Conclusions

Pearl millet and sorghum are predominately grown in arid and semiarid regions of India under rainfed conditions and continue to play a prominent role in the dry land economy in view of limited scope for expansion of irrigated area. Further, these crops possess unique features such as high nutritive value, higher fodder value, and drought tolerant. The productivity of these crops increased significantly during the green revolution era due to investments by public and private investments in R&D. Though there was productivity enhancement, due to lack of economic incentives and effective demand farmers reduced area under millets by shifting to other crops to eak out their livelihood. While sorghum and pearl millet can substantially contribute to food, nutritional and economic security of small and marginal farmers, to stimulate demand for pearl millet and sorghum, value addition at micro and macro levels with technological support and market led extension through food science and nutrition is crucial. The very fact that *rabi* sorghum has not made in roads despite R & D contributions enhancing productivity, in itself is a prima facie indicator that productivity addresses only the supply side, while consumer demand is crucial, which is possible through value addition and extension efforts incorporating the nutrition and health aspects and meeting the quality requirements of alternative users that are emerging. Farmers have been resistant to switchover to improved varieties in case of rabi sorghum because of fodder quality. Thus, high yielding varieties with fodder quality on par with local races are required to improve the profitability of rabi sorghum.

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References:

1. **Basavaraj G, Parthasarathy Rao P, Bhagavatula S** and **Ahmed W.** 2010. Availability and utilization of pearl millet in India. Journal of SAT Agricultural Research 8.

2. **Chandrakanth M G** and **Akarsha B M.** 2011. Green development for sustainable agriculture. FKCCI Journal, Karnataka, India.

3. **DAC.** 2010. Status Paper on Millets. Directorate of Millets Development, Ministry of Agriculture, Department of Agriculture and Cooperation, Jaipur.

4. **Dayakar Rao B, Reddy S** and **Seetharama N.** 2007.Reorinetation of investment in R&D of millets for food security: The case of sorghum in India. Journal of Agricultural Situation in India. 64(7): 303-305.

5. **Deshpande R S** and **Rao V M**. 2004. Coarse cereals in a drought-prone region: a study in Karnataka Social and Economic Change, Monograph Series No. 2, Institute for social and economic change, Bangalore, India.

6. **GOI. 2010-11.** Economic survey. New Delhi, India: Ministry of Finance.

7. **Khairwal I S, Rajpurohit B S, Rai K N, Yadav O P** and **Kherwa G R**. 2010. Pearl Millet Cultivation and Seed Production in Rajasthan. All India Coordinated Pearl Millet Improvement Project, Rajasthan, India.

8. **NRCS.** 2009. Vision 2025 Document - Perspective Plan. Rajendranagar, India: National research centre for Sorghum.

9. **Parthasarathy Rao P**, **Basavaraj G, Bhagavatula S** and **Ahmed W**. 2010. An analysis of availability and utilization of sorghum grain in India. Journal of SAT Agricultural Research 8.

10. **Parthasarathy Rao P**, **Birthal P S**, **Belum Reddy V S**, **Rai K N** and **Ramesh S**. 2006. Diagnostics of Sorghum and Pearl Millet Grains-based Nutrition in India, International Sorghum and Millets News Letter.

11. **Pray Carl E**. and **Nagarajan L**. 2009. Pearl millet and sorghum improvement in India. Discussion paper No. 919. International Food Policy research Institute.

12. **Pray Carl E**. and **Nagarajan L**. 2009.Improving crops for arid lands. Chapter No. 12. Millions Fed: Proven Successes in Agricultural Development. IFPRI publication.

13. **Yadav O P, Rai K N, Khairwal I S, Rajpurohit B S,** and **Mahala R S.** 2011. Breeding pearl millet for arid zone of north-western India: Constraints, Opportunities and approaches. All India Coordinated Pearl Millet Improvement Project, Jodhpur, India.

14. http://www.thehindubusinessline.com/industry-and-economy/agribiz/article2047506.ece