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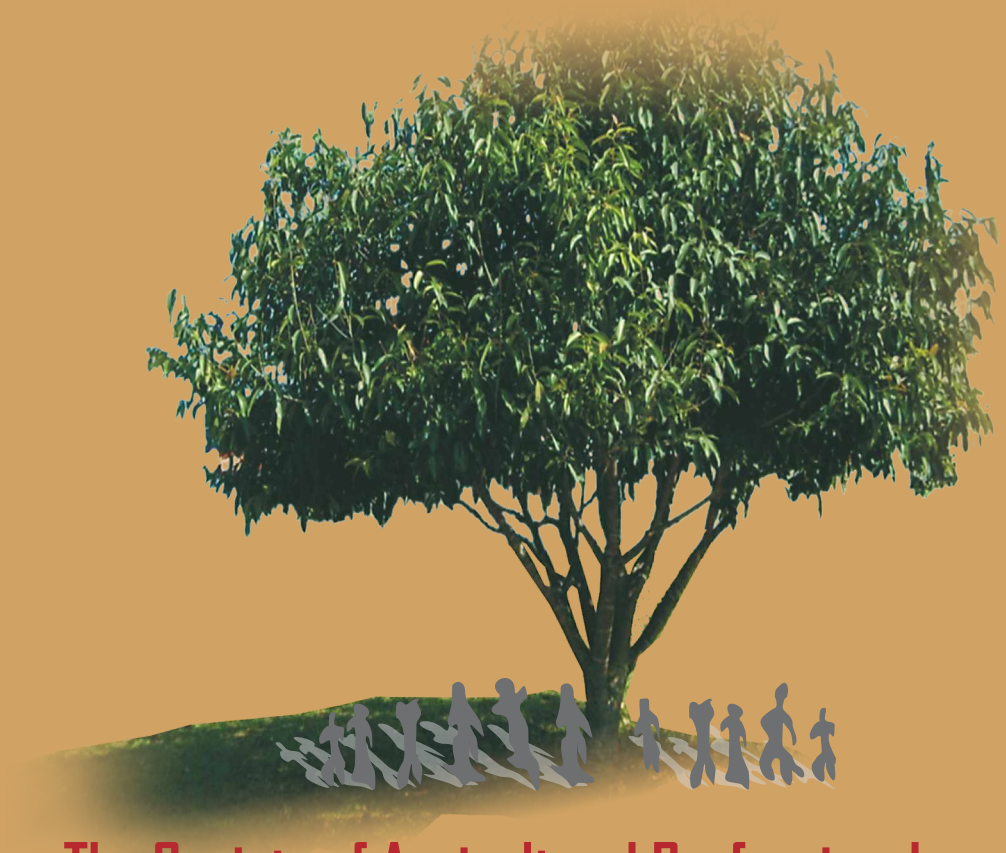

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Role of millets in smallholder farming system for improved food and nutritional security under changing climate scenario

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ABSTRACT

Millets are a major source of staple food for human, forage for the livestock, and industrial raw material. These are grown in semi-arid climate due to their ability to grow and complete their life cycle in less than 400mm rainfall. They have huge potential to enhance livelihood of the resource poor farmers in dryland and rainfed agriculture using location-specific improved production technology, trait-specific production, millets supply chain management, buy-back arrangements, value-addition of millets, refinement and commercialization of technologies and entrepreneurship development, market development for domestic and export purposes, policy advocacy and creation of awareness, which needs to be implemented at grass-root level with diversified approach. Some issues related to millets are; low remuneration, low adoption of production technologies, biotic and abiotic stress, and lack of policy support unlike other cereals need to be addressed strategically. It requires synergy among technologies, marketing systems, input supplies, credit, policies and institutions to achieve the goal of enhancing farmers' livelihood in resource-poor areas.

Key words: Millets cultivation, Technology interventions, Drivers for promotion, Improving farmers' livelihood, Millets growers

Large segment of the Indian population (70%) is dependent on agriculture which governs national economy, also food and nutritional security of the country and accounts for approximately one-fifth of the total gross domestic product (GDP). With increasing population, agriculture has prolonged scope for sustainable development to feed the mouth of vast population and livelihood support for rural population. Millets cultivation in India covers an area of 17 million ha with annual production of 18.66 million tones and are grown in different seasons, offering food for human consumption and fodder for their livestock animals in the dry-land regions of India. They are climate smart, highly adaptable, and versatile. Millets are one of the cheapest sources of energy, higher content of digestive fibres, protein, vitamins and minerals (Ashok Kumar *et al*., 2012 and 2013). In terms of nutrient intake, sorghum accounts for about 35% of the total intake of calories, protein, iron and zinc in the dominant production/consumption areas (Parthasarathy Rao *et al*., 2006). They are referred as nutri-cereals owing to possessing high nutritive values of the grains are good source of micronutrients, especially, Ca, Fe and Zn and they also contribute to more than 50% of the micronutrient requirement in low income group populations. Thus, it is essential to make them most preferred crop choices particularly in the low and average rainfall areas of the country. Besides, being a major source of staple food for human beings, it also serves as an important source of fodder, feed and industrial raw material. It is grown in semi-arid climate where other cereal crops don't stand well (Paterson *et al.,* 2009). They are the major source of forage for the livestock feeding in northern and western India. Sorghum and other millets play a major role in the agricultural GDP of major growing states of Maharashtra, Karnataka, Telangana, Rajasthan, Tamilnadu, Gujarat, Madhya Pradesh, Andra Pradesh, Chattisgarh, Uttrakhand and Haryana. They are predominantly grown on small and medium holdings which account for 90% of the sorghum and pearl millet area in the country.

Sorghum is great millet grown in about 6 million ha and producing about 6 million tones in India losing its third position to fifth position in terms of area and production. State-wise, Maharashtra occupies 54% of total sorghum area of the country followed by Karnataka (18%). Rajasthan has about 60% area of total pearl millet of the country followed by Maharashtra (10%) and Uttar Pradesh (9%). Similarly, Karnataka occupies more than 60% area of finger millet and Madhya Pradesh occupies largest area (34%) of small millets of the country. As far as bio-diversity of millets across the states is concerned, Maharashtra and Tamil Nadu are the richest with cultivation of all major and minor millets. The threat of climate change is looming large on the crop productivity of millets. The area under cultivation millets and consumption is declining due to, low remunerative price, limited productivity, high drudgery involved in their processing, negative perceptions as a food of the poors and policy neglect when compared to other crops (Karthikeyan, 2016). Whereas, area under sorghum and other millets is reduced drastically and productivity is also low. It is mainly due to low remunerative price, dependent on monsoon rains, no use of soil type-based high yielding varieties (HYVs), non-adoption of soil moisture conservation practices and improved

production technologies coupled with fast changing food habits of the people. The national average yield of sorghum has doubled since 1980 due to adoption of both improved varieties and management practices by the farmers (Pray and Nagarajan, 2009). Though, we have potential sorghum and other millets technologies developed by the research organizations, there is a wide gap between the potential yield of the scientific technologies and that of the farmers obtain in their fields due to the several reasons like, lack of knowledge and skill and input support at grass-root level, etc. However, the millets including sorghum are emerging as a potential alternative food, feed, and fodder crop because of its resilience to high temperature and drought makes it a climate-ready crop. Marketed surplus ratio (MSR) of sorghum has increased significantly over the years from a mere 24 in 1950-51 to 64.14 in 2012-13 which implies that sorghum farmers have started selling off their products after meeting the consumption needs. Similarly, MSR of bajra has also increased over the years. The marketed surplus ratio of finger millet (*ragi*) has become almost half as compared to the early 2000's (ASG, 2014). It means that there is lot of scope for value-addition and processing to earn more than the routine business.

For food and nutritional security, challenges of agro-ecological potential and climate change impacts must be considered along with growing water scarcity, land degradation while devising the agroeco-region-wise interventions. Therefore, promotion of sorghum and other millets has a large scope to mitigate the risk in agriculture unlike other food crops in drought-prone and rainfed regions. Suitable intercropping of pulse crops with these millets and allied framings is also a viable option towards nutritional and economical security in sustainable way. There are four key pathways to achieve the goal are: (i) by increasing productivity, (ii) by reducing cost of cultivation, (iii) by increasing market opportunities and (iv) by developing sustainable value chain.

AGRO-ECOLOGY OF RAINFED AGRICULTURE

Rainfed farming comprises about 91% area of coarse cereals (sorghum, pearl millet, maize and finger millet), 91% pulses (chickpea and pigeon pea), 80% of oilseeds (groundnut, rape seed, mustard and soybean), and 65% of cotton. Also, about 50% area under rice and 19% area under wheat is rainfed. Besides putting various measures to increase the productivity levels of dry land crops, efforts would also be needed to increase the cropping intensity in dry land areas which was generally 100%, implying that a single crop was taken during the year. Cropping intensities of these areas could be increased by practice of inter cropping and multi cropping (sequential) by way of more efficient utilization of resources.

CHALLENGES IN MILLETS CULTIVATION

Climate change impacts

Agriculture is more vulnerable due to warming and related aridity, shifts in rainfall patterns, and to the increased frequency and duration of extreme events. Climate projections based on the Model BCC_CSM1.1 RCP8.5 for the year 2050 are used to assess the changes in thermal and moisture regimes. Projected monthly changes show that there is great month to month variation in both maximum and minimum temperatures and rainfall. Rainfall in first-half of *kharif* is projected to be less; June and July rainfall is crucial for rice and soybean as they will be in vegetative phase; Water management is crucial. Minimum temperature during *rabi* is projected to increase by 2.5°C compared to the present conditions. Projected increases in *rabi* temperatures have great impacts on wheat and chickpea crops. The overall impact of climate change on agriculture, industries as well as livelihoods is expected to be negative, threatening not only food security but sustainability. There is urgent need for promotion of climate smart crops.

Decline in consumption of nutritious cereals

A study conducted by Indian Institute of Millets Research (IIMR) on "Macro and micro level changes in consumption of nutritious cereals in India" (*Rao et al*., 2004) stated that sorghum in all the states, and country as a whole showed decline in sorghum consumption among urban and rural masses, whereas pearl millet consumption in major producing States like, Gujarat (129%) and Rajasthan exhibited increased growth in urban areas, while in rural Gujarat, it has declined (-18.16%) and the same has increased in rural Rajasthan (39.1%). The magnitude of reduction in pearl millet consumption was highest in rural Tamil Nadu (-95.5%) followed by rural Andhra Pradesh (-80.95%). In finger millet, there is a slight decline of 9% in consumption in urban Karnataka, whereas in rural Karnataka the decline in consumption was 36% which is four-fold than in the urban consumption. Rural consumption of finger millet in Andhra Pradesh has also declined drastically (-67.27%). Some of the causal factors for the decline in consumption of nutritious cereals are underlined.

i. Easy availability of fine cereals like rice and wheat at a cheaper price to that of nutritious cereals under Public Distribution System (PDS)

ii. Rapid urbanization

iii. Nutritious cereals are socially less valued which accelerated the decline in their consumption on rising of capita income

iv. Tedious and time-consuming preparation of nutri-cereals foods

v. Preference to cash payment by laborers in lieu of taking food grain for work performed

vi. Change in food habit particularly - preference to fast food by younger generation

However, the demand for sorghum and millet in India is projected to increase from 8.1 Mt in 2010 to 10.1Mt in 2050. Further, the demand for millets utilization is increasing from 9.9 Mt in 2010 to 11.06 Mt in 2050 (Fig 1). The demand for feed and other industrial uses of sorghum and millet is the main driving

force for increase because of vibrant livestock sector and industrial growth. Furthermore, aggregate demand for sorghum and millet will continue to rise because of population growth and increase in demand for feed and nutrition prompts it critical to increase the productivity of these crops from the current level of 1 t ha^{-1}. The increasing demand for animal-based products in India with increasing population and rising incomes is another driving force for increasing the productivity. However, the targeted productivity increases should come from the area that is continuously shrinking under these crops over last few years. So, it is important to make best use of the available genetic and natural resources and markets to enhance the productivity and profitability of sorghum and millet cultivation in India.

Problems in millets cultivation

Though, the millets have wide variability to withstand in bio-physical adversities like, erratic rainfall, different soils, temperature, terminal droughts, and vulnerable to climate change impacts. There are following millets-related problems which need to be addressed with science-based solutions for further development.

- *Low productivity:* Due to inadequate irrigation facilities and low rainfall, most of the area under rain fed cultivation, no use of soil type-based high yielding cultivars, non-adoption of soil moisture conservation practices and improved production technologies led to the low productivity.
- *Biotic stress:* Difficulties in timely sowing and non-adoption of disease resistant cultivars resulted into severe infestation of shoot fly and grain mold disease, respectively in *kharif* sorghum. Due to less and isolated cultivation of sorghum is prone to severe birds' and wild boar damage.
- *Competition with cash/vegetable crops:* These millets are not treated as cash crops and therefore, growers cultivates them on medium to poor soils with low or no inputs, like fertilizers, irrigation, etc.
- *Low remunerative:* Due to low productivity, lack of standardized market, buy back arrangements based-on minimum support price (MSP) and non-inclusion in mid day meal (MDM) or public distribution system (PDS), farmers could not get remunerative price.
- *Fluctuating market prices:* Since, there are no standardized market facilities and intelligence and procurement by the governments, market prices of these millets are sometimes less than cultivation cost. Middlemen are dominated in fixation of the prices.
- *Unawareness about health and nutritional benefits:* Though, the millets are good for human health and overcome celiac diseases, their consumption is reducing drastically due to unawareness, lack of commercial ventures and policy ignorance.
- *Lack of irrigation facilities:* Since, irrigation facilities are scanty and these millets are low/no remunerative, the farmers grow other cash crop or vegetable with available irrigations. Lack of availability of assured water supply and protective irrigation for millets is a major reason for low yields.
- *Soil salinity:* Continuous rainfall and irrigation leads to accumulation of salts and drainage problems in black cotton soils. It is unique problem of this region. Therefore, the irrigation has to be used very judiciously to avoid salinization of soils as well as water-logging.
- *Low organic carbon content:* All most all rain fed soils are poor in organic carbon content, which is the important factor minimizing the productivity. Unavailability of organic fertilizers and continuous use of chemical fertilizers for cash crops led towards poor soil status.

TECHNOLOGY INTERVENTIONS

There is a large scope for increasing productivity and profitability for farmers through scaling-up of climate resilient agriculture; however, it calls for concerted efforts, adoption of location-specific and cost-effective technologies. The new technologies should also be less input intensive, cost-effective, less labour intensive and economically viable. Based-on experience of millets cultivation, some promising interventions are underlined.

Use of high yielding cultivars specific to soil types

Latest twelve *kharif* sorghum cultivars were introduced in seven sorghum growing states across the rainfed regions of the country under frontline demonstrations (FLDs). They yielded 78% more grain and 60% stover than the local cultivars which were resulted into 51 per cent more net returns than the local cultivars. Similar results were obtained in *rabi* sorghum in these areas. Soils of sorghum growing areas has been classified into three major categories based on soil depths, *viz*., shallow (<45 cm depth), medium (45-60 cm depth) and deep (>60 cm depth) with low-medium in water holding capacity. The moisture retention capacity varies therefore; soil-types based varietal selection is more suitable.

Improved practices and timely management

Impact of the demonstrated technologies under FLDs shows that adoption after FLD period was significantly increased by more than forty eight percent especially in practicing seed treatment (85%), use of high yielding varieties (70%), use of nitrogen fertilizer (57%), following time of sowing (49%) and maintaining plant spacing (48%). It was resulted into increased in higher net returns (170%), followed by grain yield (58%) with better quality (78%) and fodder yield (26%), found to be significantly positive over the pre-FLD. It proves that even small changes in use of low-cost recommended practices and timely management can have large effects on yields and monetary benefits (Chapke *et al*., 2011).

Water conservation practices

Dependent on rainfall for *kharif* and residual moisture for *rabi* crops is a major concern. Cultivation of *rabi* sorghum and pearl millet on residual soil moisture and occurrence of terminal drought are the major reasons of low productivity of *rabi* sorghum and pearl millet. In-situ moisture conservation practices like compartmental bunding and ridges and furrows, adoption of soil-based improved cultivars, nutrient management and irrigation scheduling based-on water availability whereas, organic mulching in *kharif* are the important management options for improving sorghum productivity (Patil *et al*., 2013). Results revealed that compartmental bunding during *kharif* season conserved 12.6% more soil moisture and produced 20.6% higher grain yield over farmers' practice.

Millets-based inter cropping

To achieve appropriate land use, efficient inter- and sequence-crop systems were recommended based-on soil type, rainfall and length of growing seasons. Intercropping sorghum with legumes not only produces higher yields per unit area and time, but also provides nutritional security, economic benefits and improves soil health. Sorghum+pigeonpea (2:1/3:1/6:2) and sorghum+ soybean (3:6/2:4) are the two most common intercropping systems. Medium duration sorghum genotypes are most suitable for intercropping. Soybean - *rabi* sorghum has been found more productive and economically viable system in areas receiving annual rainfall above 700 mm and medium to deep soils having high water retention capacity, and sorghum (*kharif*)-chickpea, safflower and mustard (*rabi*) under limited irrigation conditions. Many other millets-based intercrop and sequence cropping are found to be more profitable.

New niches of millets cultivation (in rice fallows)

Although millets are known to be climate resilient crops, their cultivation in traditional areas is reducing. New niches like rice fallows sorghum or millets cultivation plays significant role in economical security of the farmers. Sorghum hybrid; CSH 16 (7.50 t ha^{-1}) yielded significantly better than the locally popular hybrid Mahalaxmi 296 (5.86 t ha^{-1}) in rice fallows in Guntur district of Andhra Pradesh, during four years from 2012 to 2016. The significant increase of 27% was observed in grain and ultimately it was resulted into 73% higher monetary benefit to the farmers (Chapke *et al*., 2011a). The district yield average of sorghum is 6.80 t ha^{-1} during 2014-15 which is around seven times more than the national yield average (0.90 t ha^{-1}), Such success story can be replicated in the areas where, there is scope in to introduce sorghum and other millets in rice fallows which, assures additional income to the farmers.

Value-addition and post-harvest processing

The increasing MSR indicated that there is lot of scope for value-addition and processing to earn more than the routine business. Creation of demand for millets and millets value-added products as healthy food will boost the production and consumption scenario of millets which will have a long-term impact on the sector. Increase in demand for the millets and value-added products will boost the farmers' morale towards millets cultivation and will also help in realising better prices for their produce.

Mechanization

As the millets cultivation especially, sorghum and pearl millet is more labour-intensive and more than 55% cost goes towards labourer. Harvesting operations needs more labourer and takes major share. Hence, suitable harvesting–cum-threshing like combine machine is much essential. Moreover, proper tillage and precise placement of seed and fertilizers in the moist zone are most critical to for successful crop establishment in drylands. Since, the sowing of crops must be completed in a short span of time, use of appropriate implements is necessary to cover large area before the seed zone dries out. The above mechanization can help to reduce cost and labour requirements which will encourage millets farmers.

Promotion of bio-fortified cultivars

Evolving a number of production technologies, arable cropping in drylands continues to suffer from instability due to aberrant weather and market fluctuations. To provide stability to farm income utilizing marginal lands for market driven trait-specific production of millets which have nutraceutical values is a commercial endeavor. Iron rich bio-fortified pearl millets varieties (Dhanshakti and Shakti 1201) are available which have 80 ppm iron is almost double than other cereals. To tap increasing market demands of iron rich millets as food for anemic women and children through bio-fortified millets production can fetch more profits.

Sustainable millets production and value chain through group approach

Most important factor that accelerates the competitiveness of the sorghum and other millets in the international as well as domestic markets is the grain quality and organic produce. Use of pest and disease resistant varieties and organic millets production could create more opportunities. Enhancement of export competitiveness of Indian millets in the international as well as targeted domestic markets will help the farmers to fetch good returns for their produces in long term. For this and in view of small and marginal farmers' background, their collectivization into farmer's producer organizations (FPOs), may be an effective pathway to harness collective synergy.

Promotion of allied enterprises as integrated farming system

Since, the mono-cropping and traditional farming are not viable, addressing only a component of the farming system, *e.g* crop variety, fertilizer use or even crop husbandry per se is not expected to bring about a significant increase in the productivity as witnessed in irrigated areas. The soil, plant, animal cycle is the basis for all feed used by the animals. The livestock in the rainfed regions are weak. Farmers in this area

often sell their cattle due to the scarcity of fodder. The land holdings are being reduced with increased population pressure. There is large unexploited scope to harness system level productivity and value chains, wherein women have income-generating opportunities through women-focused activities. Therefore, the millets-based integrated farming system approach with introduction of poultry, dairy, goat farming, piggery and apiculture at each household will help to supplement the farmers' income and women empowerment.

DRIVERS TO STRENGTHEN MILLETS-BASED VALUE CHAIN

The farmers have limited resources and diversified needs under several socio-economic and farming constraints which had become their primary concern in motivational perspectives before they decided for any changes and adoption of the new practices. Sorghum and minor millets are less remunerative which requires the following necessary supports as drivers in value chain mode to make them more profitable in order to enhance farmers' income.

- **Institutional support:** There is a large scope for increasing productivity and profitability for farmers through promising production technologies developed by research and development (R&D) organizations and scaling-up of climate resilient crops viz., millets. Weather forecasting- and resource-based crop selection coupled with soil test-based recommendation have crucial role in bridging out the wide yield gap. For adoption of new technologies and farm practices requires a wide array of human skill which is equally important component.
- **Input support:** Availability of quality inputs like, seeds of HVYs, fertilizers, agro-chemicals, in time and place are the keys for adoption of new technologies for increasing productivity and profitability. Varietal replacement with high-yielding and climate smart crop backed with developing de-centralized seed systems group approach (farmers' cooperatives, SHGs, FPO, etc.) needs to be operationalized.
- **Financial support:** Hassle free and timely financial support for mechanization labour intensive operations is a stepping stone for encouraging farmers to overcome labour problems and to avoid losses for failing in timely operations. Promoting on-farm mechanization through PPP mode, incentives to entrepreneurs to set-up village level one-stop-center for agricultural mechanization and other ways are viable options.
- **Market support:** Standardized market facilities, intelligence development, get rid off from middlemen and buy back arrangements at grass root levels would enhance confidence of the millets farmers. These are the important burning issues to be addressed on priority.
- **Infrastructure support:** Millets are known to be healthy food, even primary processing can double the income of farmers as it is main bottleneck. To overcome short self-life problems of millets; storage, road, transport facilities and adequate electricity supply are essential.
- **Policy support**: There is lot of scope for value-addition and processing to earn more than the routine business. It can be promoted through entrepreneurship development in collective action mode through SHGs and FPOs. These apart, policy support for farm-gate processing, control of wild animals, buy back assurance; implementation MSP for all millets, their inclusion in MDM and PDS system will boost-up the economy of millets farmers in this region. Farmers should be covered under insurance schemes to avoid any loss due to crop failure and other natural calamities.

IMPORTANT POINTS FOR MILLETS DEVELOPMENT

From the above discussions, it is asserted that there lies a huge potential to enhance the income of the resource poor farmers in dryland and rainfed conditions which needs multi-proned strategy that should be matched these challenges. It can be achieved emphasizing plough to plate transition in order to ensure food and income security to millets growers.

- Bridging yield gap by enhancing productivity using promising production technologies from R&D organizations
- Emphasis on moisture conservation practices and also link with watershed development programme
- Introduction of millets-based crop systems and allied farming involving women like, poultry, dairy, goat farming, piggery and apiculture
- Introduction of mechanization and hassle free financial support
- Marketing facilities and inputs support in convergence mode (single window system) and collective action through FPOs
- Creating awareness about health and nutritional benefits of millets through effective mass and local media to bring change in the consumer preferences
- Promotion of value-addition through entrepreneurship development through group approach (SHGs, NGOs)
- Policy support for buy back arrangements with MSP, crop insurance, inclusion in MDM and PDS system, infrastructure for farm gate processing and warehouses

CONCLUSION

The farmers' socio-economic condition is complex and resource-poor where several factors were at interplay. The role of the farmers in the whole system is more on the receiving end as 'passive subjects' rather than 'active stake holders' despite the fact that sorghum and other millets constitutes one of their main sources of livelihood. In spite of a wider climatic adaptability cultivation of diverse millet species/varieties is

gradually decreasing in the recent past. In a way, lack of institutional support for millet crops in contrast to rice and wheat continue to shrink the millet-growing region. In addition, several communities in the dry/rain fed regions having known the food qualities of millets over generations continue to include a range of millets in the traditional cropping patterns, which recognize millet as an essential part of the diet. Thus, a shift towards demand creation should become focus on millets promotion among the consumer which may eventually plough back demand for millets cultivation on long term. Keeping the importance of driving factors of millets development process in view, an attention on trait-specific production, millets supply chain management, backward integration, value addition technology development, refinement, commercialization of technologies and entrepreneurship development, market development for domestic and export purposes, policy advocacy and creation of awareness. Thus, target beneficiaries are farmers and consumers alike. In addition, targeting on women and youth, both rural and urban, for development of the entrepreneurship on millets based products of aimed to strengthen skill so as to reach the benefits of this project to all the targeted beneficiaries directly. Providing adequate knowledge to the farmers is essential for better implementation of the agricultural development plans and to improve the farm productivity. In order to achieve the goal of food and nutritional security through millets cultivation, there is need of viable strategy comprising of three major elements: (i) scientific crop cultivation in participatory mode and capacity building with support of R&D organizations coupled with inputs supply in single window mode, (ii) promotion of value-addition and creating market demands through collective action like, formation of FPOs and SHGs, and (iii) policy support for buy back arrangements with MSP, crop insurance, inclusion in MDM and PDS system, infrastructure for farm-gate processing and warehouses.

REFERENCES

ASG, 2014. Agricultural Statistics at a Glance 2014. Ministry of Agriculture and Farmers Welfare, Government of India

Ashok Kumar A, Reddy BVS, Ramaiah B, Sahrawat KL and Pfeiffer WH, 2013. Gene effects and heterosis for grain iron and zinc concentration in sorghum [*Sorghum bicolor* (L.) Moench]. Field Crops Research 146: 86–95.

Ashok Kumar A, Reddy BVS, Ramaiah B, Sahrawat KL and Pfeiffer WH, 2012. Genetic variability and character association for grain iron and zinc contents in sorghum germplasm accessions and commercial cultivars. The European Journal of Plant Science and Biotechnology 6 (Special Issue 1): 66-70 (Print ISSN 1752-3842).

Chapke RR, Mishra JS and Patil JV, 2011. Improved Production Technologies for *Kharif* Sorghum. DSR Bulletin No. 26/2011-12/Ext., Directorate of Sorghum Research, Hyderabad 500 030, pp. 10.

Chapke RR, Mishra JS, Subbarayudu B, Hariprasanna K and Patil JV, 2011a. Sorghum cultivation in rice-fallows: A paradigm shift. Book, Directorate of Sorghum Research, Hyderabad 500 030, India, ISBN: 81-89335-34-0, pp. 31.

Rao BD, Rana BS, Jyothi SH, Karthikeyan K, Kumar KAB, Seetharama N, 2004. Alternative uses of sorghum and pearl millet in Asia. Proceedings of an expert meeting, ICRISAT, Patancheru, Andhra Pradesh, India, 1-4 July, 2003; 2004 : 14-41. 17 ref.

IPCC, 2007. Summary for Policymakers. Cambridge, United Kingdom and New York, USA.

Karthikeyan M, 2016. Small Millets in mainstream diets: Promoting Decentralised Processing Infrastructure. Policy Paper. November, 2016. DHAN Foundation, Madurai, Tamil Nadu.

Nimbarte GN, 2016. A holistic overview of farmers' problems in Vidarbha region of Maharashtra. International Journ. Current Research 8(02): 26327-26329.

Patil JV, Mishra JS, Chapke RR, Gadakh SR, and Chavan UD, 2013. Soils moisture conservation agro-techniques for rainfed *rabi* sorghum. Indian Farming 62(12): 04-07.

Parthasarathy Rao P, Birthal PS, Reddy BVS, Rai KN and Ramesh S, 2006. Diagnostics of Sorghum and Pearl Millet Grains-based Nutrition in India. International Sorghum and Millets Newsletter 47: 93-96

Paterson AH, Bowers JE and Bruggmann R, 2009. The Sorghum bicolor genome and the diversification of grasses. Nature 457: 551-556.

Pray CE and Nagarajan L, 2009. Pearl millet and sorghum improvement in India. IFPRI 2020 Vision Discussion Paper 00919. Washington DC: International Food Policy Research Institute, pp. 27. http://www.ifpri.org/publication/pearl-millet-and-sorghum-improvement-india.