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Millets for Food and Nutrition Security in India: Determinants and Policy Implications

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ABSTRACT

Background: Food security has been a target in India since its independence; the primary aim of food security is to ensure enough staple food for the entire population. Although substantial progress was made through the adoption of green revolution (GR) technologies and implementation of the food public distribution system (PDS), desirable food and nutrition security, as defined by the food and agriculture organization (FAO), is far from being realized. This paper scrutinized the potential contribution of millets in achieving food and nutrition security in India. **Methods**: The present study was conducted based on the secondary data obtained from FAO Corporate Statistical Database and published literature on food and nutrition security. The impact of the GR technologies and the PDS on food and nutrition security was examined using 58 years of acreage, production, and yield of rice, wheat, and millet, as well as comprehensive information on relevant issues including climate. **Results**: Both GR technologies and PDS unduly favored two principal crops, namely rice and wheat, marginalizing all other crops cultivated for thousands of years to meet the food and nutrition requirement of mostly developing countries including India. Millets constitute one such neglected group of crops in India, which have tremendous potential for contributing to food and nutrition security. **Conclusions**: Millets are to be included in the PDS alongside rice and wheat so that they receive an appropriate Minimum Price Support. Appropriate implementation of relevant regulations, continued research and development, and adequate support for cultivation and marketing of millets are necessary in this regard.

Keywords: *Millet; Nutrition security; India*

Introduction

In general, food security of a nation refers to a situation when 'all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (Food and Agriculture Organization, 1996). A deficiency of any component of this condition is an indication of food insecurity. Greater deficit increases the severity of food insecurity. The food and agriculture organization

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(Food and Agriculture Organization, 2013) defined food insecurity as a situation of insufficient access to safe and healthy food. The dimension of food security not only includes stable access to physical availability of food, but also sustained access to appropriate nutrition. The Food and Agriculture Organization (FAO) begins segregating food insecurity into moderate (lack of consistent access to food resulting diminished dietary quality, eating patterns, health, and wellbeing) and severe (running out of food, experiencing hunger, and having health and wellbeing at severe risk) security (Food and Agriculture Organization, 2019). However, nutrition security alone is only implied in the definition of food security without any specific focus. The UN Standing Committee on Nutrition integrates nutrition security explicitly in the situation of food security and coined the term 'food and nutrition security', which defines the condition 'when all people at all times have physical, social and economic access to food, which is consumed in sufficient quantity and quality to meet their dietary needs and food preferences. This condition is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life'. In recent years, 'nutrition security' has gained importance over 'food security'. Ingram suggests using the term 'nutrition security' as he argues that nutrition security encompasses food security (Ingram, 2020). Following the convention, we used the recommendation of the UN Standing Committee on Nutrition as 'food and nutrition security' to express the described condition.

Food security was a target in India since its independence in 1947 and perhaps even before the Great Bengal Famine in 1943-44. The Public Distribution System (PDS) was started as a system of managing food security in the 1940s, which eventually has become an important policy instrument to combat food security in India after independence. Later, the worldwide effort of Green Revolution (GR) to produce cereal foods, especially rice and wheat, to combat the calorie requirement of the increasing population played a significant role in combating food security. Despite considerable improvement in increased food production and improved distribution, ensuring enough food with appropriate nutrition remains elusive for all people at all times. Hunger and malnutrition continued in the world, including India. Although considerable progress has been made in India in improving food and nutrition security, there is still a long way to go. Given the increase of population, climate change, and nutrition requirement, India is faced with a need for new direction and policy to achieve food and nutrition security. On one hand, as a policy perspective, India introduced 'The National Food Security Act (also Right to Food Act) in 2013. The Act aims to provide subsidized food grains to approximately two-thirds of India's 1.3 billion people. On the other hand, for diversification of food production and grain-mix in the PDS, India has given importance to millets. Millets, a group of hardy and drought-resistant cereal crops, have been incorporated in the cropping system to improve food and nutritional security. In this study, the potential of millets to combat food and nutrition insecurity was explored in India with special focus on what determines its contribution and what policy actions are necessary.

Data and information sources

The study was conducted using systematic analysis of data obtained from the data centers of FAO of the United Nations and published articles on food and nutrition security in India. Crop production information, including total production and acreage for two targeted crops of GR technologies (rice and wheat) along with millets for 58 years (from 1961 to 2018) were collected from FAO Corporate Statistical Database (FAOSTAT). Trends on both production and acreage of all three crops were compared to examine the impact of GR technologies and PDS.

Another source of information in this research included the critical examination of relevant literature. Published articles, books, research reports, and authentic news, articles on the production, consumption, and development of millets as part of food and nutrition security were

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reviewed as exhaustively as possible for their nutritional performance and environmental adaptability, particularly drought resistance. Evolutionary progress of millets with their genetic improvement through research and development was also included.

Food and nutrition security in India

Although food security has been a target for a long time, nutrition security has been added recently. As Varadharajan et al. rightfully point out the issue of 'the double burden' – undernutrition (malnutrition) on the one hand and the over-nutrition (overweight and obesity) on the other hand that continues to increase all over the world (Varadharajan *et al.*, 2013). India is not exception, with severe malnutrition as a serious problem. Both the PDS and the GR technologies focused on the availability, adequacy, and access to foods, where food was defined in terms of cereals especially rice and wheat. Both efforts produced successful results in terms of increasing production and improved distribution. India has become self-sufficient in producing rice and wheat despite the growth in population. The number of people undernourished did not increase notwithstanding the increasing population; rather the intake of dietary energy and protein has increased during the last two decades (**Table 1**).

Ensuring food and nutrition security for a huge and diverse population in India, at the macro and micro-level, is a challenge and efforts have been made in many different fronts. There is little doubt that considerable efforts for achieving food and nutrition security in India have been made in the recent past and the progress made cannot be undermined. However, food insecurity and malnutrition seem to persist and perhaps will remain in the foreseeable future, unless concerted efforts are made. Thus, food and nutrition security continues to remain a target with an objective of sustained improvement. Rai et al. recommended a life-cycle approach of fivefold strategy–improving reproductive health, bolstering citizens' participation in national programs, empowering women, advancing agriculture, and better monitoring the PDS (Rai *et al.*, 2015). Ritchie et al. suggested a combined approach of maximizing domestic food production and increasing participation of global food trade to address adequate food and nutrition supply of India (Ritchie *et al.*, 2018). A SWOT analysis of the food security system in India by Pillay and Kumar, identifies two major strengths on the progress of food security in India–achieving self-sufficiency in the production of cereals (mainly rice and wheat) and implementing the PDS (Pillay and Kumar, 2018). Major identified weaknesses included inefficiency in post-harvest storage and transit, as well as lack of inclusion of large number of farmers and crops in the Minimum Price Support (MPS) system. However, much of their analysis is based on overall food production, the distribution system and policy issues, and not focusing on the neglected crop, i.e., millets. Recent studies by Chander et al. and George and McKay (Chander *et al.*, 2017, George and McKay, 2019) reported that the PDS system has achieved some degree of success in improving food security in India, but it has not been able to achieve food and nutrition security at the desired level, nor to address the malnutrition and childhood morbidity.

Climate change and crop diversification were among the two areas of ensuring food and nutrition security in India that received little attention. Sharma and Sharma (Sharma and Sharma, 2017) identify limited land and water availability, dwindling natural resources, climate change, and labor shortages as the challenges to achieve food and nutrition security. Climate change is a natural phenomenon with considerable impact on food production system, including food and nutrition security in the world and India is not an exception. The National Intelligence Council report on India suggests that a warming of 0.5 ^{o}C in India is likely by 2030 with a 2–4 ^{o}C rise in temperature by the end of the century. This will result in uneven rainfall, drought, and flooding, which will affect the agriculture and water availability. Historically, India has suffered from drought and flood, which frequency is expected to increase. **Figure 1** illustrates major cropping regions of India. In

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general, India's prime agricultural areas are drought-prone, which is expected to become more vulnerable due to climate change.

Crop diversification is another area that needs attention to improve food and nutrition security. Historically, India has been the home of multiple fields, homestead, and orchard crops. However, implementation of GR technologies focused on major cereal crops, primarily rice, and wheat, taking away emphasis from other crops. Even the recent National Food Security Mission action plan (2014) focused primarily on food grain production with limited access to pulses and coarse cereals. The over-emphasis on major cereals (rice and wheat) and de-emphasis on legumes and coarse cereals caused an increase in overall food production, but failed to improve the nutritional security. Indeed, pulses and coarse cereals have not been included in the PDS. Sarkar and VanLoon suggested an overhaul of PDS and included course cereals and legumes in the PDS to improve their demand (Sarkar, 2015). Diversification of the production system by including drought-resistant crops into the cropping system can improve nutritional security in India. Millets, a group of coarse grain cereals, can play a significant role to this end.

Millets as contributors of nutritional security in India

Millets are a group of diverse small-grain cereal crops grown in marginal soil and under stressed conditions. They comprise about a dozen crop species originated in Asia and Africa, primarily in the third world countries (Gupta *et al.*, 2017). India is the largest producer of millets producing nearly 40 percent of the world's millets despite much negative pressure from competing crops in terms of policies and production supports. Among several types of millets (pearl millet, finger millet, proso millet, foxtail millet, guinea millet, little millet, barnyard millet, etc.), pearl millet is the most common in India accounting for nearly 75 percent of the total area devoted to millets (Bhagavatula *et al.*, 2013). The millets' ability to adapt to adverse climatic conditions, requirement of minimal inputs, and superior nutritional qualities are among the specific characteristics of millets rarely found in other common cereals.

Millets possess specific molecular, biochemical, and morpho-physiological characteristics that allow them to withstand adverse environmental conditions–drought and poor soil conditions (Bandyopadhyay *et al.*, 2017). Their shorter lifecycle, short stature, and small leaf area may also offer an added advantage. Considering their adaptability to high light, high temperature, and dry weather as C4 photosynthetic capacity, millets are more efficient than common cereal crops. These mechanisms allow millets to have enhanced photosynthetic rates and lower photorespiration rates, as well as water and nitrogen use efficiency under warm conditions (Bandyopadhyay *et al.*, 2017). The millet producing areas of India as shown in **Figure 1** are on the western part, which are susceptible to drought.

Millets are important sources of nutrients and can play a significant role in improving nutritional security and preventing diseases caused by imbalanced nutrition. They are gluten-free and contain as much protein as wheat does. In terms of macronutrients, millets are either similar or superior to major cereals (Kumar *et al.*, 2018). They also contain several micronutrients, vitamins, insoluble dietary fiber, and phenolic compounds, which are essential for health benefits. They are thought to have several health benefits including the ability to address diabetes, aging, cancer, celiac disease, and cardio-vascular disease (Bhat *et al.*, 2018). Millet-based health food items are common and exhibit longer storage life. Durairaj et al. observed a significant increase in height, weight, and hemoglobin level of the school children who regularly consumed millet-based health food (Durairaj *et al.*, 2019). Even though millets are produced in adverse climatic conditions and can provide nutrition that otherwise are hard to find, their acreage continues to decline, and production and yield have stagnated. Between 1966 and 2006, India lost 44% of millet cultivation areas to other crops due to lack of policy support.

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Figure 2 provides acreage and production of millets along with rice and wheat. During the last half a century, the acreage and production of rice and wheat continued to increase in India; whereas, the total acreage devoted to millets declined and production remained the same. This is primarily due to the little attention paid to millets by researchers and policy makers except some sporadic effort of developing and adopting high-yielding and drought-prone varieties resulting to a static level of production despite declining acreages. Considering such negligence, Gupta et al. (Gupta *et al.*, 2017) termed millets as "Orphan crops" or "Lost crops". Indeed, in recent years, many countries have started focusing on the 'Neglected and Underutilized Species (NUS)' for sustainable livelihood of people living in the developing countries for secure food and nutrition supply.

Millets have been neglected due to the following possible reasons. First, these crops are mostly used by low-income subsistence farmers living in arid or semi-arid regions of Asia and Africa, who have little aspirations and aim to produce more, rather than to increase the crops' quality. They also have limited access to technology due to several factors, such as limited education and finance. Second, millets are among the food choices of low-income households. Third, which is perhaps the most important reason, is the explicit lack of attention to millets both from researchers as well as from policy makers. Only recently, some attention has been paid to breed better yielding and higher quality varieties of millets, as staple foods in the PDS in some states of India.

National and international policies toward millets

Agricultural production system was primitive in pre-independence India and no policies were planned for developing agriculture. However, since its independence, agricultural production received great attention due to food shortages and famines. Production increased substantially and India adopted the GR technologies along with other developing countries. Followed by adoption of the GR technologies, the total agricultural production increased considerably, but the benefits of such production neither increased equity among farmers nor among consumers. The development of technologies and associated policies were (and still are) biased toward rice, wheat, and maize. Today, under the umbrella of CGIAR, two research centers were devoted exclusively to improve rice production (International Rice Research Institute and African Rice Center); a center was devoted specifically for wheat and maize (International Maize and Wheat Improvement Center) and a center was devoted to potatoes (International Potato Center). The results of these international efforts are different high-yielding, short-duration varieties of rice, wheat, and maize. Rice, wheat, maize, and potato are all sources of carbohydrates. Such preferences, from demand and supply side, led to biased and narrow production systems in agriculture favoring toward those major crops. This process targeted at a production system on major carbohydrate-rich crops marginalizing all other crops that have traditionally been cultivated and consumed in the developing countries for thousands of years as subsistence agriculture. In India, millets are the fourth major crops after rice, wheat, and sorghum. Despite all the above-mentioned ideas, little effort has been done for improving millets worldwide. Although some development effort was made for pearl millet in India, but all other crops took the back seat and eventually led toward the verge of extinction since they cannot compete technologically and economically.

Given these circumstances, research and development on millets have been far from systematic though not completely absent. Among the groups, pearl millet received relatively better attention simply because of its volume and acreage. Although the GR efforts did not continue directly, breeding programs on pearl millet continued in India and no increase in yield was noticed in the latter half of 20th century (Khairwal and Improvement, 2005). Despite an improvement in yield, production remained static as the area under cultivation continued to decline losing

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ground to rice and wheat. Relative to rice and wheat, the investment on millet research and development was negligible and no policy support involved, until recently, for the improvement of millets.

Recently, the situation has changed, though not significantly, with millets and other NUS crops gaining some attention for research, development, and policy support worldwide. This is especially true after researchers and policy makers become concerned about the nature and degree of nutritional deficiency among people that had enough access to food but with little variety. Research efforts on millets are growing to improve yield, disease resistance, and wider adaptability. Policy support is also growing both for research and development to support the supply side and the incorporation in the PDS to support the demand side.

Given that the nutritional security is a global phenomenon, India has joined the international partners and governments to implement policies and regulations that would offer support to the NUSs including millets. The Seeds Act 1966, the Patent Act 1970, the Protection of Plant Variety and Farmers' Rights Act 2002, and the Biological Diversity Act 2002 are some of the regulations that offer support to the continuing development of the supply side of millets with appropriate implementation. Similarly, appropriate incorporation of millets in the PDS, along with applicable MPS, can improve the demand side of millets.

Table 1. Food and nutrition security in India (figures are on averages for three consecutive years, except for percent women anemic, which is for the middle year)

Average of three years	Dietary energy supply (%)	Value of food production ($/capita)	Dietary energy from cereals, roots, tubers (kcal/cap/d)	Protein supply (g/cap/d)	Animal protein (g/cap/d)	Percent under-nourished	People undernourished (mill)	women anemic (15-49 y) %
1999-01	103	150	63	56.3	9.0	18.2	191.2	53.3
2000-02	101	144	63	55.3	9.0	18.6	199.6	53.3
2001-03	100	145	62	54.7	9.0	20.2	220.7	53.3
2002-04	99	142	62	54.0	9.0	21.7	240.7	53.3
2003-05	100	146	62	53.7	9.3	22.2	251.1	53.3
2004-06	101	148	62	54.0	9.7	21.7	249.4	53.2
2005-07	103	156	61	55.0	10.3	19.8	230.3	53.0
2006-08	104	162	60	56.7	10.7	17.6	208.7	52.7
2007-09	104	164	60	57.3	11.0	16.7	200.6	52.4
2008-10	104	165	59	58.0	11.0	16.4	199.6	52.0
2009-11	104	169	59	58.7	11.3	16.3	200.9	51.7
2010-12	105	176	58	59.3	11.7	16.3	203.6	51.5
2011-13	105	181	58	59.7	11.7	16.3	206.4	51.3
2012-14	106	184		60.0	11.7	15.9	203.8	51.2
2013-15	106	185		60.7	12.0	15.3	198.3	51.1
2014-16	107	186		61.7	13.0	14.7	193.1	51.2
2015-17	108			63.0	13.7	14.4	190.9	51.4
2016-18	109					14.2	190.1	
2017-19						14.0	189.2	

Source: FAO http://www.fao.org/faostat/en/#data/FS

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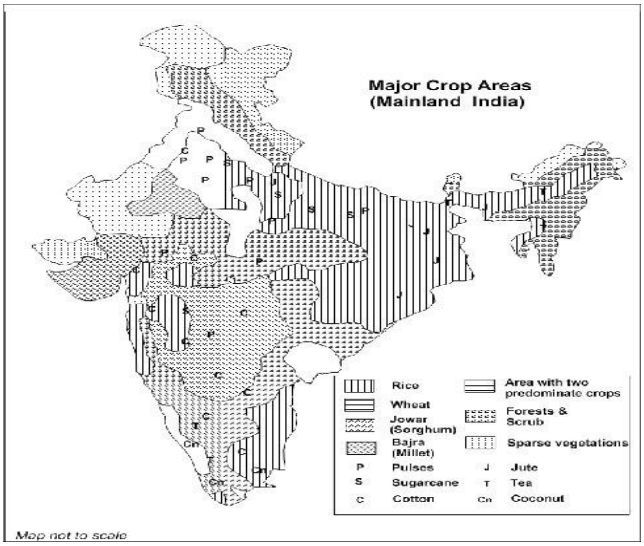

Figure 1. Major cropping regions of India(Gurditta and Singh, 2016).

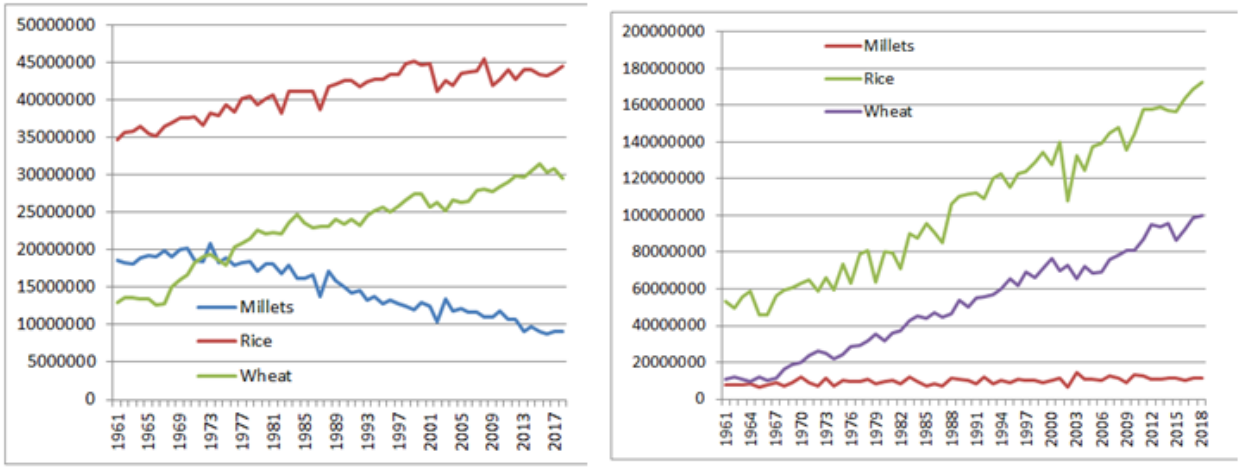

Figure 2. Acreage and production of millet, rice, and wheat [Left: acreage in hectares; right: production in tons]

Conclusion

It was realized that millets have substantial potential to contribute toward food and nutritional security in India. As a result, millets should be brought out of NUS and considered as another staple food along with rice and wheat. Accordingly, research and development efforts and policy formulations are required; some steps have been taken throughout the world, especially in India. However, these efforts are far from adequate. On the supply side, appropriate implementation of the relevant regulations is necessary to ensure continued research and development for improved varieties, availability of quality seeds, adequate support for cultivation, satisfactory technology for processing, and marketing millets. On the demand side, millets should be included in the PDS along with rice and wheat, so that they receive an appropriate MPS. At the same time, focused marketing strategies and product development of new and better millet-based products are needed.

Authors' Contributions

Islam S designed the study, reviewed the literature, collected data, organized the information, developed the draft, and formatted the manuscript. Manaloor V conceived the idea,

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reviewed literature, organized the information, and edited the manuscript. Both authors read and approved the final manuscript.

Conflicts of interests

The authors declare no conflict of interests.

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