POLICY BRIEF 1

Can Rice Facilitate Revival of Mighty Millets?

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Globally, the year 2023 is being observed as an "International Year of Millets (IYOM)" and for farmers, food policy experts, nutritionists and environmentalists, the year 2023 brought something in common which would meet their aspirations and expectations. The millets due to their nutrition and hardy attributes have the potential to address the goals and aspirations of these stakeholders at micro level and contribute to the attainment of larger sustainable developmental goals (SDGs) at macro level. On the supply side, with the rising incidences of climatic eventualities, there are growing interests on millet due to increasing vulnerability to the food production system. Millets may also act as a check against rapid depletion of natural resources like ground water and degrading soil health and also contribute to the attainment of healthy, sustainable and equitable livelihood. Similarly on the demand side, millets are being looked at to supplement nutrition and provide healthy lifestyle to the society. The desire to switch to millets in recent years instead of other important crops comes from the fact that these grains are environmentally compatible with semi-arid regions because of their tolerance to acute water stress and high temperature. They are also regarded as one of the crops that can offer the marginal and small farmers good nutrition and revenue, contributing to their livelihoods and the supply of food. Despite the high reliance on millets for the sustainability of future food system, historically, they were overshadowed by the success of green revolution and were even sidelined by the cereal-pulse dominating food system in India. Moreover, there are growing evidences supporting surplus rice supply over its demand in near future for India. So, does these evidences on surplus rice supply would be of some use for the country in revival and rejuvenation of mighty millets?

This policy brief is about "how the existing rice production ecosystem offer opportunities for revival and rejuvenation of the millets". It discusses on how the success of green revolution has overshadowed the millets in India; provides evidence about the rice supply-demand situation for the country; insights from the existing rice based cropping systems in India and suggests the existing rice cultivating regions which may be diverted for the other crops including millets for its revival and rejuvenation.

Insights from rice-based cropping system in India

Based on wide range of rainfall distribution patterns (drought, submergence, deep water), distinct differences in soils (coastal and inland salinity, alkalinity, acidity), agro-climatic situations (high humidity), and seasons, rice is primarily grown under four major ecosystems namely: irrigated rice (26.0 Mha), rainfed lowland (12 Mha), rainfed upland (4.8 Mha) and flood-prone rice ecosystem (1.3 Mha). These categories are not exclusive and are composed of different sub-systems based on location-specific variations such as 'favourable' or 'unfavourable' in terms of moisture, soil type, temperature regime, proneness to drought, submergence, both drought and submergence, growth duration (early, medium, late maturity groups) and low light intensity conditions. Additionally, the four major rice-based cropping systems also exist which are: mixed varietal cropping of rice, intercropping of rice with other crops, relay/paira/utera cropping and sequential cropping. Higher thrust on rice cultivation after green revolution has led to dominance of rice–based cropping systems in India. Albeit the massive support to the national food security, there are concerns about rice which are-long-term intensive rice cultivation using traditional methods has been linked to severe depletion of natural resources[1], declining factor productivity, multiple nutrient deficiencies, groundwater depletion, labour shortages, and higher cultivation costs, loss of ecosystem services[2], environmental pollution, raising concerns about the sustainability of agriculture etc. Further, one rice plant requires nearly 2.5 times the amount of water required by a single millet plant of most varieties[3].

In addition, rice accounts for a large portion of the monsoon resource use for cereal production [energy (80%), GHGs (90%), and water (81%)], most of the calorie loss (89%) during an exceptionally dry year, and a substantial portion of the supply of calories (74% of *kharif* cereal production), protein (70%), and iron (31%)[4] . These figures demonstrate how, in relation to its percentage of *kharif* cereal calorie output, rice cultivation contributes disproportionately much to resource consumption, greenhouse gas emissions, and climate sensitivity. Moreover, there are evidences to support crop diversification in favour of millets in rice

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based cropping systems. Also, there is more emphasis on nutri-cereal as a climate smart crop. Replacing rice with maize, finger millet, pearl millet, or sorghum could reduce irrigation water demand by 33 per cent, and improve production of iron by 27 per cent and zinc by 13 per cent[5]. While maintaining calorie production and cropped area, increasing the area under coarse cereals (such as millets and sorghum) improves nutritional supply (on average, +1% to +5% protein and +5% to +49% iron), increases climate resilience (+1% to +13% fewer calories lost during an extreme dry year), and reduces GHGs (-2% to -13%), irrigation water demand (-3% to -21%), and energy demand (-2% to -12%)[4].

Green revolution and its effects on fine cereals and millets

The major intervention under the green revolution (GR) in India includes the introduction of bundle of technologies called high yielding varietal technologies (HYVT) to then existing agricultural system with a prime goal of yield enhancement to address the food security challenges of its growing population. The HYVT includes introduction of high yielding varieties (HYV) of rice and wheat; use of agro-chemicals like chemical fertilizers and pesticides; farm mechanization including use of tractor, mechanized threshers and pumps to lift groundwater for irrigating crops and controlled water supply to the crops. The seeds of GR yielded following fruits-

(A) Effect on cultivation area: After 1950-51, the gross cultivated area in the country had increased from 129.43 to 153.88 Mha between 1950-51 and 2018-19. The area under rice, wheat, maize and pulse cultivation increased from 30.81 to 45.80 Mha; 9.75 to 31. 1 Mha; 3.18 to 9.90 Mha and 19.09 to 28.80 Mha, respectively between 1950-51 and 2020-21, while the cultivation area under sorghum, pearl millet and total coarse cereals decreased drastically from 15.57 to 4.40 Mha; 9.02 to 7.70 Mha and 37.67 to 24.10 Mha, respectively between 1950-51 and 2020-21 (Fig. 1).

(B) Effect on per capita availability and consumption: Over the period, per capita availability of rice and wheat increased while it declined for the millets (Other cereals in Fig. 2)[6] and consequently the per capita consumption of millets declined (Fig. 3). However, per capita consumption of rice and wheat declined over the period and shifted towards consumption of high value commodities due to growth in per capita income.

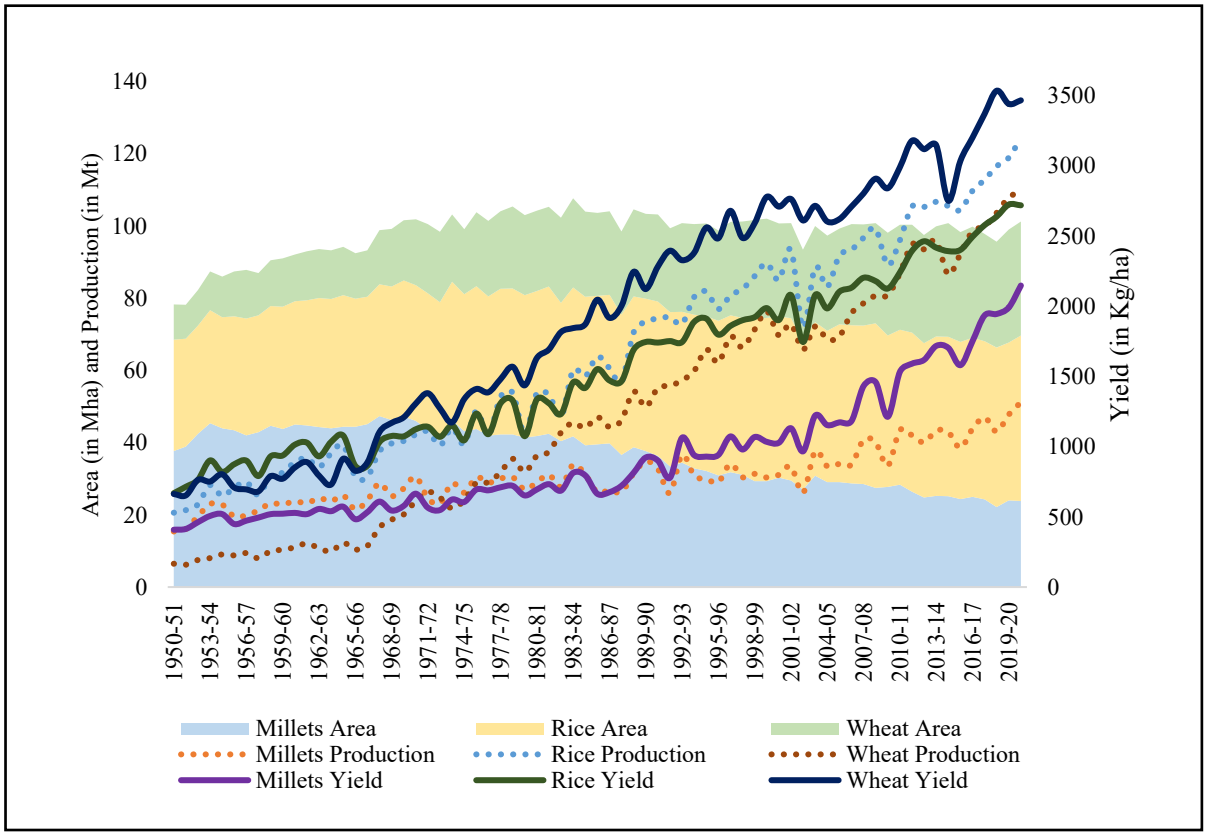

Fig 1: Trends in annual area, production and productivity of rice, wheat and millets

Source: Based on DAC, GoI

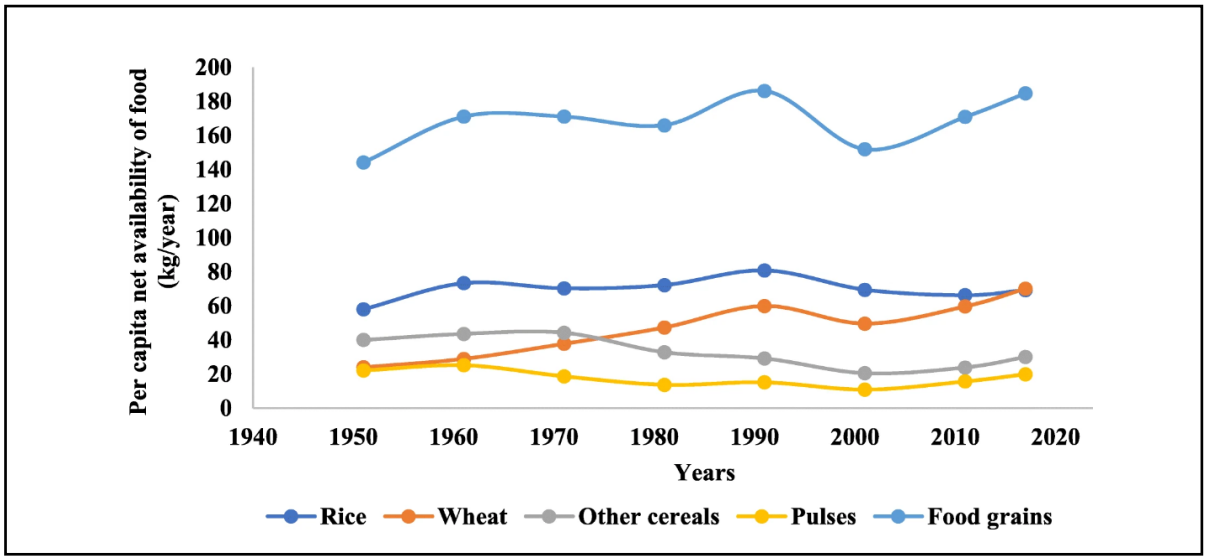

Fig. 2: Per capita net availability of food grains in India since 1951

Source: Eliazer et al., (2019)

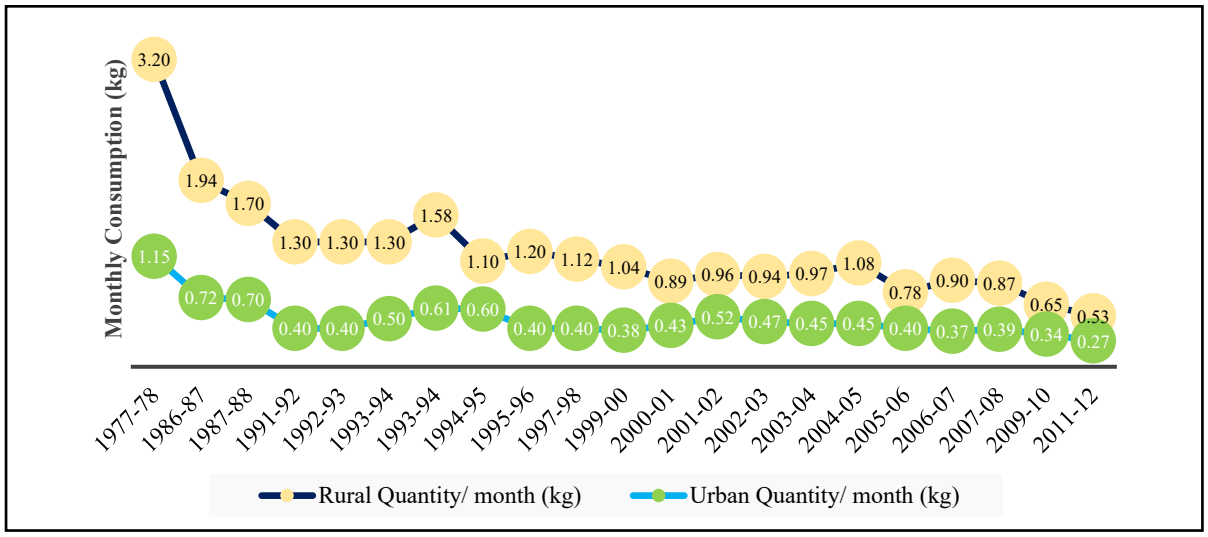

Fig. 3: All India per capita monthly consumption of millets in rural and urban areas

Source: Based on various rounds of NSSO Household Consumption Surveys

How the fine cereals have competed with millets?

The reasons for competition of fine cereals with the millets in food system could be due to: a) area substitution, b) revenue substitution, c) research and development bias, and d) policy prejudice for rice and wheat. Area substitution of millets by the fine cereals could be due to higher profits from cultivation of fine cereals as well as development of irrigation infrastructure which favoured the cultivation of rice and wheat. The irrigation might not only have diverted away the dryland and upland areas from the millets but could have brought additional uncultivable area under the fine cereals. Further, the genetic modification of rice and wheat by introgressing traits for photo insensitivity and reduction in crop duration have also favoured these crops in the intensive cropping systems.

Moreover, the higher yield coupled with price support and market support for rice and wheat would have generated higher per hectare economic returns than their millet counterparts. Consequently, the revenue generated from the fine cereals would have substituted the revenue from millets and motivated farmer's willingness to cultivate less of the millets. The ten year crop varieties registration data with the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA) between 2009 to 2018 further indicates supremacy of fine cereals in the agricultural research agenda of the country while only sorghum and pearl millet got due research attention among the millets (Fig. 4).

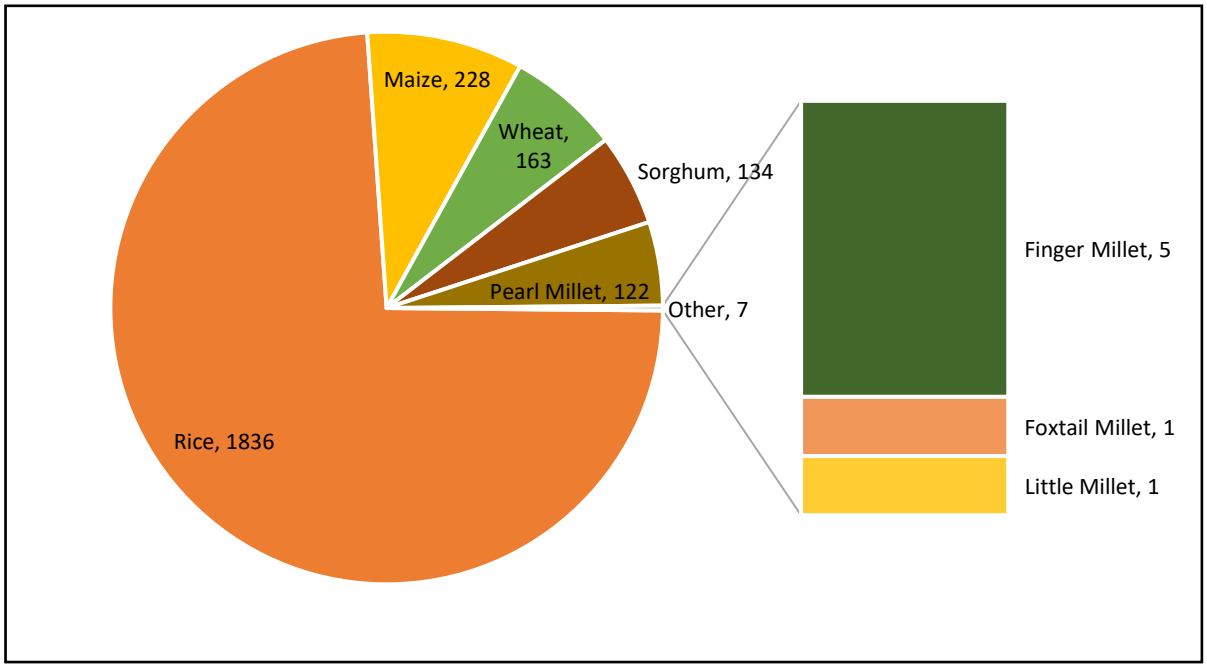

Fig. 4: Number of cereals and millets varieties registered with PPV & FRA during 2009-2018.
Source: PPV&FRA

Additionally, in past few decades policy prejudice towards fine cereals was also observed as there were assured procurement and price support mechanism for rice and wheat and these grains were chief part of social welfare programmes of the government like public distribution system (PDS), Mid day Meal (MDM) and so on unlike the millets. Moreover, the literary evidences suggest that, along with the demand and supply side factors, policy related factors have also fuelled our movement away from the millets. The demand side factors include: a) dietary diversification towards high value commodities, b) rising per capita income and intrusion of western diets in our existing food consumption system, c) perception of poor social status with consumption of millets amidst availability of diverse food alternatives, d) shorter shelf life of processed millets grains and products, e) pre-requisition of skills to process millets grains into ready to eat and other value added products, f) easy availability of cheaper food alternatives, g) inadequate information and awareness on the nutritional benefits of millets etc.

On the other hand, a) poor millet value chain infrastructure, b) relatively lower yield of millets, c) inadequate output price to ensure profitability amidst lower yield, d) inadequate quality seeds availability of millets, e) poor stakeholders linkages in the millet value chain, f) success of green revolution technologies on rice and wheat crops, etc. are some of the supply side factors which led to declining supply of millets in past few decades. On the policy side, input subsidies as well as price support in favour of rice and wheat crops had ignored millet supply as well as their demand.

Future rice market situation and opportunities for millets

The future rice market situation as generated from the rice demand and supply estimation of NITI Aayog suggests that under different scenarios of growth in supply of rice, the country would maintain the surplus of rice in next ten years to come. It is evident from the supply demand balance given in Table 1 that, the extent of surplus would range between 18.50 to 69.24 million tonnes by the year 2032-33[7]. The surplus supply of rice above the future demand gives space for two assertions. First, can the country curtail some of its surplus rice area without affecting the food security of its growing population? and the second, if it do so, can the liberated area be allocated for millets among other crops like pulses or oilseeds?

As per the buffer stocks norms of the government of India for the central pool, the yearly stocks of rice including the operational and strategic reserve should be in the range of 7.61 to 13.58 million tonnes, while the surplus figures given in the table above suggests that the future supply would be in excess of future demand and buffer stock limits had the norms remain unchanged. Thus, the country can take a decision on curtailing surplus rice area and allocating some of the liberated area for the cultivation of millets. This would not only address the problem of surplus food management but also would provide boost to the revival of millets.

Table 1: Rice supply-demand balance (in million tonnes) in India

	Simplistic approach#			Behaviouralist approach#					
				@ 6 per cent GDP growth rate			@ 8 per cent GDP growth rate		
	2021-22	2028-29	2032-33	2021-22	2028-29	2032-33	2021-22	2028-29	2032-33
All India Exp. GR in supply for 10 years	9.12	16.12	20.36	29.61	40.64	47.69	30.84	42.79	50.40
All India Exp. GR in supply for 15 years	9.71	17.73	22.66	30.20	42.25	49.99	31.43	44.40	52.70
State level Exp. GR in supply for 25 years	8.46	14.64	18.50	28.95	39.16	45.83	30.18	41.31	48.54
State level Exp. GR in supply for 35 years	11.44	22.86	30.36	31.93	47.38	57.69	33.16	49.53	60.40
Supply trends in Exp. GR of Pre-Liberalization period*	12.6	22.90	29.10	33.09	47.42	56.43	34.32	49.57	59.14
Supply trends in Exp. GR of Post-Liberalization period*	15.8	30.20	39.20	36.29	54.72	66.53	37.52	56.87	69.24

GR: Growth rate; # approaches of demand estimation

Source: Author's estimation based on NITI Aayog, 2018

Strategies to revive millets in the rice based cropping system

Revival of millets would require both the push (supply side) and pull (demand side) strategies. On the supply side, existing rice based cropping system offers two distinct opportunities for the revival of millets which include: either to replace rice from some regions with millets, or to introduce millets as a sequential crop by intercropping with pulses and oilseeds after rice. However, the first alternative rises few most pertinent questions. First question would be *from where to liberate the rice area*? second, *will millets be the most appropriate crop in the rice liberated areas*? third, *is there sufficient production and post-production infrastructure and facilities available for the promotion of millets so as to economically benefit the farmer*? Steps have been initiated through the National Food Security Mission (NFSM) under 'Nutri-cereal' component to promote the nutri-cereals. According to which, districts with > 10000 ha area under jowar and bajra; >5000 ha under ragi and > 2000 ha under small millets are selected for promotion of nutri-cereals. As of now 202 districts in 14 states have been selected for promoting nutri-cereals under NFSM. However, if targeting rice area for promotion of millets, the knowledge on different agro-ecosystems where rice is being cultivated and the associated pros and cons in rice cultivation in those ecologies would be crucial. Further, the knowledge on the land suitability for rice based on the biophysical and weather parameters would be of immense significance. In India, about 4.8 Mha, or 11 per cent of the nation's total rice acreage, is covered by rainfed upland rice ecosystem. This region is primarily in the Eastern Zone, which includes Assam, Bihar, Chhattisgarh, Eastern Uttar Pradesh, Jharkhand, Madhya Pradesh, Odisha, West Bengal, and the North East Hill Region. The upland rainfed ecosystem is vulnerable to drought. Further, the ICAR-National Rice Research Institute, has delineated suitable areas for rice in the country at the district level based on the biophysical and weather dependent variables. According to which the zones where the North-Eastern states are located are excellent for growing rice. While Eastern states like Chhattisgarh, West Bengal, and Odisha fall inside the suitable or extremely suitable group[8]. The majority of central India is in a zone that is moderately appropriate for rice farming, whereas, the states in the north-west are in an unsuitable zone. The number of districts in India's total number of districts that fall into the categories of very suitable, suitable, somewhat acceptable, and unsuitable are 145, 196, 115, and 207, respectively (Fig. 5).

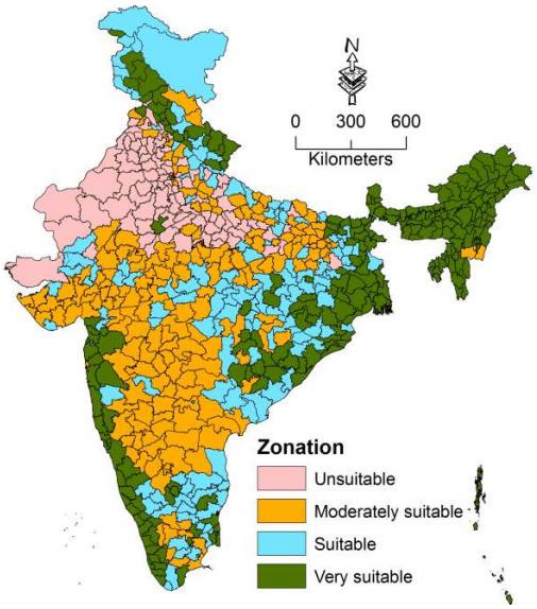

Fig. 5: Unsuitable rice areas which can be liberated in favour of crop diversification

Source: Pathak et al., 2020

These unsuitable districts are located in 15 states but only five states (Punjab, Haryana, Gujarat, Rajasthan and Uttar Pradesh) constitute 93 per cent of these unsuitable rice cultivated areas as well as production, while 21 per cent of rice production of the country comes from these regions. However, there might be certain zones in these states where rice-rice cropping system would be prevailing. In such zones, rice area in *kharif* may be liberated and allocated for other crops including millets. Yet another estimate reports the state wise number of districts where rice productivity is below the productivity of alternative cereals[9]. The state-level yields of *kharif* crops and outcomes of rice replacement scenarios under these estimates are depicted in Table 2.

Table 2: The state-level yields of *kharif* crops and outcomes of rice replacement scenarios

State	Number of rice-growing districts where an alternative cereal yield > rice yield			
	Maize	Sorghum	Pearl Millet	Finger Millet
Andhra Pradesh / Telangana	17	0	0	0
Assam	0	0	0	0
Bihar / Jharkhand	10	3	2	0
Gujarat	4	4	5	1
Haryana	2	0	0	0
Himachal Pradesh	9	0	0	1
Karnataka	11	2	1	0
Kerala	0	0	0	0
Madhya Pradesh / Chhattisgarh	38	31	17	0
Maharashtra	22	14	4	2
Odisha	4	0	0	0
Punjab	1	0	0	0
Rajasthan	7	0	5	0
Tamil Nadu	4	0	0	0
Uttar Pradesh / Uttarakhand	4	1	2	4
West Bengal	6	0	0	0
Total	**139**	**55**	**36**	**8**

Source: Davis et al., 2018

The above database indicates the higher yield potential of alternative cereals over rice in different districts of India. Thus, such information can also be used to identify the target regions for promotion of millets.

To answer the second question, the district agricultural contingency plan (DACP) available with the Ministry of Agriculture and Farmers Welfare, Government of India would be of great use. District level contingency plans are technical documents that contain integrated information on agriculture and allied enterprises, such as horticulture, livestock, poultry, and fisheries, as well as technological solutions for all the major weather-related aberrations, including extreme events such as droughts, floods, heat waves, cold waves, untimely and high intensity rainfall, frost, hailstorms, and pest and disease outbreaks. The DACP also provide information on the alternative crops in the event of any climatic eventualities. Identifying districts and appropriate millet crop for it would address the second question and would help to revive the millet area and production in the country.

Moreover, the answer to third question require a holistic approach from farm to fork. It should consider the seed availability and access, availability of location specific good agricultural practices (GAPs) for the millet cultivation, market and post-harvest infrastructure and stakeholders to provide resilience to the millet value chain, policy support through price incentives and trade facilitation between farmers and other actors and so on. As of now, there are only 25 nutricereal seed hubs spreaded across 12 states in the country which need to be strengthened to produce quality seeds of different millets and supply it to the seed chain on millets for their wider distribution. Additionally, processing of millets require specialised infrastructure and skills. Thus, provision of capacity building and infrastructural support can be crucial to push revival of millets. Government support to the Indian Institute of Millets Research (IIMR), Hyderabad, as the Centre of Excellence for promoting its technologies and best practices in millet farming at an international level is appropriate initiative in this direction.

Contrarily on the demand side, result of a large scale consumer survey on millets by ICRISAT suggests that about 40 per cent of the respondents feel that since millets are not being consumed in their home, they too do not consume it. While about 22 per cent of the respondents do not like its taste, 85 per cent of the respondents knew about the health benefits of millets from the social sources[10]. It suggests the importance of promoting millet consumption through the social platforms and promoting value addition of millets for enhancing its taste and bringing out new and delicious recipies. Further, since the millets are not part of mainstream food system from past few decades, there may be chances that the new generation may not be knowing how to eat it and in what form it can be consumed. In this regard, there is need to promote different recipes of millet based products through different channels to the consumers. Moreover, few states have introduced millets in their mid-day meal (MDM) programme as a nutrient supplement. There is need to learn from their experience and replicate it at larger scale to promote its consumption. Additionally, the push to production coupled with higher food security allocation under the national food security programme (NFSM) would be cruicial to boost its consumption. Moreover, value addition and its exports to the rest of the world would also be a right move in right direction benefiting both the people and planet.

As a second alternative, millets can be introduced as a sequential crop by intercropping with pulses and oilseeds after rice or as a sole crop. In this context, the experience of ICAR-IIMR indicates that the yield of sorghum in rice fallow range between 6-7 t/ha but many contraints are also associated[11]. ICRISAT's 20 year time series data on rice fallows in India suggests that Chhattisgarh has approximately 4.1 Mha of rice fallows, or nearly 35 per cent of all rice fallows, compared to Madhya Pradesh and Odisha, which each have nearly 1.8 Mha of rice fallows, or roughly 15 per cent of all rice fallows, in Indian states. This indicates a high likelihood of interventions in the aforementioned three states. States with 5 to 8 per cent of the overall share include Jharkhand, Maharashtra, and West Bengal, while states with less than 3 per cent of the total share include Telangana, Assam, and a few other states. For any short-crop intensification, even 1 per cent of the rice crop lying fallow equates to 95000 hectares, which is a sizeable area[12]. Such rice fallow areas provide opportunities to introduce short duration millets to utilize the residual soil moisture and bring additional income for the farmers.

Conclusion

For revival of millets amid the fine cereals dominating food production system, a renewed thinking is required. The growing health awareness and per capita consumer income is diversifying food plate of consumers. With these dynamics in socioeconomic conditions, per capita rice consumption is declining while its supply surplus is estimated to grow in future. Thus, surplus supply of rice with India provides opportunities for crop diversification, ameliorating soil health, diversifying food consumption basket, efficient management of foodgrains and live a healthy life. During the "International Year of Millet-2023", the much neglected grains got due attention for their potential to contribute to some of the sustainable developmental goals. In this context, both push and pull strategies need to be judiciously employed for their revival both in the field and the plate.

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