Revitalizing Agriculture Extension Services for Millets: A Comprehensive Review of Strategies, Challenges, and Innovations

Abstract:

This review paper highlights the importance of millets in addressing agrarian and nutritional challenges and the need to revitalize millet agriculture extension services. The paper discusses the nutritional, environmental, and economic significance of millets and the common challenges faced by millet farmers, such as low yields, pest and disease management, and market access. The review also defines and explains the role of agricultural extension services in promoting millet farming practices and discusses traditional and contemporary extension approaches, such as farmer training, knowledge-sharing platforms, and digital technology. The paper evaluates the effectiveness of government policies and programs aimed at supporting millet cultivation and provides case studies of regions or communities where successful millet extension services have made a significant impact. The review concludes that revitalizing millet agriculture extension services is crucial for promoting sustainable millet farming practices and improving the livelihoods of millet farmers. By embracing millets as a staple crop, we can enhance agricultural diversity, mitigate the impact of climate change, and foster sustainable food systems.

Introduction:

Millets are a group of small-seeded grasses that have been cultivated for thousands of years and are an important source of food and nutrition in many parts of the world. They are climate-resilient crops that can grow in marginal conditions and require fewer inputs than other grains like wheat and rice[1]. Millets have immense health benefits, such as the slow release of glucose during digestion, making them favorable for diabetic patients, and they are rich in fiber and mineral micronutrients such as iron. However, the importance of millets as a staple food was replaced by wheat and rice, thanks to the Green Revolution. To address the problems of loss of crop diversity, industrial agriculture, and the need for sustainable crop substitutes, there is a need to revitalize millet cultivation[4]. Agricultural extension services play a crucial role in promoting millet cultivation by providing farmers with the necessary knowledge, skills, and technologies to improve their yields and income[5]. In this review paper, we will provide a comprehensive overview of the strategies, challenges, and innovations in revitalizing agriculture extension services for millets.

Historical Perspective:

The history of agricultural extension services in the context of millets can be traced back to the ancient times when farmers shared their knowledge and experience with each other[2]. However, the formalization of agricultural extension services began in the 19th century when agricultural societies were established in several European countries, India, China, Malaysia, and the United States[3]. These societies disseminated relevant information and advice to farmers, but their impact was limited.

The modern era of agricultural extension services began in the 20th century when the basic principles of extension services evolved mostly in the more advanced countries[8]. Agricultural extension services have been created and recreated, adapted and developed over the centuries, and their evolution extends over nearly four thousand years[3].

In the context of millets, agricultural extension services play a crucial role in promoting millet cultivation by providing farmers with the necessary knowledge, skills, and technologies to improve their yields and income[3]. The impact of agricultural extension services on millet cultivation has been significant, as they have helped farmers adopt improved technologies and management practices, growing yields and livelihoods[6].

Importance of Millets:

Millets are an important crop that has immense nutritional, environmental, and economic significance. Here are some of the reasons why revitalizing their cultivation is crucial:

a. Nutritional significance:

Millets are rich in minerals such as calcium, iron, copper, and magnesium, and are a good source of B-vitamins and antioxidants[1][2]. They have a low glycemic index and are gluten-free, making them favorable for diabetic patients[1]. Millets are nutrient-dense and can help address malnutrition, especially in vulnerable populations[2].

b. Environmental significance:

Millets are climate-resilient crops that can grow in marginal conditions and require fewer inputs than other grains like wheat and rice[1][7].They can easily thrive in extreme conditions like drought, and some wild varieties can even prevail in flooded areas and swampy grounds[1].Millets are more resilient to changes in climate than any other cereals[7].The cultivation of millets can help enhance biodiversity conservation and preserve genetic diversity[2].

c. Economic significance:

Millets can provide an affordable and nutritious option and help guarantee food security[7]. They offer a reduced dependence on synthetic fertilizers and pesticides, which can lower production costs for farmers[2]. Millets can serve as an income crop for farmers and can provide new sustainable market opportunities for producers and consumers[7].The use of millets in commercial/packaged food will encourage farmers to grow millets and will open new opportunities and revitalize the farmers[1].

Challenges in Millet Farming:

Millet farming faces several challenges that can impact its profitability and sustainability. Here are some of the common challenges faced by millet farmers:

1. **Pest and disease management:** Millet crops are susceptible to several pests and diseases, including birds, rodents, insects, fungal infections, and viruses [8]. These outbreaks can lead to substantial yield losses if not managed effectively. Farmers must employ integrated pest management techniques, such as crop rotation, use of resistant varieties, timely pest scouting, and implementing appropriate pest control measures, to protect their millet crops from potential damage.

2. **Low yields:** Millet yields can be low due to several factors such as poor soil fertility, inadequate rainfall, and lack of access to improved seeds and fertilizers[9][10]. This can impact the profitability of millet farming and make it less attractive to farmers.

3. **Market access:** Millet farmers often face challenges in accessing markets due to poor infrastructure, lack of market linkages, and limited market information[9]. This can lead to low prices and reduced profitability for farmers.

4. **Labor-intensive farming practices:** Millet farming requires several labor-intensive practices such as planting, weeding, and harvesting, which can be time-consuming and costly[9][10]. This can make millet farming less attractive to farmers, especially those with limited labor resources.

5. Climate change: Millet farming is vulnerable to the impacts of climate change, such as droughts, floods, and extreme weather events[9][12]. These can lead to reduced yields and income for farmers.

Agriculture Extension Services:

Agricultural extension services are a critical component of the agricultural sector, providing farmers with the necessary knowledge, skills, and technologies to improve their yields and income. The role of agricultural extension services in improving millet farming practices is crucial, as millet farming faces several challenges that can impact its profitability and sustainability. Here are some of the ways in which agricultural extension services can help improve millet farming practices:

1. Providing technical assistance: Agricultural extension services can provide farmers with technical assistance on various aspects of millet farming, such as soil management, water management, pest and disease management, and crop rotation[13].

2. Disseminating information: Agricultural extension services can disseminate relevant information on millet farming practices, such as new technologies, best practices, and market trends[5].

3. Offering training: Agricultural extension services can offer training programs to farmers on various aspects of millet farming, such as seed selection, planting techniques, and harvesting methods[14].

4. Facilitating access to inputs: Agricultural extension services can help farmers access improved seeds, fertilizers, and other inputs necessary for millet farming[15].

5. Linking farmers to markets: Agricultural extension services can help farmers access markets by providing market information, facilitating market linkages, and supporting value addition[16].

Historical Extension Approaches:

Traditional approaches to extension services for millet cultivation have evolved over time, and their effectiveness and limitations have been evaluated. Here are some of the traditional approaches to extension services for millet cultivation:

1. **Demonstration plots:** Extension agents would establish demonstration plots to showcase improved millet farming practices to farmers[17]. This approach was effective in promoting the adoption of new technologies and practices.

2. **Farmer field schools:** This approach involved organizing groups of farmers to learn and experiment with new millet farming practices in their fields[18]. This approach was effective in promoting farmer-to-farmer learning and knowledge sharing.

3. **Radio and television programs:** Extension agents would use radio and television programs to disseminate information on millet farming practices to farmers[19]. This approach was effective in reaching a large number of farmers, especially those in remote areas.

4. **Farm visits:** Extension agents would visit farmers in their fields to provide technical assistance and advice on millet farming practices[20]. This approach was effective in providing personalized support to farmers.

5. **Workshops and training programs:** Extension agents would organize workshops and training programs to provide farmers with the necessary knowledge and skills to improve their millet farming practices[21]. This approach was effective in promoting the adoption of new technologies and practices.

The effectiveness of these traditional approaches to extension services for millet cultivation varied depending on the context and the specific needs of farmers. While these approaches were effective in promoting the adoption of new technologies and practices, they had some limitations, such as:

1. **Limited reach:** Traditional extension approaches often had limited reach, especially in remote areas[23].

2. **Lack of sustainability:** Traditional extension approaches were often project-based and lacked sustainability[22].

3. **Limited resources:** Traditional extension approaches often faced resource constraints, such as limited funding and staffing[24].

4. **Limited impact:** Traditional extension approaches often had limited impact on the livelihoods of farmers, especially those with limited resources[25].

Modern Extension Strategies:

Contemporary extension approaches have been developed to improve millet farming practices. These approaches include digital technology, farmer training, and knowledge-sharing platforms. Here are some of the contemporary extension approaches and their impact on millet production:

1. Digital technology: The use of digital technology, such as mobile phones and the internet, has revolutionized extension services by providing farmers with access to real-time information on

weather forecasts, pest and disease management, and market prices[26]. This approach has been effective in reaching a large number of farmers, especially those in remote areas.

2. Farmer training: Farmer training programs have been developed to provide farmers with the necessary knowledge and skills to improve their millet farming practices[27]. These programs have been effective in promoting the adoption of new technologies and practices.

3. Knowledge-sharing platforms: Knowledge-sharing platforms, such as farmer field schools and farmer-to-farmer learning networks, have been developed to promote knowledge sharing and learning among farmers[28]. These platforms have been effective in promoting farmer-to-farmer learning and knowledge sharing.

4. Market linkages: Extension services have been developed to facilitate market linkages for millet farmers by providing market information, facilitating market linkages, and supporting value addition[29]. This approach has been effective in improving market access and prices for millet farmers.

5. Mechanization: The use of modern farming equipment, such as harvesters and threshers, has been effective in improving millet farming efficiency and reducing labor costs[30].

Innovations in Extension Services:

Several innovative practices and technologies are being used to promote millet farming. These include:

1. Improved seed varieties: Research institutions and extension services are developing improved seed varieties of millets that are resistant to pests and diseases, drought-tolerant, and high-yielding[31]. These improved seed varieties can help farmers improve their yields and income.

2. Precision farming techniques: Precision farming techniques, such as soil testing, nutrient management, and water management, can help farmers optimize their millet farming practices and reduce production costs[32].

3. Efficient processing technologies: Efficient processing technologies, such as millet dehullers and grinders, can Precision farming techniques: Precision farming techniques, such as soil testing, nutrient management, and water management, can help farmers optimize their millet farming practices and reduce production costs[33].help farmers add value to their millet crops and improve their profitability.

4. Digital technology: Digital technology, such as mobile phones and the internet, can help farmers access real-time information on weather forecasts, pest and disease management, and market prices[35]. This approach has been effective in reaching a large number of farmers, especially those in remote areas.

5. Farmer training: Farmer training programs have been developed to provide farmers with the necessary knowledge and skills to improve their millet farming practices[34]. These programs have been effective in promoting the adoption of new technologies and practices.

Successful extension programs and their outcomes:

1. Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet: This program conducts extensive research and develops new technologies to improve the resiliency of sorghum

and millet production in semi-arid regions[36]. Through inclusive development, the program invests in the next generation of private and public leaders in sorghum and millet food systems. The program's plant breeding and production systems management projects focus on supporting smallholder farmers and farmer cooperatives to produce climate-smart sorghum and pearl millet crops adapted to ever-changing production environments. Food processing and value addition projects strengthen demand and markets[36].

2. K-State Innovation Lab: This program landed a $750K award to study sorghum and millet in Madagascar[37]. The program proposes further diversifying the existing farming systems in response to environmental, product, and market changes.

3. Research and extension services: Research and extension services are critical for improving millet yields and quality and promoting their adoption by farmers[6]. Governments and international organizations are investing in research on millets to develop high-yielding varieties that are resistant to pests and diseases and adapt to changing climatic conditions. Extension services provide farmers with the necessary knowledge and skills to grow millets and manage their crops effectively.

Policy and Government Initiatives:

The government of India has implemented several policies and programs aimed at supporting millet cultivation. These policies and programs are designed to promote millet cultivation, increase production, and improve the livelihoods of millet farmers. Here are some of the policies and programs and their effectiveness in revitalizing the millet sector:

1. Sub-Mission on Nutri-Cereals (Millets): The Department of Agriculture and Farmers Welfare (DA&FW) is implementing a Sub-Mission on Nutri-Cereals (Millets) under the National Food Security Mission (NFSM) in 212 districts of 14 states since 2018-19[38]. The program provides incentives to farmers through the states/UTs on crop production and protection technologies, cropping system-based demonstrations, production and distribution of certified seeds of newly released varieties/hybrids, and more. The program has been effective in promoting millet cultivation and increasing production.

2. Millet promotion programs: Several states, including Haryana, Odisha, Assam, Chhattisgarh, Karnataka, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Maharashtra, and Rajasthan, are implementing state millet missions to increase production and consumption[39]. These programs include farmers' training, farmers' awareness camps, village-level camps, Bajra Mahotsav, school programs, road shows, publicity, and more. These programs have been effective in promoting millet cultivation and increasing production.

3. Free seed distribution: The Agriculture Department has drawn plans to distribute free kits of seeds to farmers for increasing the area of cultivation of millets in rainfed areas[40]. This program has been effective in promoting millet cultivation and increasing production.

4. Policy support: Governments can develop and implement policies that recognize the importance of millets and provide incentives for their cultivation, such as price support mechanisms, subsidies for inputs, research funding, and favorable trade policies[41]. These policies can provide financial incentives and support to farmers, making millet cultivation more attractive and economically viable. Governments can consider providing input subsidies such as seeds, fertilizers, and pesticides to reduce the cost burden and encourage farmers to adopt millet cultivation practices. Subsidizing

irrigation infrastructure, price support, marketing, and processing can all promote millet cultivation. These policies have been effective in promoting millet cultivation and increasing production.

Case Studies:

1. The role of collective action in the marketing of underutilized plant species: Lessons from a case study on minor millets in South India: This study highlights the critical role of collective action in the successful commercialization of underutilized plant species, such as minor millets, in South India[42]. The study found that collective action, such as the formation of farmer groups and cooperatives, can help farmers access markets, negotiate better prices, and improve their livelihoods.

2. Networks and Low Adoption of Hybrid Technology: The Case of Pearl Millet in Rajasthan, India: This study examines the low adoption of hybrid technology for pearl millet cultivation in Rajasthan, India[43]. The study found that the lack of access to extension services and the limited reach of extension services were major barriers to the adoption of hybrid technology. The study recommends the use of innovative extension approaches, such as farmer-to-farmer learning networks, to promote the adoption of new technologies.

3. A Case Study of ICRISAT: This case study examines the work of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in promoting millet cultivation in India[44]. The study found that ICRISAT's extension services, such as the development of mobile apps and the use of farmer field schools, have been effective in promoting millet cultivation and improving the livelihoods of millet farmers.

4. Why invest in Research & Development for sorghum and millets? The business case for East and Southern Africa: This study examines the business case for investing in research and development for sorghum and millets in East and Southern Africa[45]. The study found that the lack of information on sorghum and millets from formal extension services forces farmers to rely on social networks. The study recommends the use of innovative extension approaches, such as the use of digital technology and farmer-to-farmer learning networks, to promote the adoption of new technologies.

5. Effectiveness of extension methods in adopting the planting of improved varieties of sorghum and millet in Sheikan locality, Sudan: This study examines the effectiveness of extension methods in promoting the adoption of improved varieties of sorghum and millet in Sheikan locality, Sudan[46]. The study found that the use of farmer field schools and demonstration plots was effective in promoting the adoption of improved varieties of sorghum and millet.

6. SELCO Foundation- SDG7 for millets, local entrepreneurship, and climate action: This study examines the work of the SELCO Foundation in promoting millet cultivation and local entrepreneurship in India[47]. The study found that the use of innovative extension approaches, such as the development of solar-powered millet mills and the use of extension technology, has been effective in promoting millet cultivation and improving the livelihoods of millet farmers.

Conclusion:

The review highlights the importance of millets in addressing agrarian and nutritional challenges and the need to revitalize millet agriculture extension services. Millets are climate-resilient crops that offer several benefits, including high nutritional value, low cultivation costs, and short crop cycles. Millet cultivation faces several challenges, such as low yields, pest and disease management, and market access. Traditional and contemporary extension approaches, such as farmer training, knowledge-sharing platforms, and digital technology, can help overcome these challenges and promote sustainable millet farming practices. Government policies and programs, such as the Sub-

Mission on Nutri-Cereals (Millets) and state millet missions, can provide financial incentives and support to farmers, making millet cultivation more attractive and economically viable. Successful extension programs, such as the Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet and the K-State Innovation Lab, have had a positive impact on millet production by supporting smallholder farmers and farmer cooperatives to produce climate-smart sorghum and pearl millet crops adapted to ever-changing production environments. Case studies highlight the importance of innovative extension approaches, such as the use of digital technology, farmer-to-farmer learning networks, and the development of mobile apps, in promoting millet cultivation and improving the livelihoods of millet farmers. Revitalizing millet agriculture extension services is crucial for promoting sustainable millet farming practices and improving the livelihoods of millet farmers. By embracing millets as a staple crop, we can enhance agricultural diversity, mitigate the impact of climate change, and foster sustainable food systems.

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