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POLICY BRIEF

# Role of Mechanization Towards a Sustainable Revival of Millet Cultivation

**Acknowledgements:** This paper was developed by Subir Kumar Chakraborty, Narendra Singh Chandel and Champat Raj Mehta, and for the Centre for Sustainable Agricultural Mechanization (CSAM).



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# Executive Summary

Realization of agricultural production goals while compromising environmental issues is a common concern that reverberates across the globe. Fragile agricultural eco-system of Asia-Pacific region in terms of its susceptibility to climate change imperatives can be checked by widespread adoption of millet cultivation. This will not only nurture the owners of small and fragmented land holdings having high dependence on rainfed agriculture but will also suit the low investment capacity of the farmers and the ecological limitations of this region. Millet cultivation will deplete the overall contribution of agriculture to climate change and shall provide solutions to tackle the nutritional challenges of the vulnerable population groups.

There are numerous markers to indicate an overall dearth of agricultural mechanization in the Asia-Pacific region. Pre and post-harvest operations associated with millet cultivation lack the machinery-based solutions in terms of technology, machinery, trained personnel and protocols for processing operations, grain handling and storage.

This policy paper attempts to justify adoption of millets in the Asia-Pacific region and reports the trend in production and extant of spread of millet agriculture across the region. In particular, it introduces the readers to a road map for the promotion of millets to plug the gaps and counter the constraints so that a sustainable comprehensive pre and post production mechanization of millet agriculture can be realised. The paper highlights about the availability of equipment and machinery for tillage, sowing and harvesting; also brings to the fore a complete value chain for post-harvest processing of millets along with the primary and secondary operations leading to the generation of value added products.

The recommendations of this policy paper bench upon the actions required right from the approaches for sustainable mechanization in line with that available for major cereal crops along with the associated government support. It also delves upon the total value chain of the millets to make value addition viable and marketable. All the recommendations are in sync with the millet producing countries of the Asia-Pacific region for adoptable farm mechanization and post-harvest solutions towards an uninterrupted acceptance of millet in the agrarian eco-system of this region.

# I. Introduction

Attainment of the seventeen sustainable development goals of the United Nations relies heavily upon the shape and form of the agriculture and food systems of the future. Having said that one has to be mindful of the fact that agriculture is one sector which is most vulnerable and at the same time the biggest contributor to climate change. The agri-food sector alone contributes to more than 33 per cent of anthropogenic greenhouse gas emissions. The vagaries of climate change are hitting the already fragile agriculture sector of Asia-Pacific region mired with, small and fragmented land holdings, inefficient and obsolete gender insensitive technologies, rainfed agriculture, high level of land degradations and so on. All this is leading to low farm productivity with depleted farm incomes. Mechanization can offer a multitude of solutions for countering the climate change challenges for agriculture of the Asia-Pacific region in terms of increasing agricultural income, reducing drudgery of agricultural workers and combating land degradation.

Millets are also called nutri-cereals because of the wide array of nutritional benefits that they offer, high protein content make them a perfect replacement for the protein requirement of the vegans and the vegetarians. As compared to traditional cereals like wheat and rice; millets have a far better content of folic acid, iron, zinc, calcium, etc. and on top of that they have a low glycemic index (Chakraborty et al., 2020). Spiraling health concerns post the COVID pandemic has made a major chunk of world population shift from popular junk foods to healthy food options like millets due to their health boosting and immunity enhancing properties. This has also induced a sudden spurt in the millet-based products market. It is anticipated that the present millet market size of US$11.5 billion is expected to grow at a CAGR of 4.6% and attain a US$14.4 billion market by 2029 (Anon. 2024a).

Millets are climate-smart crop that can resist drought and are almost immune to fertility of the soil. They also help in soil health by adding a lot of organic matter to the soil, improve its water holding capacity and reduce the greenhouse emissions. At present millets are cultivated in the dry, semi-arid and sub-humid regions of the world in an area of more than 32 million hectare. The major millet producing countries are India, Niger and China, and account for 55% of the global production. Coming with a baggage of so many benefits, it is pathetic that over the past sixty years the area under the millet cultivation in India has been decreasing, over the last decade the productivity has marginally increased; while production has almost remained constant (Fig. 1). Other countries in the Asia-Pacific region like Bangladesh, Democratic People's Republic of Korea, Myanmar, Nepal, Pakistan, and Viet Nam have produced more than 10 thousand metric tonnes of millets annually during the past couple of years. Cultivation of millets is also picking up in Afghanistan, Japan, New Zealand, and Republic of Korea.

The United Nations General Assembly at its 75th session in March 2021 declared 2023 the International Year of Millets (IYM 2023) upon the proposal of the government of India. Hopefully, this will give the spurt in the right spirit for the traditional methods of farming that practice and promote multi, mixed and inter-cropping to support the farmers against the monsoonal failures and ensures a sustainable livelihood. India is the largest producer of millets. The government of India started promoting millet in October 2007 by including millets in the National Food Security Mission; again millets were promoted under the Initiatives for Nutritional Security through Intensive Millets Promotion (INSIHP) from 2011-12 to 2013-24. The Indian government took up the case of millet popularization with renewed vigour and earnest by declaring 2018 as "Millet Year", and a nationwide campaign was

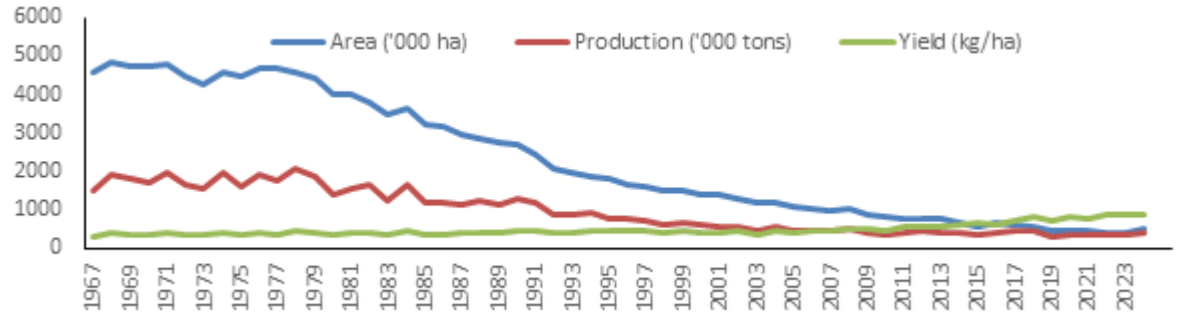


*Fig. 1 Trend of area under cultivation, production and yield of minor millets in India (Anon. 2024b).*

unleashed for mechanization of millet production, technology dissemination, creating millet seed hubs, fixing minimum support prices and its inclusion in public distribution system.

The utilization of machinery to enhance the mechanization of the millets production in India has consistently been a key topic of discussion associated with improving productivity. From 2005 onwards, the use of tractors and machinery became prevalent in millet-growing regions, often provided as a package of customer services, primarily through the rental market (Mehta et al., 2014). Presently, mechanized cultivation represents a rapidly expanding technological sector in India, driven by the government's incentives in the form of purchase subsidies on agricultural machinery through direct benefit transfer (DBT) scheme. As of 2021-22, the overall level of farm mechanization in India stood at 47% (Mehta et al., 2023). Among the major crops, wheat, rice, and maize have attained high mechanization levels of 69%, 53%, and 46%, respectively. These are followed by pulses (41%), oilseeds (39%), cotton (36%), sugarcane (35%), and millets (33%). The low level of mechanization in millet cultivation varies significantly, influenced by factors such as the economic conditions of farmers, access to technology, and the distinct characteristics of millet farming across diverse agro-climatic regions. Moreover, various challenges that are encountered in the adoption of mechanized solutions include the relatively high initial cost of machines, absence of proper training, potential environmental considerations, and socio-economic factors. The non-adoption of modern machinery not only contributes to a low level of mechanization but also exacerbates labour-intensive efforts, increases cultivation costs, prolongs the time spent in the field, and diminishes overall returns.

Reduced mechanized processing has been associated with increased post-harvest losses across the entire gamut of agricultural field and orchard produces. Mechanized operations result in a decrease of human interventions thus making the output consistent in quality, ultimately leading to an increase in the farmers' income. Millets are grown by marginal farmers; in this eco-system women are the key actors in the agri-food system (Sukumaran et al., 2023). They carry out the processing of millets by hand pounding to get the millet rice to be used for various culinary, social and religious purposes.

This policy document focuses on how mechanization of production and processing of millets can help in its sustainable popularization along with increasing its palatability and consumer acceptance while overcoming the associated challenges that plague it otherwise. There are also recommendations to give cues to the policy makers and front-line workers about how the aforesaid goals can be realized in real life conditions adoptable under the field conditions.

# II. Mechanization of Millets Production

Embracement of mechanized production will lead to transformation of millet production, improving productivity, and implementation of national level government policy and reforms. This in turn shall alleviate the strain on the inter-connected nexus of land, water, and energy, resulting in environmental benefits and contributing to negating the climate change causing footprints. Research and development in the field of machinery for millet production has been given high priority by the Indian Council Agricultural Research (ICAR), State Agricultural Universities, research institutions, and the agricultural machinery manufacturers. Specifically, there has been an increase in state support for projects, coupled with funding for the agricultural machinery industry sourced from entities such as the National Innovation Foundation (NIF), Sub-Mission on Agricultural Mechanization (SMAM), Rashtriya Krishi Vikas Yojana (RKVY), and other scientific research and extension initiatives. Enterprises relevant to the field have also intensified their research and development efforts focusing on seed preservation, enhanced crop protection, and the development of efficient, low-loss harvesting and threshing machinery focused for the millet production eco-system (Nandede, et al., 2018). Additionally, extensive research is being conducted on technologies for small seed sowing, intercultural machinery, light-weight multi-millet threshers, and efficient millet harvesting machinery. Research endeavours have covered animal, power tiller and tractor operated technologies for precision seeding and planting of millets. Thorough studies on threshing and cleaning devices of harvesting machinery aimed at enhancing threshing quality, cleaning efficiency and reducing loss and impurities are high priority research aimed at improving the millet production system.

While enhancing millet production and productivity without expanding the cultivated area is feasible through the mechanization of production and post-production operations within designated catchment areas, the mechanization of pre-production operations presents significant challenges. Challenges in this regard include a lack of awareness about new machines, limited availability of machinery in production catchment, inadequate financial support for adopting new technologies, insufficient training of extension workers in machine functionality and compliance with standards requirements. Recognizing the paramount importance of increasing millet production, the Government of India has prioritized this goal and implemented a series of measures in the recent years. These measures encompass heightened publicity, increased training initiatives, and enhanced technical guidance.

ICAR-Central Institute of Agricultural Engineering (CIAE), Bhopal, India under the Ministry of Agriculture and Farmers' Welfare, Government of India have modelled a complete comprehensive spread of activities focused toward promotion of millet cultivation, especially on the mechanization aspects (Fig. 2). Thorough research and development considering all the agronomical aspects of millet, seed morphology, field requirement, etc. are considered for development of pre-production implements and machinery (Fig. 3); while the seed morphology, compositional characteristics, etc. are considered before developing the post-harvest machines. Success in the targeted end-use of the conceptual design leads to its maturation as a technology which is then handed over to a firm for mass manufacturing. Emulating a perfect example of public-private collaboration for betterment of the agrarian society. The popular technologies are further facilitated to government sponsored schemes so that the penetration of the technology can be increased and all farmers can benefit. At present there is a whole

gamut of technologies starting from land preparation, sowing, inter-culture, harvesting, threshing to post-harvest equipment like millet mill, popping machines and other value addition machines. With these technologies in the offing, ICAR-CIAE is also mentoring farmer producer organizations, non-government organizations, start-ups, etc. and fostering the growth and promotion of millet agriculture.

Prevalence of similar socio-political and agro-economical fabric across the countries of the Asia-Pacific region makes a perfect case for the emulation of the aforesaid model in their millet production catchment to fulfil the long-term goals of sustainable growth with assured nutritional security while protecting the agrarian communities from the vulnerabilities of climate change.

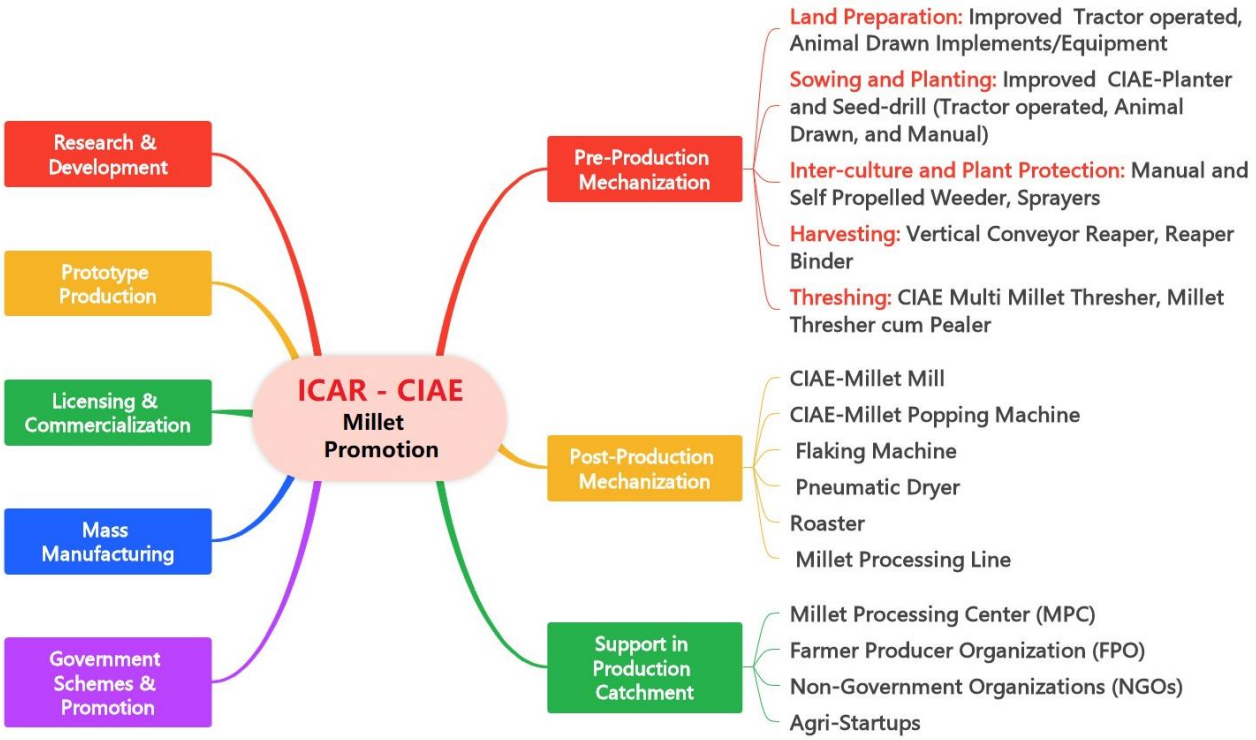


*Fig. 2 Pictorial representation of the methodological approach modelled by ICAR-CIAE for promotion of millets in India.*

*(a)*

*(b)*


*(c)*

*(d)*

*Fig. 3 Technologies developed for mechanization of millet agriculture: (a) Animal drawn three-row millet seed drill (b) Tractor operated six-row millet planter (c) Reaper binder for minor millet harvesting (d) Multi-millet thresher*

# III. Post-Harvest Mechanization of Millets

Processing of millets involves hardship; be it being done by middle aged tribal women in a remote village or a progressive millet processor attempting to use mechanized means for the same. Mechanized interventions for millet milling are available with a set of machines comprising a destoner, a millet dehusker and a millet rice polisher. The small size of millet grains affects the cleaning machines with many challenges. The morphology of the millet grain is such that germ is perched right at the outer periphery of endosperm just beneath the husk. A slight variation in the adjustments of the dehusker or polisher results in exposing the germ of the grain to air resulting in the spoilage of grain and making it unsuitable for storage.

Finger millet (ragi), however, is easy to process and has got community acceptability in its production catchment. It also increases soil fertility and can be easily inter-cropped; in other words, ragi pose a threat to the prosperity and promotion of minor (little, kodo, barnyard, foxtail, etc.) millet crops. Over sorghum and ragi, minor millet grains have a tougher seed coat and are more difficult to process. It is therefore imperative that the processing facilities for millets should facilitate multi-commodity processing for varied end uses. This would not only make such facilities viable but would encourage and promote sustained multi-cropping resulting in an improved soil fertility with improved carbon. One of the key drivers to process millets is the nutritional value associated with them. Millets are generally bland to taste. Less or no irrigation requirement during their cultivation results in the presence of non-sweet carbohydrates. This also prevents the locust attack in the millet fields which in turn enables the cultivation of millet with limited to no application of chemical insecticides and pesticides. However, there are anti-nutritional factors present in millets which hinder its popular food acceptance amongst the general public.

Various value-added products can be derived from every stage of millet value chain (Fig. 4). The biomass generated from the millet crop is a popular animal feed, while the biomass slurry can be used for green energy generation. Almost all the value-added products common to paddy stand for millet as well, be it popping, parboiled grains, malt slurry, etc. Over the time research and development work in the area of post-harvest value addition of millets have resulted in creation of dedicated machines certified by the Bureau of Indian Standards (BIS) for millet processing viz. millet cleaner cum grader (IS 19039:2023), millet dehusker (IS 19040:2023) and millet destoner (IS 19041:2023).

Technologies like millet-based extruded products, millet-based bakery products, smoothies, weaning foods, geriatric foods, etc. are all available off the shelves routed through scientific journals, magazines and plethora of other resources.

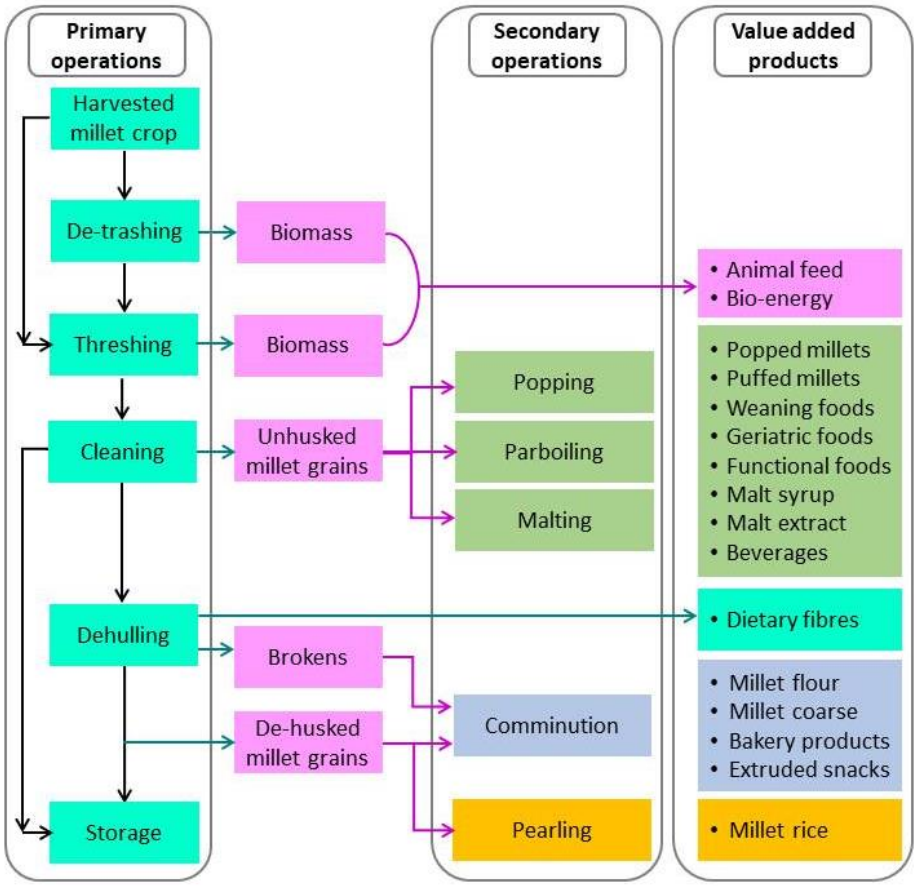


*Fig. 4 Flowchart of operation-specific process paths for generating value added products in the millet value chain.*

A major impediment to the popularization of millets is the perception of the public towards millets as a "poor's food". It is therefore pertinent to include millets into development of processed foods which are generally made from major cereals. Absence of standards for processed millet products is a genuine bottleneck for promotion and commercial viability of the value-added products.

In India, a sizeable portion of the millets is grown by the tribal farmers in pockets inhospitable for major cereal grains and other cash crops. ICAR-CIAE identified one such production catchment in central India where the lack of millet processing facilities was forcing the farmers to sell their produce off to the traders at hearsay prices resulting in a depleting popularity towards the crop amongst the community. With the aim of promotion of mechanized millet processing right in the core millet production catchment, a Millet Processing Centre (MPC) has been established by ICAR-CIAE in collaboration with a non-government organization (NGO) (Fig. 5).


*(a)*


*(b)*

*Fig. 5 Outreach activity for technology dissemination related to post-harvest mechanization of millet processing (a) Millet processing centre (b) Women self-help group operating the processing centre to produce value added commodities from millets.*

The MPC is equipped with millet thresher, millet mill, de-stoner cum grader, grain polisher, pulveriser, flour sifter and a packaging machine leading to products like, threshed millet, millet rice, millet flour and millet coarse (Chakraborty et al., 2018). It is run by the women self-help group of the NGO and is catering to more than 400 farming families, resulting in a total saving of 56% in the cost of production of milled millet (millet rice) as compared to manual processing, and enhancing the selling price of millet rice by more than 36% (based on 2011 base price). The local agricultural office ratifies that the area under millet cultivation has increased by more than 30% post the creation of MPC. This is a typical example of empowering women while catering to climate-friendly local needs while reviving a traditional crop. Similar MPCs based on the aforesaid model are working successfully in the tribal belts of southern India as well. Also, MPCs have been set up at different locations of central India, wherein FPOs and Agri Start-ups are working successfully with millet based post-harvest machineries and are commercially producing value added products. Millet is produced all across the Asia-Pacific region; societal adoption of above said model will yield rich benefits nutritionally and economically in a climate friendly manner.

# IV. Recommendations

Loss-reducing mechanized interventions bolstered with technical and policy support covering all the aspects of millet production and processing, encompassing land preparation, sowing, harvesting, processing, storage and transportation have to be addressed in a need-of-the-hour approach to foster this ancient climate-savvy crop. The governments have to ensure that there is perfect synchronization between the technical requirements and policy support while keeping into loop the machinery manufacturers, processors, farmers, funding agencies, NGO's, FPO's etc. Millet mechanization and the geographical spread of area under millet cultivation will align with some of the Sustainable Development Goals; viz. Goal 1 (No poverty), Goal 2 (Zero Hunger), Goal 3 (Good Health and Wellbeing), Goal 12 (Responsible Consumption and Production) and Goal 13 (Climate Action). Some of the recommendations that can be useful for the apropos interest groups are:

- The application of high-efficiency and low-loss millet production machinery at par with wheat and paddy needs to be expanded further to ensure a more balanced and comprehensive approach across millet growing regions.
- There is an urgent need to intensify research efforts, particularly focused on development of farm machinery, like efficient millet harvesters and precision multi-millet threshers.
- Smart mechanization tools have to be applied to millet farming as well. This would not only keep in check food loss and waste to mitigate climate change impact but also attract youth to take up farming of millets.
- The millet processing machines should be multi-crop friendly; ensuring better economics of the installed machineries and encouraging farmers to persist with multi-cropping agriculture.
- There is an urgent need to establish quality standards for various value-added millet products. Clear cut definition in terms of nutrition levels, physical properties, allowances of anti-nutritional factors, packaging materials and storage conditions need to be documented and listed in gazettes.
- There is a need to include different agricultural machinery suitable for production and post production mechanization of millets under different subsidy schemes of government for their promotion and reduce cost of cultivation.
- Seed subsidy is given for certified and released seeds only, whereas millet farmers are using whatever is available to them. Addressing these issues is crucial for advancing agricultural technology and ensuring sustainable millet production.
- State-sponsored national and regional initiatives for creation and promotion of entrepreneurship in the area of post-harvest processing and management of millets in the form of business models, either solo or in private-public partnership models are need-of-the-hour.
- Millets being climate-resilient crops, the mechanization initiatives should be resilient with climate-change policies. Rather than relying on petroleum-powered mechanization, solar or electric-operated eco-friendly machinery will enhance efficiency across various operations, from planting to harvesting.
- Everlasting growth in the area of millet production can be achieved only when mechanized harvesting and post-harvest solutions for millets are to be backed up with a solid framework to elicit feedback from the farmers through robust extension approaches. There should be a concrete effort to establish links among the Asia-Pacific region countries for cooperation, emulation and replication of models related to mechanization of pre- and post-production millet cultivation.

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[1] Sample Footnote

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