

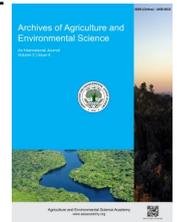


e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



CASE STUDY



Impact of the COVID-19 pandemic on the agronomic practices of rice farmers: A case study in Mymensingh district of Bangladesh

Raguib Hassan¹, Md. Harun Or Rashid¹, Subrato Kumar Kuri², Taslima Zahan³, Akbar Hossain⁴, Prodipto Bishnu Angon², A. K. M. Mominul Islam¹, Sabina Yeasmin¹ and Md. Parvez Anwar^{1*} 

¹Department of Agronomy, Bangladesh Agricultural University, Mymensingh - 2202, Bangladesh

²Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh - 2202, Bangladesh

³On-farm Research Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

⁴Bangladesh Wheat and Maize Research Institute, Dinajpur, Bangladesh

*Corresponding author's E-mail: parvezanwar@bau.edu.bd

ARTICLE HISTORY

Received: 17 April 2025

Revised received: 18 June 2025

Accepted: 21 June 2025

Keywords

Agronomic practices

COVID-19 pandemic

Peri-urban farmer

Rice farming

ABSTRACT

This study was conducted to determine the changes occurred in agronomic practices during the COVID-19 pandemic among rice farmers in rural and peri-urban areas of Mymensingh district of Bangladesh. A survey was conducted among 64 farmers including 32 from rural areas and 32 from peri-urban areas. This study examined the characteristics of farmers, the extent of changes in agronomic practices adopted, problems faced by farmers during the pandemic, strategies adopted to cope with the pandemic situation, and possible solutions. There were significant differences in agronomic practices between rural and peri-urban farmers, with education, training exposure, and extension personnel contact being substantial factors for both the groups. Farmers faced different problems related to agronomic practices; however, rural farmers faced more problems compared to peri-urban farmers. In terms of strategies, rural farmers emphasized local sourcing for agricultural inputs, while peri-urban farmers emphasized on marketing via mobile phone calls. Both rural and peri-urban farmers suggested that more incentives from the government would be the most effective solution during the post-pandemic time. Rural farmers had more stable rice yields than peri-urban farmers despite making more changes in agronomic activities during the pandemic. Most of the rural farmers changed their fertilizer application techniques and patterns, while majority of the peri-urban farmers changed their seed selection and planting techniques to cope with the pandemic. The findings of the present study will help to formulate strategies to cope with similar situations in the future to ensure food security in the country and livelihood of the farming community.

©2025 Agriculture and Environmental Science Academy

Citation of this article: Hassan, R., Rashid, M. H., Kuri, S. K., Zahan, T., Hossain, A., Angon, P. B., Islam, A. K. M. M., Yeasmin, S., & Anwar, M. P. (2025). Impact of the COVID-19 pandemic on the agronomic practices of rice farmers: A case study in Mymensingh district of Bangladesh. *Archives of Agriculture and Environmental Science*, 10(2), 381-392, <https://dx.doi.org/10.26832/24566632.2025.1002xx>

INTRODUCTION

COVID-19 is a contagious illness caused by the SARS-CoV-2 virus. On December 31, 2019, Wuhan, Hubei Province, China, reported the first case of the virus. In the past, some infectious disease outbreaks have been connected to viruses that first appeared in birds, pigs, bats, and other animals before evolving

and becoming dangerous to humans (WHO, 2020). The global economy, public health, and social systems was significantly and widely impacted by the COVID-19 pandemic. The COVID-19 outbreak shocked the world's economies in 2020 (Goswami *et al.*, 2024). As this pandemic spread around the globe, global food supplies started to run short, especially when supply chains were disrupted (Anwar, 2020; Adelodun *et al.*, 2021a). On

average, agricultural businesses experienced declined in exports of most of the agricultural products. COVID-19 has had a considerable impact on perishable food and caused remarkable food shortages especially in the least developed countries, conflict zones and war-affected regions. Additionally, COVID-19 threatened food security even in some developed countries, whereas developing countries were the most affected due to their high dependency on securing their food supplies (Mouloudj *et al.*, 2020; Adelodun *et al.*, 2021a). Agronomic practices refer to the cultivation and management techniques used to improve crop yields, soil fertility, and overall plant health. The agronomic practices that are important and practiced by farmers include crop rotation, soil tillage, fertilization, irrigation, weed control, pest and disease management, and seed selection and planting. These practices are impacted by agricultural inputs (availability of seed, fertilizers, labour, machinery, pest and plant protection equipment) and marketing costs (Firman & Allen, 2007). Intercropping, organic agriculture and minimum-to no-tillage management are some of the most important sustainable agronomic practices that result in increased soil biodiversity and improved soil structure and health. COVID-19 has significantly altered agronomic approaches worldwide. Lack of seeds, fertilizer, and other inputs significantly reduced crop productivity as a result of supply chain disruptions, border closures, lockdown and quarantine procedures (Adelodun *et al.*, 2021a). The capacity to cultivate, harvest, and transport crops were also hampered by labour shortage and social segregation policies. In addition, the pandemic hampered agricultural product access to markets along with local and/or regional distribution, which resulted in food shortages and price increases. The crisis highlighted the vulnerability of food systems and the need to develop more resilient and sustainable agronomic methods (Martin & Bergmann, 2021). The COVID-19 outbreak affected the availability of food items, crop productivity, and the supply chain in Bangladesh (Anwar, 2020; Adelodun *et al.*, 2021b). This occurred as a result of a shortage of manpower, transportation resources, and mobility restrictions. As a result of problems with agricultural production and supply chain management, it became difficult to get food with reasonable prices. Consequently, food became less affordable due to rising poverty levels and increasing food costs (Rahman *et al.*, 2022). In Bangladesh, rice is the staple food and an integral aspect of the nation's culture, economics and society.

This study attempted to get a comprehensive investigation into the changes in agronomic practices in the rice farming community of Mymensingh district of Bangladesh during the COVID-19 pandemic. Through an analysis of data and interviews with all the stakeholders in the agricultural sector, this study sheds light on the challenges faced by farmers, the measures they adopted to mitigate the impact of the pandemic on rice farming, and the ways in which agronomic practices were adapted and evolved to meet changing circumstances. By providing a better understanding of the impact of the pandemic on the rice farming activities and community of the study area this study can suggest policy and practice, helping to ensure a resilient and sustainable

rice farming system that can ensure food, income, and livelihoods for millions of people in Bangladesh in a pandemic situation in future (Anwar, 2020; Rahman *et al.*, 2022). The overall goal of the proposed research was to identify any changes in the agronomic practices by the rice farmers due to the COVID-19 pandemic in the Mymensingh district of Bangladesh. Thus, this study was designed to determine whether rice producers in rural and peri-urban areas have changed their agronomic techniques as a result of the COVID-19 pandemic and to identify the problems faced by the rice farming community and their adopted strategies for coping with the COVID-19 pandemic.

MATERIALS AND METHODS

Study area, study design and methodological approach

The study was conducted in the Baira and Char Nilakshmiya Union of Mymensingh Sadar, Bangladesh. Baira union is close to the Mymensingh city and is situated in the urban periphery; on the other hand, Char Nilakshmiya is a rural area. The reason behind selecting these two unions was to determine whether or not COVID-19 and its assorted restrictions impacted on agronomic practices vary between peri-urban and rural areas. In this study, farmers were asked questions to determine changes in agronomic practices during COVID-19. Only the responses to the variables during the pandemic (January 2020 to March 2022) were collected. This study used both quantitative and qualitative research methods to gain a thorough understanding of the complicated issues regarding changes in agronomic practices in rice farming due to the COVID-19 outbreak in Mymensingh region of Bangladesh. To verify the information provided by the respondents and to gain a detailed understanding of the changes in agronomic practices of the farmers as a result of the COVID-19 epidemic, qualitative methods such as focus group discussion (FGD) and key informant interviews (KII) were used. The changes in agronomic practices as a result of the pandemic and other issues, as well as potential farmer actions were assessed using a quantitative survey approach. The participants were only the rice-farming farmers in the study area. Thirty-two respondents were randomly chosen from each of the Baira Union (a peri-urban area), and the Char Nilakshmiya Union (a rural area) and therefore, total 64 farmers were responded for the study. The study followed all the research ethical guidelines on human participants of the university.

Research instrument, methods and data collection procedure

Every research approach has its own set of data collection tools for performing studies. Accuracy and precision are obviously significant qualities in study measurement, and data need to be actively recognized, carefully picked, and methodologically acquired. The face-to-face interview method was employed in this investigation. This survey method is helpful for exploratory, explanatory, and descriptive research. This approach is most likely the best one for social research because it makes it simple to obtain empirical data with little effort and expense. A pretested structured interview schedule was carefully created with the

study's goals in mind to gather pertinent data. The scheduled questions and assertions were clear, concise, and basic enough for the respondents to understand. Both closed-form and open-form questions were there on the schedule. Where appropriate, scales were incorporated into the timetable. The survey was carried out between August and September 2022. Using a set of interviews, 64 farmers were surveyed by one trained enumerator and the researcher himself. Before properly outlining the study's aims and utilizing as much local language as feasible, the researcher first built rapport with the respondents. Therefore, without any hesitation, the responders provided accurate answers to the questions. If any respondents had queries that needed clarification, those questions were explained. Responses from participants and other residents of the study region were highly cooperative.

Focus group discussions and interviews with key informants

Two FGDs were conducted in September 2022. Each union had one session, with eight participants in each group. FGDs were carried out using a checklist. Through this strategy, various concerns, actions, and issues affecting the livelihood of rice farmers as a result of COVID-19 pandemic were identified. The researcher served as the facilitator for the FGD sessions and was assisted by two assistants. Based on the FGD findings, the survey results were enhanced. For the purpose of interpreting the survey's findings, additional data from the FGDs were used. At the end of September 2022, three important sources were interviewed. The Union Parishad member, an NGO employee, and an Agriculture Extension Officer (AEO) were the Key informants. The researcher was able to learn about current living conditions, the status of the farmers, farming issues caused by the COVID-19 outbreak in the study area, and other information through interviews with key informants.

Measurement of the variables

The nine traits of the farmers were chosen to serve as the study's independent variables. These included age, household size, education, farming experience, farm size, annual family income, training, and media contact for extension programs. The following is a quick overview of the methods used to measure these variables. A respondent's real, full years from birth to the time of the interview were used to calculate his age. Each year of age received one point. One's year of schooling served as a proxy for education. In an educational setting, each level was graded with one point, while a respondent who could only sign their names was given 0.5 points. For instance, if a respondent completed 10 years of study and passed the Secondary School Certificate (SSC) exam, their educational score was provided as 10. The educational score of a respondent was '0' if he or she could not read or write. The actual number of people living in a respondent's family was used to calculate household size. The individuals included in the family were the responder, his wife, kids, daughters, and other dependents. For example, if a respondent's family consisted of five people, his or her household size score would be five. To operationalize farming experience,

the total number of years that each respondent had spent cultivating rice was calculated. The scoring was determined by the respondents' real experiences. The whole area of land used by a respondent's family for farming operations, measured in terms of the area's complete utility to the family, was referred to as the respondent's farm size. The following equation was used to calculate the size of each respondent's farm in hectares:

$$F_s = a + b + 1 + 2(c + d) + e + f + g + h + i$$

Where F_s = Farm size; a = Cultivable land in and around the homestead area; b = Own land under own cultivation; c = Own land given to others on Mymensingh; d = Other's land taken on Mymensingh; e = Lease (given to others); f = Lease (land was taken); g = Fallow; h = Pond; i = Garden/Forests, etc.

The total financial gain a family received from cash crops, vegetables, poultry, cattle, fisheries, services, businesses, remittances, and other sources during a given year was known as annual family income. To calculate the annual family income score, the earnings from these sources were combined. In Taka, the annual household income was stated. The number of days a respondent spent receiving training from various organizations over the last five years was used to calculate their exposure to training. Each day of training on which the responder participated received a score of one (1). When someone is exposed to the extension education via various extension media, this is referred to as extension media contact. The amount to which a farmer had contact with 13 different media outlets was used to calculate an extended media contact score for this variable. Each farmer was asked how frequently he or she interacted with the various media that were chosen. The extent of the respondent's media contact was calculated by averaging the ratings from 11 different information sources. The extent of contact might be between 0 and 33, with 0 denoting no extension media contact and 33 denoting the most likely extent media engagement.

Determining the value of the dependent variable

This refers to the changes that occurred in the practices performed by farmers in the field during rice production. The questions were related to whether farmers faced any hikes in cost, scarcity or disruption in the supply chain of seeds, fertilizers, pest and disease control equipment and irrigation due to the pandemic that resulted in changes in agronomic practices (crop rotation, soil tillage, fertilization, irrigation, weed control, pest and disease management, seed selection and planting). Agronomic practices are influenced by the availability of seeds, fertilizers, labour, machinery, pest and disease control equipment and marketing costs. All these items were open. The total question number was 7. Mark for each question was assigned on the basis of changes that occurred; hence, some questions were assigned 3 marks, and some were assigned 2 marks. Thus, the scores obtained for all the questions were summed to obtain the total change score of each respondent.

Measurement of problem confrontation

Close-ended questions were used to identify the problems the farmer was experiencing as a result of the COVID-19 pandemic. Many questions regarding various topics were posed to the farmers. The degree to which the stated obstacles were confronted was determined using a 4-point rating scale with the options high, medium, low, and no. The scores were given according to the following scales: 3, 2, 1, and 0. With a problem score ranging from 0 to 36, the greatest problem is indicated by a score of 36, while 0 indicates no problems with regard to farming methods or other issues. The problem confrontation index (PCI) was established to determine the severity of issues. The PCI ranged from 0 to 96, with 0 denoting no difficulty and 96 denoting the worst condition. Their responses were given the appropriate scores using a closed-ended question. The issues caused by the COVID-19 pandemic in the affected area were ranked using the problem confrontation index (PCI) score. The respondents also made suggestions for potential fixes to the issues.

Effect of the pandemic on rice production and strategies taken by farmers

This refers to the changes that occurred in the productivity of rice due to the pandemic. Farmers were asked whether the yield increased, decreased or remained the same. Their responses were recorded as yes (increase), no (decrease) or no change. By using closed-ended questions, it was possible to determine the approaches farmers used to combat impact of COVID-19 pandemic. Their responses were recorded, and the percentage of each response was examined. Farmers were asked about individual agronomic practices (crop rotation, soil tillage, fertilization, irrigation, weed control, pest and disease management, and seed selection and planting) they changed in both rural and peri-urban areas. Their responses were recorded as yes or no, and percentages were calculated.

Data analysis

After the respondents' information was gathered, it was coded, assembled, tabulated, and then examined. Standard units were created from the local units. By using the proper scoring methodologies, the qualitative data were converted into quantitative data. The data were examined in accordance with the study's goals. The data analysis was performed using the SPSS computer. The respondents' chosen attributes were described using a variety of statistical measures, including range, mean, number percent, standard deviations, and rank order. The Pearson's product moment correlation coefficient (r) was calculated to determine the associations between the various traits of the fish farmers and their attitudes. The following formula gives the r value for the person's product moment correlation coefficient.

$$r_{xy} = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

Where r_{xy} = Person's product moment correlation coefficient; \bar{x} and \bar{y} = Means of the variables x and y .

Both Microsoft Excel and IBM SPSS Statistics 25 were used to assess the information gathered through questionnaires (Angon et al., 2022; Angon & Islam, 2022). Pearson's product moment correlation coefficient " r " was used to examine the correlation between several variables. Microsoft Excel 2019 was used to calculate percentages, means, and standard deviation.

RESULTS AND DISCUSSION

Selected characteristics of the farmers

Different aspects of the farmers' lives affected how they made a living each day. Eight farmer characteristics, including age, education level, farming experience, household size, farm size, training experience, annual income, and extension media interaction, were chosen as independent factors in the current study. Table 1 provides information about the respondents' characteristics. In rural areas, farmers ranged in age from 24 to 70 years, with an average age of 45.6 years and a standard deviation of 10.56 years. The standard deviation is 7.69, and the average age is 49.9 years in urban areas. The farmers were divided into three age groups based on their chronological ages: young (up to 35), middle aged (36–50), and old (>55). Table 1 shows that 53.1% of the farmers in rural areas were middle-aged, 21.9% were young, and 25% were older than 55 years. In the urban area, 46.9% of the farmers were middle-aged, 0% were young, and 17% were older than 55 years (Table 2). The farmers' educational backgrounds ranged from illiterate to graduate. The average score in rural area is 6.63, while the standard deviation is 4.41. The average score for the peri-urban area is 7.03, and the standard deviation is 4.19. The farmers were divided into six categories based on their level of education: illiterate (zero), only able to sign (0.5), primary (1–5), secondary (6–10), higher secondary (11–12), and graduate (>12). In rural areas, 15.6% of farmers had no formal education, 6.3% could only read and write, 15.6% had only completed their primary education, 50% had completed their secondary education, 6.3% had completed their higher secondary education, and 6.3% had graduated (Tables 1 and 2). In the peri-urban area, 9.4% of the farmers lacked a high school diploma, 6.3% could only read and write, 18.8% had a primary education, 43.8% had a secondary education, 15.6% had a higher secondary education, and 6.3% had a graduate degree (Table 2). The respondents' household ranged in size from three to eight members in rural areas and from three to six members in peri-urban areas. Peri-urban areas had an average score of 4.25 and a standard deviation of 1.19, whereas rural areas had an average score of 4.97 and a standard deviation of 1.33. The respondents were divided into three categories based on the size of their households: small (up to 4), medium (5 to 8) and large (>8) families. In rural areas, 40.6% of respondents said that their families were tiny, 59.4% said that their families were medium, and 0% said that their families were enormous. According to the data for the peri-urban area, 39.1% of the respondents had small families, 60.9% had medium families, and 0% had large families.

Table 1. Salient features of the selected characteristics of the respondents (rural area).

Characteristics	Categories		Respondents N=32		Score range		Mean	SD
	Level	Value	Number	%	Min.	Max.		
Age	Young	≤35	7	21.9	26	74	45.62	10.56
	Middle aged	36-50	17	53.1				
	Old aged	>50	8	25				
Educational level	Illiterate	0	5	15.6	0.5	15	6.625	4.41
	Can sign only	0.5	2	6.25				
	Primary	1-5	5	15.6				
	Secondary	6-10	16	50				
	Higher secondary	11-12	2	6.25				
	Graduate	>12	2	6.25				
Household size	Small	≤4	13	40.6	3	8	4.97	1.33
	Medium	5-8	19	59.4				
	Large	>8	0	0				
Farming experience (Years)	Low	≤20	17	53.1	5	60	23.38	12.419
	Medium	21-40	14	43.8				
	High	>40	1	3.1				
Farm size (Hectare)	Landless	<0.02	0	0	0.0307	2.432	0.884	0.757
	Marginal	0.02-0.2	6	18.8				
	Small	0.21-1	15	46.8				
	Medium	1.01-3	11	34.4				
	Large	>3	0	0				
Annual income (Lakh BDT)	Low	≤2	0	0	228693	495127	369932.12	79244.10
	Medium	3-4	19	59.4				
	High	>4	13	40.6				
Training experience (Days)	Low	<1	10	31.25	0	12	4.46875	3.91
	Medium	2-10	20	62.5				
	High	>10	2	6.25				
Extension media contact	Low	≤16	10	31.25	13	26	19.28	4.28
	Medium	17-32	22	68.75				
	High	>32	0	0				
Changes occurred in the agronomic practices	Low	≤5	7	21.9	2	12	8.03	2.19
	Medium	6-8	9	28.1				
	High	>8	16	50				

Table 2. Salient features of the selected characteristics of the respondents (peri-urban area).

Characteristics	Categories		Respondents N=32		Score range		Mean	SD
	Level	Value	Number	%	Min.	Max.		
Age	Young	≤35	0	0	36	65	49.94	7.69
	Middle aged	36-50	15	46.9				
	Old aged	>50	17	53.1				
Educational level	Illiterate	0	3	9.4	0	16	7.03	4.19
	Can sign only	0.5	2	6.25				
	Primary	1-5	6	18.75				
	Secondary	6-10	14	43.75				
	Higher secondary	11-12	5	15.6				
	Graduate	>12	2	6.25				
Household size	Small	≤4	19	59.4	3	6	4.25	1.19
	Medium	5-8	13	40.6				
	Large	>8	0	0				
Farming experience (Years)	Low	≤20	26	81.3	9	27	15.65	5.05
	Medium	21-40	6	18.7				
	High	>40	0	0				
Farm size (Hectare)	Landless	<0.02	0	0	0.023	1.78	0.5785	0.5079
	Marginal	0.02-0.2	11	34.4				
	Small	0.21-1	14	43.7				
	Medium	1.01-3	7	21.9				
	Large	>3	0	0				
Annual income (Lakh BDT)	Low	≤2	1	3.1	278869	598209	441607.31	102154.257
	Medium	3-4	11	34.4				
	High	>4	20	62.5				
Training experience (Days)	Low	<1	12	37.5	0	11	3.46	3.74
	Medium	2-10	19	59.4				
	High	>10	1	3.1				
Extension media contact	Low	≤16	16	50	10	22	16.69	3.728
	Medium	17-32	16	50				
	High	>32	0	0				
Changes occurred in the agronomic practices	Low	≤5	10	31.25	2	14	7.06	3.00
	Medium	6-8	12	37.5				
	High	>8	10	31.25				

The smallest farm size among farmers in rural areas was determined 0.031 hectares, while the greatest was 2.432 hectares. Farm sizes ranged from 0.884 to 0.757 hectares on average. The smallest farm size in an urban environment was determined 0.023 hectares, and the greatest was found 1.78 hectares. Farm sizes ranged from 0.5785 to 0.5079 hectares on average. The respondents were divided into five groups based on the size of their farms (Tables 1 and 2). According to the data, the majority of farmers in rural areas (46.8%) had small farms, followed by those who had medium-sized farms (34.4%) and those who had large farms (0.00%). The majority of farmers in the peri-urban area (43.7%) fall into the small farm size group, while 34.4% have marginal farms, 21.9% have medium farms, and 0.00% had large farms.

The respondents' yearly incomes in rural areas ranged from Tk 228693 to Tk 495127, with an average of Tk 369932 and a standard deviation of Tk 79244.10. With an average of Tk 441607.31 and a standard deviation of Tk 102154.257, respondents' yearly income in peri-urban areas ranged from Tk 278869 to Tk 598209. According to their annual income, the respondents were categorized into three groups: low (up to 2), medium (3-4) and high (>4). The farmers' annual revenue distribution is shown. According to the data, 0% of people in rural areas had a low annual income, 59.4% had a medium annual income, and 40.6% had a high family income. A total of 34.4% of people in peri-urban areas had medium yearly incomes, 62.5% had high family incomes, and 3.1% had low annual incomes. The respondents' average training experience in rural areas was 4.47 days, with a standard deviation of 3.91 and a range of 0 to 12 days. The respondents' average training experience in peri-urban areas was 3.46 days, with a standard deviation of 3.74, and ranged from 0 to 11. According to their score, the respondents were split into three groups based on their training experience: low (>1), middle (2-10) and high (>10). In rural areas, the data showed that 62.5% had moderate training experience, 6.25% had high training experience, and 31.25% had low training experience. According to the data, 59.4% of people in peri-urban areas had moderate training experience, 3.1% had high training experience, and 37.5% had low training experience (Tables 1 and 2).

The respondents had media interaction in rural areas for an average of 19.3 days, with a standard deviation of 4.28 days, ranging from 13 to 26 days. The number of respondents who had extended media contact in peri-urban areas ranged from 10 to 22, with an average of 16.7 and a standard deviation of 3.73. According to their scores on extended media contact, the respondents were classified into three groups: low (up to 16), medium (17-32), and high (>32). According to the data, 68.75% of people in rural areas had medium extension media contact, 0% had high extension media contact, and 31.25% had low extension media contact. According to the data (Tables 1 and 2), in the peri-urban area, 50% had medium extension media contact, 0% had high extension media contact, and 50% had low extension media contact. Changes in respondents' agronomic practices in rural areas varied from 2 to 12, with an average of 8.03 and a standard deviation of 2.19. Changes in respondents' agronomic practices in peri-urban areas ranged from 2 to 14, with an average of 7.06 and a

standard deviation of 3.00. The respondents were categorized into low (up to 5), medium (6-8), and high (>8) categories based on the changes that occurred in the agronomic methods. The data showed that in rural areas, 28.1% of agronomic practices have changed in a medium or higher way, 50% have changed more significantly, and 21.9% have changed in a lower or more moderate way. In the peri-urban areas, 37.5% of the agricultural practices experienced moderate changes, 31.3% experienced greater changes, and 31.3% experienced less changes. The data show that rural areas undergo more changes in agronomic practices than peri-urban areas since the mean value of the rural areas is greater than 8 and falls into the category of high agronomic practice changes. The peri-urban areas, on the other hand, experienced fewer changes in agronomic practices. The change in agronomic practices, on the other hand, had a mean value of 7.06 and fell into the medium group.

Relationships between farmers' selected personalities and mostly changed agronomic practices

For both rural and peri-urban areas, there was no correlation between age and the degree of change in agronomic techniques, as shown by the 'r' value (-0.102 and 0.162, respectively). As a result, the null hypothesis in question could not be ruled out (Table 3). For rural areas, the magnitude of changes in farmers' agronomic practices and their degree of education were significantly correlated at the 0.01 level of probability, according to the computed 'r' value (0.445*), and the association had a positive trend. Therefore, the null hypothesis in question was not accepted. For peri-urban areas, the degree to which farmers' agronomic practices changed was significantly correlated with their level of education at the 0.01% probability level and followed a positive trend, according to the computed "r" value (0.440*): As a result, the null hypothesis in question was disproved. For rural areas, according to the calculated 'r' value (0.431*) displayed, there was a significant association between farmers' household size and the degree to which their agronomic practices changed at the 0.01 level of probability, and that relationship followed a positive trend. Therefore, the null hypothesis in question was not accepted. For the peri-urban area, the calculated 'r' value (-0.058) indicated that there was no correlation between household size and the degree of change in agronomic practices. As a result, the relevant null hypothesis could not be disproved (Table 3). It is clear from the findings that changes in agronomic practices did not depend on household size during the epidemic. For rural areas, there was no correlation between farming experience and the degree of change in agronomic methods, as shown by the 'r' value (-0.144). As a result, the null hypothesis in question could not be ruled out. For peri-urban areas, there was no correlation between farming experience and the degree of modification of agronomic methods, as indicated by the computed "r" value (0.234). As a result, the null hypothesis in question could not be ruled out. The findings showed that changes in agronomic practices during the pandemic did not depend on farm experience. In other circumstances, the outcomes might have been different.

Table 3. Pearson's correlation coefficient (r) between dependent and independent variables.

Farmers' characteristics (Independent variables)	Focus variable	Coefficient of correlation (r)	
		Rural	Peri-urban
Age	Changes occurred in the agronomic practices	-0.102	0.162
Education		0.445*	0.440*
Household size		0.431*	-0.058
Farming experience		-0.144	0.234
Farm size		0.101	-0.309
Annual family income		0.002	0.089
Training		0.653**	0.683**
Extension media Contact		0.774**	0.865**

*Significant at the 0.05 probability level; **Significant at the 0.01 probability level.

Table 4. Problems faced by farmers due to COVID-19 (N= 32 in each group).

Categories	Value	Numbers	%	Min	Max	Mean	SD	
								Rural areas
Problems faced by Farmers	Low	≤7	4	12.5	5	25	12.84	4.96
	Medium	8-16	25	78.1				
	High	>16	3	9.4				
	Peri-urban areas							
	Low	≤7	3	9.4	7	16	11.38	2.61
	Medium	8-16	29	90.6				
High	>16	0	0					

For rural areas, the calculated "r" value (0.101) indicated that there was no correlation between the size of the farm and the degree to which the agronomic technique had changed. As a result, the relevant null hypothesis could not be disproved. For the peri-urban area, the calculated "r" value (-0.309) indicates that there was no correlation between the amount of the farmers' modifications in agronomic techniques and their level of farming experience. As a result, the relevant null hypothesis could not be disproved (Table 3). Wealthy farmers may have been more willing to change agronomic practices since, in rural regions, farm size is a sign of affluence. For both rural and peri-urban areas, there was no correlation between annual family income and the degree of modifications in agronomic techniques, as indicated by the computed "r" value (0.002 and 0.089, respectively). As a result, the null hypothesis in question could not be ruled out (Table 3).

For rural areas, the magnitude of changes in farmers' agronomic practices and their level of training were significantly correlated at the 0.01 probability level and followed a positive trend, according to the estimated "r" value (0.653**). Therefore, the null hypothesis in question was disproved (Table 3). For peri-urban areas, the calculated "r" value (0.683**) revealed a significant association at the 0.01 level of probability and a positive trend between the amount of training of farmers and the extent of changes in their agronomic practices. As a result, the null hypothesis in question was disproved. Training exercises serve to broaden perspectives and aid in the adoption of new methods. The farmers who received training may have been more enthusiastic about adjusting their agronomic techniques to prosper because the pandemic created a condition that had never been witnessed before. For rural areas, according to the calculated "r" value (0.774**), there was a substantial correlation between farmers' exposure to extension media and the extent of changes in their agronomic practices at a probability of 0.01%, and the connection trended positively. As a result, the null hypothesis in question was disproved. According to the calculated "r" value (0.865**), there was a substantial correlation between the farmers' of peri-urban exposure to extension media and the degree to which

their agronomic practices changed at a probability of 0.01%, and the association was positive in the peri-urban area. As a result, the null hypothesis in question was disproved (Table 3).

Problems faced by farmers due to COVID-19 pandemic

The farmers experienced during the COVID-19 pandemic, which has a significant impact on changes in agronomic methods. The scale for problem confronting covered up to 10 issues related to their farming. Scores ranged from 0 to 32. A total of 5 to 25 were observed for the rural areas. The majority of respondents (78.1%) had medium problems with their farming and agronomic practices, 12.5% had low problems, and 9.4% had high problems. The observed values for the peri-urban areas ranged from 7 to 16. The majority of respondents (90.6%) had medium difficulty with agronomic farming techniques, followed by 9.4% who had a low problem and 0% who had a high problem (Table 4). On the problem confrontation scale, farmers responded to each problem as high, medium, low, or not at all. The problem confrontation index (PCI) was calculated to determine the severity of the problems. The data in Table 5 revealed certain issues faced by farmers as a result of COVID-19 and their relative rankings in terms of severity in rural and peri-urban areas. 'Problem in marketing' and 'Transport impediments' were found to rank first and second, respectively for residents of rural areas. The 'Increase in farming cost' was in third position. According to the rank order (Table 5), 'Field work disruption due to social distancing norm' came in the top place among peri-urban residents. According to the PCI, the 'Cost of labour' was the second most common problem for the farmers. The third problem faced by the farmers was 'Labour availability'. Importantly, the data expressed those rural farmers faced more problems than peri-urban farmers. This is because rural farmers' problems had greater PCI (problem confrontation index) values than did those of peri-urban farmers, and the mean value was also greater for rural farmers (i.e., 12.84 for the peri-urban area and 11.38 for the peri-urban area). The mean value also indicated that farmers in both the rural and peri-urban areas faced medium-level problems (<16).

Table 5. Problems faced by farmers in rural areas due to the pandemic (N= 32 in each group).

S. No.	Problems faced by farmers	Level of problems											
		Rural areas						Peri-urban areas					
		H	M	L	N	PCI	RO	H	M	L	N	PCI	RO
1.	Problem in marketing	25	6	1	0	88	1	15	6	10	1	52	8
2.	Transport barriers	22	7	2	1	82	2	19	7	2	4	73	4
3.	Increase in farming cost	19	9	3	1	78	3	18	4	8	2	70	5
4.	Cost of labour	18	7	5	2	73	4	23	5	1	3	80	2
5.	Labour availability	16	5	6	5	64	5	22	2	6	2	76	3
6.	Availability of consumer	15	1	14	2	61	6	12	11	7	2	65	6
7.	Impact of on income and food	10	9	10	3	58	7	8	3	14	7	44	9
8.	Economic condition	9	8	13	8	56	8	11	7	13	1	60	7
9.	New competition in market	12	5	9	6	55	9	3	9	10	10	37	11
10.	Disruption due to Covid-19 infection	7	10	8	7	49	10	5	10	8	9	43	10
11.	Field work disruption due to social distancing norms	4	8	12	8	40	11	24	6	2	0	86	1
12.	Shift to another crop	3	11	7	11	38	12	1	12	9	10	36	12

Notes: RO = Rank order, PCI= Problem Confrontation Index, N = Not at all (score: 0), L = Low (score: 1), M = medium (score: 2), H = High (score: 3).

Table 6. Strategies taken by farmers to confront the pandemic in rural areas (N=32 in each group).

Strategy	Rural areas	Peri-urban areas
	Yes (%)	
Local sourcing of agricultural inputs	78	76
Supply chain management	69	64
Marketing via mobile calls	66	81
Collaboration with agencies like DAE, different NGOs	61	63
Innovative farming techniques	53	59
Diversification of crops	6	13

Table 7. Possible solutions for mitigating the problems created by COVID-19 (both rural and peri-urban areas, N=64).

S. No.	Possible solutions	Yes (Number of respondents)	Rank order
1.	More financial support from government	62	1
2.	More training	60	2
3.	Eradication of middleman	57	3
4.	More incentives in Agricultural mechanization	54	4
5.	Loan at minimum interest rate	50	5
6.	Special transport facility for perishable crops	49	6
7.	More innovative technologies from research organizations	45	7
8.	More availability of quality seeds	44	8
9.	More engagement programs for farmers to introduce them with information and technology	41	9
10.	Ensuring uninterrupted power supply for irrigation	38	10

Strategies taken by farmers to overcome problems

The purpose of this section is to provide a clear understanding of the strategies used in agronomic practices by farmers to address COVID-19. As many as 6 strategies were included in connection with their farming. For rural and peri-urban areas, the same strategies were included and ranked according to the farmers' responses (Table 6). Local sourcing was most common in rural areas, with 78% of farmers responding that they started using it during the epidemic. Supply chain management ranked second; 69% of the farmers said that they tweaked supply chain management. Sixty-six per cent of the farmers reported that they adopted marketing via mobile calls, which ranked third. In collaboration with agencies such as the DAE, different NGOs ranked fourth, and 61% of the farmers said that they collaborated with the mentioned agencies for marketing, the sourcing of agricultural inputs and expert opinions. The adoption of innovative farming techniques ranked fifth; 53% of the farmers responded that they had adopted innovative farming techniques such as IPM. The diversification of crops ranked sixth, and only 6% of the farmers responded to this. 81% of farmers in peri-urban areas reported using local suppliers throughout the epidemic (Table 6). Local sourcing came in second, with 76% of farmers stating that they

started using it during the pandemic. Supply chain management ranked third; 64% of the farmers said that they made tweaks in supply chain management. In collaboration with agencies such as the DAE, different NGOs ranked fourth; 63% of the farmers said they collaborated with the mentioned agencies for marketing, the sourcing of agricultural inputs and expert opinions. The adoption of innovative farming techniques ranked fifth; 59% of the farmers responded that they had adopted innovative farming techniques such as integrated pest management (IPM). The diversification of crops ranked sixth; only 13% of the farmers responded to this.

Suggested solutions for the problems

Farmers were asked through a checklist along with some ways to mitigate the abovementioned problems to develop their present livelihood conditions. They mentioned some possible solutions that were ranked according to their opinions. Among the probable 10 solutions, more financial support from the government ranked first (Table 7). More training and the eradication of middlemen are also the major possible solutions for these problems ranked second and third, respectively. The farmers also opined in favour of providing more incentives for agricultural mechanization.

Table 8. Changes in rice yield in rural and peri-urban areas.

Area	Increase (%)	Decrease (%)	No change (%)
Peri-urban	5	34	61
Rural	11	23	66

Table 9. Individual agronomic practices changed in rural and peri-urban areas (N=32 in each group).

Name of practice	Rural areas	Peri-urban areas
		Yes (%)
Fertilization	57	49
Weed control	45	33
Seed selection and planting	43	54
Soil tillage	37	35
Irrigation	26	19
Crop rotation	1	0

Effect of pandemic on rice production in rural and peri-urban areas and individual agronomic practice changes

Farmers were asked about the changes in rice productivity during the pandemic, and their responses were recorded as yes (increase), no (decrease) or no change. In the peri-urban area (Table 8), 5% of the farmers experienced an increase in yield, 34% experienced a reduction in yield, and 61% experienced no change in yield, indicating that they achieved similar yields before the pandemic. In rural areas, 11% of farmers reported increased yields, 23% reported yield reductions, and 66% reported no changes in yield. Rice production was more stable in rural areas than in peri-urban areas. Farmers were asked about individual agronomic practices (crop rotation, soil tillage, fertilization, irrigation, weed control, pest and disease management, seed selection and planting) in both rural and peri-urban areas. They mentioned what type of agronomic practices changed, which were ranked according to their responses (Table 9). For rural areas, 57% of the farmers responded that they changed fertilization, which was the highest change. Weed control ranked second, as 45% of the farmers responded "yes to this". Seed selection and planting ranked third; 43% of the farmers responded that there were changes in seed selection and planting, and soil tillage (37%), irrigation (26%) and crop rotation (1%) were ranked fourth, fifth and sixth, respectively. For the peri-urban area, 54% of the farmers responded that they had selected and planted seeds, which was the highest percentage. Fertilization was the second most common practice for 49% of the farmers. Soil tillage ranked third; 39% of the farmers responded that there were changes in seed selection and planting. The weed control (33%), irrigation (19%) and crop rotation (0%) treatments ranked fourth, fifth and sixth, respectively (Table 9). It is evident that farmers in both peri-urban and rural areas have changed different types of agronomic practices, which indicates that the extent of problems was different and that is why preferences for changes in agronomic practices were also different.

During the study, eight independent variables of farmer characteristics, viz. age, education level, farming experience, household size, farm size, training experience, annual income, and extension media interaction were considered to have the best relationship with the changed agronomic practices due to COVID-19 pandemic. The magnitude of changes in farmers' agronomic practices

and their level of education were significantly correlated in both rural and peri-urban areas. People with broader perspectives are more likely to explore novel solutions to challenges. Farmers with education are thought to be more progressive and innovative than those without education, and they may do better in various scenarios, such as the COVID-19 pandemic. Therefore, it may be claimed that the respondent's education level and the degree to which agronomic techniques have changed to adapt to changing conditions in every situation are closely related.

Interestingly, there was a significant association between farmers' household size and the degree to which their agronomic practices changed in the rural areas; whereas no correlation was found in the peri-urban areas. The result indicates that changes in agronomic practices sometimes depend on household size during the pandemic. However, the changes in agronomic practices were not dependent on farming experience or farm size. The magnitude of changes in farmers' agronomic practices was significantly correlated with their level of training experience both in rural and peri-urban areas. Training exercises serve to broaden perspectives and aid in the adoption of new methods. The farmers who received training may have been more enthusiastic about adjusting their agronomic techniques to prosper because the pandemic created a condition that had never been witnessed before (Anwar, 2020). Also the farmers who changed their agronomic practices during the COVID-19 pandemic condition had received mostly a medium level of training. The training might be helpful for them to make decisions in changing their agronomic practices. The present study identified a substantial correlation between farmers' exposure to extension media and the extent of changes in their agronomic practices. Farmers were able to face the challenges in farming due to extension media interactions. Extension media contact assisted farmers in farming with limited resources and marketing (Rahman et al., 2022). It also assisted farmers in changing their agronomic practices to the emerging pandemic and its various problems because the pandemic is new and a major disruption occurred in the supply chain of agricultural inputs (Adelodun et al., 2021a). In rural areas, 68.8% of people had medium-extension media contact and 50% of the peri-urban people had medium-extension media contact. This exposure

might help people to get rid of the negative impact of COVID-19 on agriculture and rice farming in particular. The Majority of respondents faced medium problems with their farming and agronomic practices during the COVID-19 period. During the pandemic, people were scared of the new disease and remained at home; moreover, due to social distancing norms, all forms of transport facilities were hampered, especially in rural areas, which is not good in our country. Therefore, 'problem in marketing' and 'transport impediments' were found to rank first and second, respectively, for residents of rural areas. This may be the reason for this problem ranking first in rural areas. The increase in farming cost was in third position. As the pandemic disrupted the supply chain and transportation, the costs of agricultural inputs increased, which may increase farming costs. The fourth problem faced by the farmers was 'labour availability'. We know that during the pandemic people had to remain at home, and they had to face movement restrictions imposed by the government to prevent the spread of the virus, which resulted in the unavailability of labour.

People of the peri-urban areas had to face problems related to the "field work disruption due to social distancing norms". During the first wave of the pandemic, people were afraid of the new disease and remained at home. Due to social distancing norms, labour availability was also disrupted. For this reason, farmers faced problems while working in the field. The problem confrontation index (PCI) was also high for the 'cost of labour'; therefore, it was the second most common problem for the farmers. As a result of the lockdown, migratory labourers were not able to travel, which is why the cost of hiring labourers was high. The third problem faced by the farmers was 'labour availability'. We know that during the pandemic, people had to remain at home to prevent the spread of the virus, which resulted in the unavailability of labour. Additionally, the rural farmers faced more problems than peri-urban farmers. The local sourcing was the most common in rural areas and supply chain management was the second most common strategies that were followed during the pandemic (Rahman *et al.*, 2022). Most of the farmers weakened supply chain management and some farmers adopted marketing via mobile calls. Most of the farmers in peri-urban areas reported using local suppliers throughout the pandemic. The study suggested some probable solutions for the problems associated with COVID-19 pandemic. More financial support from the government could be the most useful solution for farmers at both rural and peri-urban areas. Farmers struggled from the financial crisis due to supply chain disruption, unavailability and increased cost of agricultural inputs, and decreased purchasing power and increased unemployment problem during COVID-19 period. More training and the eradication of middlemen are two major possible solutions to these problems. When training for more innovative technologies in farming becomes available, yield will increase, and farmers will suffer less during uncertain disasters such as pandemics. Presence of middleman is an age-old problem; this increases the product price, and this is one of the reasons why farmers lose interest in farming. The farmers also provided some suggestions for providing more incentives for agri-

cultural mechanization, as it will reduce labour costs and make farming more profitable than traditional farming, and during the labour crisis in the peak season, it will help to a great extent (Mouloudj *et al.*, 2020). Rural farmers changed fertilization, mostly and most of the peri-urban farmers changed seed selection and planting. From the data, it is evident that farmers in both peri-urban and rural areas have changed different types of agronomic practices, which indicates that the extent of problems was different and that is why preferences for changes in agronomic practices were also varied.

Recommendations and policy implications

Bangladesh is a fast-developing country, and the agricultural sector is the most important sector because it provides food security, so disruptions in this sector due to pandemics are of great concern. The climate is changing rapidly, and more situations, such as COVID-19, may occur in the near future. This study provides an overview of how farming changed during the pandemic, how farmers adopted such practices and what solutions were preferred by farmers. This study will also help to formulate strategies for farmers in rural and peri-urban areas, as problems and changes in agronomic practices are different for farmers in these two areas.

- The study highlights that the most preferred solution by farmers to cope with a similar situation in the future is more incentives and support from the government. Thus, policymakers should provide farmers with the necessary support to help them cope with any future pandemic or crisis. This could include financial aid, subsidies, or tax breaks, among others.
- The study indicated that farmers' engagement in programs to introduce information and technology was one of the least preferred solutions. Therefore, there is a need to develop more farmer-friendly technological solutions and tools that will be beneficial to farmers. These tools could include mobile applications, online resources, and artificial intelligence that will help farmers make better decisions and improve their productivity.
- Middlemen were one of the major problems faced by farmers during the pandemic. Farmers opined that the eradication of middlemen could help reduce their problems. Thus, policymakers should consider creating more direct links between farmers and consumers to eliminate middlemen, which will help farmers earn more income and reduce the cost of production.
- The study indicated that farmers' education, training exposure, and extension media contact had a significant relationship with changes in agronomic practices. Thus, there is a need for more training and educational programs for farmers to help them adapt to changing circumstances. The government could also partner with nongovernmental organizations (NGOs) to provide training programs for farmers to help them adopt new practices and technologies.

- Collaboration with agencies such as DAEs and different NGOs was one of the strategies adopted by farmers during the pandemic. Thus, policymakers should create more opportunities for collaboration between farmers and these agencies to help farmers access the necessary resources and support to cope with crises.
- Transport barriers and marketing problems were the top two problems faced by rural farmers during the pandemic. Thus, policymakers should work to improve transportation infrastructure and create better marketing channels to help farmers reach consumers more easily. This could include creating marketplaces and delivery services that will help farmers sell their produce directly to consumers.

Conclusion

Present study investigated into the overall impact of the pandemic on rice farming practices and farmers, farmers' responses to problems faced along with their strategies to cope with the changing situation and possible solutions to their problems. Among the selected characteristics of farmers in rural areas, farm size, training exposure and extension media contact were significantly related to changes in agronomic practices, whereas in peri-urban areas, education, training exposure and extension media contact were significantly related to changes in agronomic practices. Rural farmers faced more problems than peri-urban farmers. The extent of their problems was also different. Among the 12 problems affecting rural farmers, the first three problems were problems related to marketing, transportation barriers and increased farming costs, and the first three problems faced by peri-urban farmers were field work disruptions due to social distancing norms, labour costs and labour availability. Preferences in changing individual agronomic practices were also differing between rural and peri-urban farmers. Most rural farmers changed their fertilization techniques and patterns, while most peri-urban farmers changed their seed selection and planting techniques. Farmers in Bangladesh are very sceptical about new technologies, especially in terms of changing crop rotation and cropping patterns, and it is evident in the study that a minimum number of farmers changed this practice as a strategy. Farmers' strategies to cope with the pandemic were also different between rural and peri-urban areas. Rural farmers emphasized mostly the local sourcing of agricultural inputs, whereas peri-urban farmers emphasized marketing via mobile calls. Local sourcing of agricultural inputs was the second most common strategy used by the peri-urban farmers. Supply chain management was the second most common strategy for rural farmers, while it was the third most common for peri-urban farmers. Collaboration with agencies such as the DAE, different NGOs, innovative farming techniques and crop diversification were the last three strategies for both rural and peri-urban farmers. Both rural and peri-urban farmers opined that more incentives from the government would be their most preferred solution, followed by more training and the eradication of middlemen. More engagement programs for farmers to introduce them with information

and technology and an uninterrupted power supply were the last two preferred solutions.

DECLARATIONS

Author contribution statement: Conceptualization, methodology, software and validation, Formal analysis and investigation: R.H., S.K.K. and M.P.A.; Writing—original draft preparation: R.H., M.P.A., and A.K.M.M.I.; Writing—review and editing, visualization, supervision: A.K.M.M.I., M.H.R., S.Y., TZ, A.H., and P.B.A.; Project administration, Funding acquisition: A.K.M.M.I. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Ethics approval: This study was conducted as per the research ethical guidelines of the institute.

Consent for publication: All co-authors gave their consent to publish this paper in AAES.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

Supplementary data: No supplementary data is available for the paper.

Funding statement: No external funding is available for this study.

Additional information: No additional information is available for this paper.

Open Access: This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial 4.0 International License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) or sources are credited.

Publisher's Note: Agro Environ Media (AES) remains neutral with regard to jurisdictional claims in published maps, figures and institutional affiliations.

REFERENCES

- Adelodun, B., Kareem, K. Y., Kumar, P., Kumar, V., Choi, K. S., Yadav, K. K., Yadav, A., A. El-Denglawey, Marina Cabral- Pinto, Son, C. T., Krishnan, S., Khan, N. A. (2021a). Understanding the impacts of the COVID-19 pandemic on sustainable agri-food system and agroecosystem decarbonization nexus: A review. *Journal of Cleaner Production*, 318, 128451, <https://doi.org/10.1016/j.jclepro.2021.128451>
- Adelodun, B., Ajibade, F.O., Ibrahim, R.G., Ighalo, J.O., Bakare, H.O., Kumar, P., Eid, E.M., Kumar, V., Odey, G. and Choi, K.S. (2021b). Insights into hazardous solid waste generation during COVID-19 pandemic and sustainable management approaches for developing countries. *Journal of Material Cycles*

- and Waste Management, 23(6), 2077–2086. <https://doi.org/10.1007/s10163-021-01281-w>
- Angon, P. B., Khan, M. M. R., Islam, M. S., & Parvin, R. (2022). Evaluating the parameters influencing agricultural productivity due to the limitations of smartphone-related knowledge among farmers. *Archives of Agriculture & Environmental Science*, 7(1), 80-85. <https://doi.org/10.26832/24566632.2022.0701011>
- Angon, P. B., & Islam, M. S. (2022). A comparative analysis between food affordability and healthy life among the rural and urban people of Bangladesh. *IPTEK The Journal for Technology and Science*, 33(2), 85-93. <https://iptek.its.ac.id/index.php/jts/article/view/13552>
- Anwar, M. P. (2020). Impact of COVID-19 pandemic from farm to fork: hard-won lessons. *Fundamental and Applied Agriculture*, 5(3), 289-294. <https://doi.org/10.5455/faa.111527>
- Firman, D.M., & Allen, E.J. (2007). Chapter 33 - Agronomic Practices. In Book Title (Potato Biology and Biotechnology. <https://doi.org/10.1016/B978-0-444-51018-1.X5040-4>
- Martin, S., & Bergmann, J. (2021). (Im)mobility in the Age of COVID-19. *International Migration Review*, 55(3), 660–687. <https://doi.org/10.1177/0197918320984104>
- Goswami, M., Giri, A., Nandan, H., Joshi, N., Kumar, V., Kumar, P., Singh, N. (2024). Seasonal variation assessment of ambient air quality during COVID-19 lockdown in Uttarakhand state, India. *MAUSAM*, 75(3), 703-714. <https://doi.org/10.54302/mausam.v75i3.6067>
- Mouloudj, K., Bouarar, A.C., & Fechit, H. (2020). The impact of COVID-19 pandemic on food security. *Les cahiers du CREAD*, 36(3), 159-184. <https://www.ajol.info/index.php/cread/article/view/202191/190642>
- Rahman, M. T., Akter S., Rana, M. R., Sabuz, A. A., & Jubayer, M. F. (2022). How COVID-19 pandemic is affecting achieved food security in Bangladesh: A perspective with required policy interventions. *Journal of Agriculture and Food Research*, 7, 100258. <https://doi.org/10.1016/j.jafr.2021.100258>
- WHO. (2020). Director-General's opening remarks at the media briefing on COVID19 -March 2020. World Health Organization, Geneva, Switzerland. <https://www.who.int/docs/default-source/coronaviruse/transcripts/who-audio-emergencies-coronavirus-full-press-conference-24feb2020-final.pdf>