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Assessing the Multi-Dimensional Challenges Faced by Bikaner Farmers during the COVID-19 Pandemic through Sentimental Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. Author AKS designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Author RKV reviewed, edited and guided the draft preparation. Author VK managed the literature searches, helped in collecting data from the respondents. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study aims to unravel the intricate challenges farmers confront in the aftermath of COVID-19, delving into the effects on agricultural extension services and the marketing of agricultural products.
Study Design: Ex-Post facto research design.

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Place and Duration of Study: The study was done by collecting data from farmers in Bikaner, Rajasthan, India, between July 2022 and August 2022.
Methodology: The study gathered 586 responses through open-ended survey questions from 250 farmers, and a meticulous data-cleaning process reduced the constraints to 316. Sentiment analysis using Azure Machine Learning identified 136 highly negative statements, further refined through factor analysis into nine groups comprising 123 constraints. This rigorous methodology enhances precision, providing a nuanced understanding of farmers' challenges in agricultural extension services and product vending during the COVID-19 pandemic. The sentiment analysis score reflects the severity of constraints faced by farmers.
Results: The livestock and their management dimension scored the lowest (0.212), reflecting significant obstacles such as cattle deaths and declining milk prices. Following closely, disruptions in agricultural services (0.218) underscored difficulties in accessing crucial services and a decline in input quality. Labor and workforce challenges (0.226) included shortages and healthcare difficulties while marketing and transporting constraints (0.231) highlighted problems like increased post-harvest losses and market closures. Financial challenges (0.233) involved limited access to relief funds and cooperative closures.
Conclusion: Through systematic constraint identification, sentiment analysis, and factor analysis, this study unveils nuanced insights into farmers' challenges during the pandemic, enriching our understanding of agricultural resilience. The refined constraints underscore the severity and diverse nature of obstacles farmers face in COVID-19.

Keywords: COVID-19 Impact; agricultural resilience; farmer constraints; extension services; supply chain disruptions; market challenges; pandemic effects on agriculture; and livelihood sustainability.

1. INTRODUCTION

The advent of the COVID-19 pandemic has reshaped global dynamics, ushering in unprecedented change and challenges. One sector profoundly affected by this upheaval is agriculture [1]. Supply chains, the lifeblood of agricultural systems, experienced disruptions, creating a ripple effect across the agricultural landscape. Amid these challenges, farmers found themselves navigating uncharted territories, grappling not only with the immediate impacts of the pandemic on their operations but also with the intricate web of constraints affecting their ability to access essential agricultural extension services and effectively vend their produce [2-5]. The effects on agriculture were multifaceted, encompassing supply chain interruptions, labor shortages, market closures, and fluctuating demand patterns. The constraints faced by farmers in the wake of COVID-19 extended beyond the tangible challenges of planting and harvesting [6]. Farmers encountered obstacles in receiving crucial agricultural extension services, which are vital for staying abreast of best practices, technological advancements, and sustainable farming methods. Concurrently, the process of vending their agricultural produce became increasingly complex. Market closures, logistical challenges, and shifts in consumer behavior added layers of difficulty, impacting their economic stability. This study is designed to delve into the heart of these challenges, aiming to provide a comprehensive understanding of farmers' constraints during these tumultuous times. The need for such an investigation is paramount. Informed decision-making and targeted policy interventions demand a nuanced understanding of farmers' specific hurdles, ensuring that support systems are tailored to their unique needs [7]. By unraveling the complexities of the challenges posed by the pandemic, this study seeks to contribute valuable insights to the discourse on agricultural resilience. However, it's crucial to acknowledge the inherent limitations of this study. The dynamic nature of the pandemic and its varied impact across regions and agricultural contexts may introduce complexities that cannot be fully captured within the scope of this research.

2. METHODOLOGY

The constraints were systematically gathered through open-ended questions in the survey, resulting in 586 responses from 250 farmers within the Bikaner district, Rajasthan, India. A meticulous assessment of the collected constraints was conducted to ensure relevance to the context of agricultural extension services and the vending of agricultural produces during the COVID-19 pandemic. This involved the

removal of irrelevant statements and the consolidation of constraints with similar meanings. As most responses were initially provided in Hindi and other regional languages, translation into English was carried out. Following an extensive data-cleaning process, the constraints were refined to 316. Once the process of data collection is done, the process of data cleaning starts to prepare the data for sentimental analysis (opinion mining), which will show the nature of the text, either positive, negative, or neutral, the range of the score exhibited by the azure machine learning software used for analyzing the sentiment will lie between 0 to 1.

Chart 1. Sentiment analysis

S. No.	Sentiment	Sentiment Score
1.	Positive	Closes to 1
2.	Neutral	Circles around 0.5
3.	Negative	Closes to 0

Sentiment analysis was conducted using Azure Machine Learning software to identify highly negative statements within the dataset, resulting in 136 negative statements. The sentiment analysis [8] output was further subjected to factor analysis to categorize constraints with similarities. The outcome of the factor analysis revealed the formation of nine distinct groups comprising 123 constraints. Notably, 13 constraints were excluded from the study during this analytical process. This rigorous approach to constraint identification and categorization enhances the precision of the study's findings, providing a nuanced understanding of the challenges farmers face in the context of agricultural extension services and product vending during the COVID-19 pandemic [9]. The utilization of sentiment analysis and factor analysis adds a layer of depth to the analysis, allowing for a better interpretation of the constraints and their impact on agricultural practices in the given scenario. The smaller the sentimental analysis score indicates, the more severity the farmers have faced. The overall constraints are explained in Table 10.

3. RESULTS AND DISCUSSION

Table 1 outlines the constraints farmers confronted in livestock and animal husbandry management during the COVID-19 pandemic. Notably, one-fourth of cattle succumbed to lumpy diseases, representing a critical concern with a score of 0.022. The decline in milk prices due to reduced demand (0.055) and the limited availability of testing and diagnostic services for livestock diseases during lockdowns (0.124) further underscore the multifaceted challenges encountered.

The increased prevalence of livestock diseases during the pandemic (0.216), difficulty in securing insurance coverage for livestock (0.241) and disruptions in the supply chain of veterinary medicines and vaccines (0.245) contribute to the compounding difficulties faced by farmers. Moreover, the reduced access to veterinary experts and professionals (0.302) and the decreased availability of veterinary vaccines (0.345) highlight the impact of the pandemic on essential support services for livestock management. Additionally, challenges in accessing credit for livestock maintenance (0.354) showed the financial instability of the farmers in sustaining their livestock [10].

Table 2 delineates the constraints farmers encountered concerning labor and workforce issues during the COVID-19 pandemic. Notably, the decline in agricultural productivity due to labor shortages (0.086) emerges as a critical concern, indicative of the profound impact of workforce disruptions on farming operations. Challenges in providing healthcare and sanitation facilities for farm workers (0.089) highlight the multifaceted nature of concerns encompassing the well-being of the labor force. The increased competition for skilled agricultural labor (0.124) and the difficulty in complying with labor regulations and safety standards (0.128) further underscore the complexities faced by farmers in managing their workforce effectively. The limited access to training and education programs for farm workers (0.143) poses challenges for skill development and capacity building within the agricultural labor force [9-10].

Moreover, the labor shortage for essential tasks such as sowing and harvesting (0.211) and challenges in sourcing affordable housing for farm laborers (0.272) contribute to farmers' operational constraints. The decline in the interest of younger generations in pursuing farming careers (0.290) indicated the broader societal shifts impacting the agricultural workforce. Additionally, challenges in maintaining social distancing among farm workers (0.314) highlight the implications of pandemic-related safety measures on farm operations. Limited access to local authorities and government

officials for assistance (0.389) and the reduced availability of migrant laborers (0.440) were found in the study area.

Table 3 outlines farmers' various constraints concerning environmental factors during the COVID-19 pandemic, each associated with a specific severity score. The disruption of traditional agricultural practices due to social distancing requirements (0.081) emerges as a significant concern, signifying the nuanced impact of pandemic-related measures on established farming methodologies. Challenges in accessing sustainable water management practices (0.095) and soil erosion and degradation leading to reduced arable land (0.114) point to environmental sustainability challenges exacerbated by the pandemic. Furthermore, the decline in soil quality due to unsustainable farming practices (0.124) and water scarcity resulting from reduced monsoon rainfall (0.276) highlight the intricate interplay between environmental factors and agricultural productivity. The difficulty in preserving and promoting local agricultural traditions (0.280) speaks to the cultural dimensions of farming practices and the potential threats the pandemic poses [11].

The increased frequency of extreme weather events affecting crop yields (0.305) underscores the vulnerability of agricultural ecosystems to climate-related disruptions during the pandemic. The inability to access practices for disaster-resilient agriculture (0.334) compounds these challenges, emphasizing the need for adaptive strategies in the face of evolving environmental conditions [2]. Moreover, the closure of agricultural fairs and exhibitions (0.354) reflects disruptions in avenues for knowledge exchange and market access for farmers. The table also highlights the impact on biodiversity conservation, with constraints such as the disruption of cultural practices supporting biodiversity (0.355) and the loss of biodiversity in agricultural ecosystems (0.356). The difficulty in preserving traditional agricultural landscapes (0.370) and the inability to access subsidies for organic certification (0.392) further accentuate the multifaceted challenges farmers face in maintaining environmental sustainability practices.

Table 4 outlines the socio-cultural constraints faced by farmers during the COVID-19 pandemic, presenting each challenge alongside its corresponding severity score. These constraints illuminate the intricate connections between cultural practices and the resilience of farming communities amidst the ongoing crises. Challenges in sustaining cultural traditions for resilient farming (0.156) reflect the vulnerability of traditional practices, highlighting the potential erosion of knowledge crucial for adapting to changing agricultural conditions. The decreased participation in farmer training and capacity-building programs (0.159) indicates a broader impact on knowledge-sharing platforms, diminishing the avenues for skill development among farmers. Challenges in sustaining cultural traditions related to soil fertility (0.160) and sustaining cultural diversity in farming practices (0.172) underscore the cultural dimensions intertwined with sustainable agricultural practices. The disruption of rituals celebrating ecological farming practices (0.202) further emphasizes the potential strain on cultural heritage associated with environment-friendly farming. Table 4. also indicates the impact on community cohesion, as reduced engagement with local agricultural experts and elders (0.181) and challenges in fostering cultural resilience in farming communities (0.332) suggest a potential loss of intergenerational knowledge transfer crucial for community well-being. Moreover, the decline in the cultural significance of farming activities (0.334) and challenges in sustaining cultural practices linked to agriculture (0.323) point to the broader societal shifts affecting the perception and value attributed to traditional farming practices. The disruptions in cultural and religious gatherings important for farming rituals (0.235) and limited access to community support networks during social distancing measures (0.346) further accentuate the challenges farming communities face in maintaining cultural practices integral to their identity and well-being [11].

Table 5 outlines the financial constraints encountered by farmers during the COVID-19 pandemic, offering insights into the diverse challenges impacting their economic stability. Challenges in securing microfinance loans for small farmers (0.075) point to the difficulties faced by small farmers in accessing essential financial resources. The increased competition for limited government relief funds (0.126) highlights the heightened demand for financial support, potentially leading to disparities in fund distribution among farmers. The loss of income from canceled contracts with various agricultural stakeholders (0.131) and the inability to access disaster relief funds, price supports, and

insurance coverage (0.188) underscore the economic repercussions of disruptions in the agricultural supply chain. Farmers face challenges obtaining insurance coverage for crop losses (0.220), exacerbating financial strains resulting from unpredictable events. The closure of agricultural cooperatives, credit cooperatives, and societies (0.249) and the limited access to credit and loans for agricultural investments (0.260) point to the adverse impact on cooperative financial structures, disrupting traditional sources of financial support for farmers [12]. The table also highlights increased costs for personal protective equipment, sanitization, and safety measures (0.231), reflecting farmers' additional financial burden to ensure compliance with health and safety protocols. Challenges in securing affordable farm insurance policies (0.239) contribute to the overall financial stress experienced by farmers. Furthermore, the closure of agricultural cooperatives' savings and credit programs (0.276) compounds the challenges in accessing credit and financial services, limiting the avenues available to farmers for managing their financial needs. The delayed payments and increased competition for government relief funds (0.347) further intensify the economic strain on farmers, potentially leading to delays in critical financial assistance.

Table 6 elucidates farmers' constraints regarding government and policy during the COVID-19 pandemic. The inability to access government subsidies and incentives (0.188) reflects a critical challenge, indicating that farmers faced difficulties availing essential support measures provided by the government. This constraint has direct implications for the financial well-being of farmers and the sustainability of their agricultural practices. Challenges in obtaining legal assistance for land tenure issues (0.261) point to the hurdles farmers encounter in navigating legal complexities related to land ownership. Legal uncertainties could significantly impact farmers' security in land tenure, affecting their long-term planning and investment decisions. The difficulty in accessing grants for sustainable agriculture (0.277) highlights the challenges farmers face in adopting and implementing sustainable farming practices. This constraint may hinder efforts to promote environmentally friendly agricultural methods and practices. The closure of agricultural research institutions, Krishi Vigyan Kendras (KVK), and agricultural universities (0.331) suggest disruptions in the availability of crucial agricultural research and knowledge dissemination. The closure of these institutions hampers farmers' access to valuable resources, innovative technologies, and research-driven guidance. The closure of agricultural input subsidy programs (0.401) signifies a substantial challenge, as farmers rely on input subsidies to alleviate the financial burden of purchasing essential agricultural inputs. The absence of these programs could exacerbate the economic strain on farmers, particularly during challenging periods like the COVID-19 pandemic. Challenges in obtaining permits for land use changes (0.269) and permits for agricultural activities (0.328) emphasize farmers' bureaucratic challenges in navigating regulatory processes. Such constraints may impede farmers' ability to adapt their land use practices and implement necessary agricultural activities. Moreover, challenges in obtaining permits for the movement of farm machinery (0.418) indicate logistical challenges that farmers encounter in mobilizing essential machinery [8-11].

Table 1. Constraints faced by farmers related to livestock and their management during COVID-19

S.No.	Livestock and their Management	Score
1	One-fourth of cattle died due to lumpy diseases.	0.022
2	The decline in milk prices is due to reduced demand.	0.055
3	Limited availability of testing and diagnostic services for livestock diseases during lockdowns.	0.124
4	Increased prevalence of livestock diseases during the COVID-19 pandemic.	0.216
5	Difficulty in securing insurance coverage for livestock.	0.241
6	Disruption in the supply chain of veterinary medicines and vaccines.	0.245
7	We have reduced access to veterinary experts and professionals.	0.302
8	Decreased availability of veterinary vaccines.	0.345
9	Challenges in accessing credit for livestock maintenance.	0.354
	Overall	0.212

Table 2. Constraints faced by farmers related to labor and workforce during COVID-19

S.No.	Labor and Workforce Challenges	Score
1	The decline in agricultural productivity due to labor shortages.	0.086
2	Challenges in providing healthcare and sanitation facilities for farm workers.	0.089
3	Increased competition for skilled agricultural labor.	0.124
4	Difficulty in complying with labor regulations and safety standards.	0.128
5	Limited access to training and education programs for farm workers.	0.143
6	Shortage of labor for sowing and harvesting	0.211
7	Challenges in sourcing affordable housing for farm laborers.	0.272
8	Decline in the interest of younger generations in pursuing farming careers.	0.29
9	Challenges in maintaining social distancing among farm workers	0.314
10	Limited access to local authorities and government officials for assistance	0.389
11	Reduced availability of migrant laborers	0.440
	Overall	0.226

Table 3. Constraints faced by farmers related to environmental factors during COVID-19

S.No.	Environmental Factors	Score
1	Disruption of traditional agricultural practices due to social distancing requirements	0.081
2	Challenges in accessing sustainable water management practices	0.095
3	Soil erosion and degradation lead to reduced arable land	0.114
4	Decline in soil quality due to unsustainable farming practices	0.124
5	Water scarcity due to reduced monsoon rainfall	0.276
6	Difficulty in preserving and promoting local agricultural traditions	0.280
7	Increased frequency of extreme weather events affecting crop yields	0.305
8	Inability to access practices for disaster-resilient agriculture	0.334
9	Closure of agricultural fairs and exhibitions	0.354
10	Disruption of cultural practices supporting biodiversity conservation	0.355
11	Loss of biodiversity in agricultural ecosystems	0.356
12	Difficulty in preserving traditional agricultural landscapes	0.370
13	Inability to access subsidies for organic certification	0.392
	Overall	0.264

Table 4. Constraints faced by farmers related to socio-cultural during COVID-19

S.No.	Socio-Cultural Challenges	Score
1	Challenges in sustaining cultural traditions for resilient farming	0.156
2	Decreased participation in farmer training and capacity-building programs	0.159
3	Challenges in sustaining cultural traditions related to soil fertility	0.160
4	Decreased participation in community-based development projects/activities	0.168
5	Challenges in sustaining cultural diversity in farming practices	0.172
6	Disruption of rituals highlighting the cultural heritage of traditional farming	0.173
7	Reduced engagement with local agricultural experts and elders	0.181
8	Disruption of rituals celebrating ecological farming practices	0.202
9	Disruption of cultural and religious gatherings important for farming rituals	0.235
10	Challenges in sustaining cultural practices linked to agriculture	0.323
11	Challenges in fostering cultural resilience in farming communities	0.332
12	Decline in the cultural significance of farming activities	0.334
13	Reduced participation in local governance and decision-making processes	0.342
14	Limited access to community support networks during social distancing measures	0.346
	Overall	0.235

Table 5. Constraints faced by farmers related to financial challenges during COVID-19

S.No.	Financial Challenges	Score
1	Challenges in securing microfinance loans for small farmers	0.075
2	Increased competition for limited government relief funds	0.126
3	Loss of income from canceled contracts with various agricultural stakeholders	0.131
4	Inability to access disaster relief funds, price supports, and insurance coverage	0.188
5	Difficulty in obtaining insurance coverage for crop losses	0.220
6	Loss of income from canceled farm volunteer and intern programs	0.226
7	Increased costs for personal protective equipment, sanitization, and safety measures	0.231
8	Challenges in securing affordable farm insurance policies	0.239
9	Limited access to credit and financial services	0.246
10	Closure of agricultural cooperatives, credit cooperatives, and societies	0.249
11	Inability to access credit and loans for agricultural investments	0.260
12	Reduced income from non-agricultural side businesses	0.265
13	Limited access to credit, financial services, and farm credit schemes	0.265
14	Closure of agricultural cooperatives' savings and credit programs	0.276
15	Limited access to price support for agricultural products	0.284
16	Challenges in accessing credit for fruit and vegetable farming	0.339
17	Delayed payments and increased competition for government relief funds	0.347
	Overall	0.233

Table 6. Constraints faced by farmers related to government and policy during COVID-19

S.No.	Government and Policy Challenges	Score
1	Inability to access government subsidies and incentives	0.188
2	Challenges in obtaining legal assistance for land tenure issues	0.261
3	Challenges in obtaining government permits for land use changes	0.269
4	Difficulty in accessing grants for sustainable agriculture	0.277
5	Difficulty in obtaining permits for agricultural activities	0.328
6	Closure of agricultural research institutions, KVKs, and agricultural universities	0.331
7	Closure of agricultural input subsidy programs	0.401
8	Challenges in obtaining permits for the movement of farm machinery	0.418
	Overall	0.309

Table 7 outlines the constraints faced by farmers in the domain of technology and information during the COVID-19 pandemic. The interruption in the flow of information through traditional communication channels (0.043) signifies a notable challenge, suggesting that farmers faced disruptions in receiving crucial information through conventional communication methods. This constraint may have hindered the dissemination of essential agricultural knowledge and guidance. Reduced access to cold storage facilities (0.091) is a critical constraint that could affect post-harvest management. The limited availability of cold storage facilities may have led to difficulties preserving and storing agricultural produce, impacting the supply chain. Interruption in the supply of irrigation equipment (0.151) represents a significant challenge for farmers, especially in regions heavily dependent on irrigation. The disruption in the supply chain of irrigation equipment could have affected farmers' ability to manage water resources for their crops efficiently [12].

The decline in participation in agricultural workshops and seminars (0.220) underscores knowledge exchange and capacity-building challenges. Farmers' reduced engagement in these educational forums may have hindered their access to new technologies, innovative practices, and updates on agricultural advancements. Challenges in accessing printed agricultural materials (0.300) highlight constraints in the availability and distribution of educational resources in printed formats. Limited access to such materials may impede farmers' ability to stay informed about best practices, advancements, and relevant information. The challenges in organizing collective farming activities (0.300) indicate disruptions in

collaborative agricultural initiatives. Collective efforts, such as group farming activities, may have faced logistical hurdles, affecting community-based agricultural practices. Interruption in the supply of fruit processing machinery (0.319) signals a constraint in post-harvest processing capabilities [8]. The disruption in the supply chain of fruit processing machinery may have impacted farmers involved in fruit cultivation and processing. The interruption in the supply of fertilizers and pesticides (0.324) suggests challenges in accessing essential inputs for crop protection and nutrient management. This constraint could have directly affected crop yields and quality [13]. Disruption of agricultural knowledge sharing within communities (0.349) emphasizes challenges maintaining community-level information exchange. The breakdown in communal knowledge-sharing networks may have impeded the diffusion of valuable insights among farmers. Interruption in the supply of cold storage equipment (0.388) indicates challenges in acquiring essential infrastructure for preserving perishable agricultural products. Challenges in sourcing affordable greenhouse equipment (0.392) highlight barriers to adopting greenhouse technologies. The affordability factor could have deterred farmers from investing in greenhouse structures for protected cultivation [13].

Table 8 outlines the constraints faced by farmers concerning agricultural services during the COVID-19 pandemic. Farmers reported being denied access to crucial agricultural training and extension services in person, as well as pest and disease surveillance and control services and agricultural machinery repair (0.047). The restrictions on in-person services could have hindered farmers' ability to receive timely guidance and support, impacting their decision-making processes. The decline in the quality of agricultural inputs due to supply chain disruptions (0.086) represents a significant challenge. This constraint implies that disruptions in the supply chain may have reduced the quality of inputs, potentially affecting crop yields and overall agricultural productivity. Challenges in securing storage and handling facilities for produce (0.106) highlight difficulties in managing harvested crops. The lack of proper storage and handling facilities could have resulted in post-harvest losses, negatively impacting farmers' income and food security. Farmers faced challenges sourcing affordable irrigation solutions (0.138), indicating barriers to accessing critical water management technologies. This constraint may have affected the ability of farmers to efficiently irrigate their fields, particularly in regions dependent on irrigation. Difficulty in accessing farm advisory services and quality seeds (0.139) underscores challenges in obtaining expert guidance and high-quality planting materials. The unavailability of these essential resources could impede farmers' efforts to adopt improved agricultural practices. Challenges in accessing soil testing and analysis services (0.145) suggest limitations in obtaining critical information about soil health. The lack of soil testing services may have hindered farmers from making informed fertilization and soil management decisions [14].

Decreased investment in agricultural infrastructure and digital farming technologies (0.200) indicates a constraint in adopting modern technologies. The reduction in investment may have slowed the adoption of digital solutions and advanced farming practices, limiting overall agricultural progress. Challenges in sourcing high-quality seeds and planting material (0.209) indicate difficulties in obtaining key inputs for crop cultivation. The quality of seeds and planting material directly influences crop performance, and challenges in sourcing them could impact overall agricultural outcomes. The closure of agricultural input shops (0.227) signifies disruptions in the retail infrastructure for essential agricultural inputs. Closing these shops may have hindered farmers' access to critical inputs, exacerbating challenges in farming operations. Challenges in mobilizing community resources for agriculture (0.252) suggest difficulties in community-level coordination for agricultural activities. Limited mobilization of community resources may have impeded collective efforts, such as group farming initiatives. Difficulty sourcing manures, bio-fertilizers, fertilizers, and pesticides (0.255) highlights challenges in accessing inputs aligned with organic farming practices. The unavailability of organic inputs may have affected farmers practicing organic agriculture. The decline in the availability of certified organic inputs (0.303) suggests a reduction in the supply of inputs adhering to organic certification standards. This constraint may have posed challenges for farmers committed to organic farming practices. Challenges in sourcing essential farm inputs such as seeds (0.332) indicate broader difficulties in obtaining critical inputs necessary for farming. This constraint may have resulted in compromised agricultural productivity. Challenges in obtaining technology for remote

farm management (0.332) underscore limitations in adopting remote sensing and management technologies. The lack of access to such technologies may have hindered farmers' ability to monitor and manage their farms remotely. Challenges in sourcing affordable land for agricultural expansion (0.358) highlight acquiring additional land for farming. This constraint may limit farmers' capacity for agricultural expansion and diversification. Challenges in organizing collective farming activities (0.360) indicate obstacles in coordinating collaborative agricultural initiatives. The difficulties in organizing collective activities may have impacted community-level farming practices.

Table 9 delves into the constraints faced by farmers concerning the marketing and transportation aspects of their agricultural produce during the COVID-19 pandemic. Increased post-harvest losses due to transportation challenges (0.059) signify that transportation-related obstacles have led to higher losses following harvest. These challenges could range from logistical issues to disruptions in the transportation infrastructure, impacting farmers' ability to get their produce to market promptly. Closing local markets and agricultural fairs and limiting sales opportunities (0.104) highlight a significant challenge. The closure of these avenues for selling agricultural products may have severely curtailed farmers' access to direct markets, affecting their income and market reach. Challenges in marketing milk and dairy products (0.114) suggest difficulties promoting and selling dairy-related produce. The constraints may include disruptions in the dairy supply chain, reduced consumer demand, or challenges in reaching markets for dairy products. Decreased export opportunities for agricultural products (0.160) indicate limitations in accessing international markets. The decline in export opportunities may have affected farmers engaged in export-oriented agriculture, leading to potential financial losses. Delayed procurement of perishable crops (0.166) points to challenges in the timely collection of crops with a limited shelf life. Delays in procurement may have contributed to increased spoilage and economic losses for farmers. Finding reliable transportation for farm workers (0.185) suggests difficulties in arranging transportation for agricultural labor. The constraint might affect farm productivity since the unavailability of transportation hampers labor movement to and fro from farms. Challenges in marketing organic produce (0.214) indicate specific difficulties faced by farmers engaged in organic farming. These challenges may include limited access to markets that value organic products or obstacles in effectively marketing organic produce [14].

Decreased demand for agricultural products due to reduced consumer spending (0.259) highlights the impact of broader economic trends on agricultural demand. Reduced consumer spending during the pandemic may have led to a decline in overall demand for agricultural products. Decreased demand for high-value crops (0.259) emphasizes farmers' challenges in cultivating high-value crops. The reduced demand may have affected farmers specializing in high-value agricultural products, impacting their income and market prospects. The inability to access organic farming markets (0.263) underscores challenges specific to farmers practicing organic agriculture. The constraint suggests limitations in accessing markets that specifically cater to organic products. Decreased consumer demand for certain agricultural products (0.276) points to shifts in consumer preferences during the pandemic. The constraint may indicate a decline in demand for specific agricultural products, influencing farmers' choices and cultivation strategies. Closure of meat markets and processing units (0.324) signifies disruptions in the meat supply chain. The closure of these markets and units may have affected livestock and meat production farmers, leading to economic losses. The decline in aquaculture, beekeeping, fisheries, spices, and vegetable exports (0.347) highlights farmers' challenges in diverse agricultural sectors [15-16]. The decline in exports across various sectors may have implications for the income and sustainability of farmers in these domains. Disruption of the supply chain leads to difficulty procuring agricultural inputs (0.366), which indicates challenges in accessing essential inputs for farming operations. The constraint may have broader implications for overall farm productivity and efficiency. Closure of poultry processing units (0.375) underscores challenges in the poultry industry. The closure of processing units may have impacted poultry farmers, affecting their ability to process and sell poultry products.

Table 10 indicates an escalation in challenges faced by farmers overall. The livestock and their management dimension scored the lowest (0.212), reflecting significant obstacles such as cattle deaths and declining milk prices. Following closely, disruptions in agricultural services

(0.218) underscored difficulties in accessing crucial services and a decline in input quality. Labor and workforce challenges (0.226) included shortages and healthcare difficulties while marketing and transporting constraints (0.231) highlighted problems like increased post-harvest losses and market closures. Financial challenges (0.233) involved limited access to relief funds and cooperative closures. The socio-cultural challenges (0.235) brought forth challenges in preserving cultural traditions. Technology and information constraints (0.261) encompassed interruptions in information flow and reduced access to technology. Environmental factors (0.264) involved disruptions due to social distancing and challenges in water management. Finally, government and policy challenges (0.309) included difficulties accessing subsidies and closing research institutions. This ordering underscores the increasing severity of constraints farmers face across various dimensions, with higher scores indicating fewer challenges and lower scores indicating higher challenges. The finding of this part of the objective was found similar to the study of [16].

Table 7. Constraints faced by farmers related to technology and information during COVID-19

S.No.	Technology and Information constraints	Score
1	Interruption in the flow of information through traditional communication channels	0.043
2	Reduced access to cold storage facilities	0.091
3	Interruption in the supply of irrigation equipment	0.151
4	Decline in participation in agricultural workshops and seminars	0.220
5	Challenges in accessing printed agricultural materials	0.300
6	Challenges in organizing collective farming activities	0.300
7	Interruption in the supply of fruit processing machinery	0.319
8	Interruption in the supply of fertilizers and pesticides	0.324
9	Disruption of agricultural knowledge sharing within communities	0.349
10	Interruption in the supply of cold storage equipment	0.388
11	Challenges in sourcing affordable greenhouse equipment	0.392
	Overall	0.261

Table 8. Constraints faced by farmers related to agricultural services disruptions during COVID-19

S.No.	Agricultural Services Disruptions	Score
1	Denied access to agricultural training and extension services in person, as well as pest and disease surveillance and control services and agricultural machinery repair services	0.047
2	The decline in the quality of agricultural inputs due to supply chain disruptions	0.086
3	Challenges in securing storage and handling facilities for produce	0.106
4	Challenges in sourcing affordable irrigation solutions	0.138
5	Difficulty in accessing farm advisory services and quality seeds	0.139
6	Difficulty in accessing soil testing and analysis services	0.145
7	Decreased investment in agricultural infrastructure and digital farming technologies	0.200
8	Challenges in sourcing high-quality seeds and planting material	0.209
9	Closure of agricultural input shops	0.227
10	Challenges in mobilizing community resources for agriculture	0.252
11	Difficulty in sourcing manures, bio-fertilizers, fertilizers, and pesticides	0.255
12	The decline in the availability of certified organic inputs	0.303
13	Challenges in sourcing essential farm inputs such as seeds	0.332
14	Challenges in obtaining technology for remote farm management	0.332
15	Challenges in sourcing affordable land for agricultural expansion	0.358
16	Challenges in organizing collective farming activities	0.360
	Overall	0.218

Table 9. Constraints faced by farmers related to marketing and transporting COVID-19

S.No.	Marketing and Transporting Constraints	Score
1	Increased post-harvest losses due to transportation challenges	0.059
2	Closure of local markets and agricultural fairs limiting sales opportunities	0.104
3	Challenges in marketing milk and dairy products	0.114
4	Decreased export opportunities for agricultural products	0.160
5	Delayed procurement of perishable crops	0.166
6	Challenges in finding reliable transportation for farm workers	0.185
7	Challenges in marketing organic produce	0.214
8	Decreased demand for agricultural products due to reduced consumer spending	0.259
9	Decreased demand for high-value crops	0.259
10	Inability to access organic farming markets	0.263
11	Decreased consumer demand for certain agricultural products	0.276
12	Closure of meat markets and processing units	0.324
13	Decline in aquaculture, beekeeping, fisheries, spices and vegetable exports	0.347
14	Disruption of the supply chain and leading to difficulty in procuring agricultural inputs	0.366
15	Closure of poultry processing units	0.375
	Overall	0.231

Table 10. Overall Distribution of constraints faced by farmers in receiving the agricultural extension services and vending agricultural produce during COVID-19

S.No.	Constraints	Score
1	Livestock and their Management	0.212
2	Agricultural Services	0.218
3	Labor and Workforce	0.226
4	Marketing and Transporting	0.231
5	Finance	0.233
6	Socio-Cultural	0.235
7	Technology and Information	0.261
8	Environmental Factors	0.264
9	Government and Policy	0.309

4. CONCLUSION

This study illuminates farmers' intricate challenges after the COVID-19 pandemic, underscoring the profound impacts on agriculture and the livelihoods of those at the forefront of food production. The disruptions to supply chains, labor shortages, and market closures have created a complex web of constraints for farmers, requiring a nuanced understanding of practical support. The study highlights the multifaceted nature of these challenges, encompassing not only immediate agricultural concerns but also the broader issues of accessing essential extension services and navigating the marketing landscape. As agriculture stands at the nexus of economic stability and food security, this research emphasizes the urgent need for tailored interventions. Informed policymaking must address farmers' unique constraints, ensuring that support mechanisms align with their evolving needs. The insights from this study serve as a foundation for developing targeted strategies to enhance agricultural resilience in the face of ongoing uncertainties. However, recognizing the evolving nature of the pandemic and the diverse agricultural contexts, ongoing research and adaptive interventions remain crucial to promoting sustainable and resilient agricultural practices. Ultimately, this study contributes to the ongoing dialogue on bolstering agricultural systems safeguarding the backbone of global food security.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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