Heterogenous Effects of COVID-19 on Rural Livelihoods in Bangladesh: Evidence from a Panel Study

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INTRODUCTION

COVID-19 has had devastating impacts globally. In economic terms, in 2020 the global economy contracted by 4.3% (World Bank, 2021) and global employment reduced by an estimated 255 million full-time jobs (ILO, 2021). Especially developing countries have been hit hard by the pandemic plunging an additional 88 to 115 million people into extreme poverty (World Bank, 2020). Declines in employment and income, jointly with only partially effective government support programs, and fall of living standards caused widespread food insecurity (Egger et al., 2020).

In an attempt to curtail the impact of the pandemic, national governments imposed several forms of movement restrictions which disrupted domestic and global agricultural value chains (Barrett, 2020; Elleby et al., 2020). An increasing body of literature is beginning to emerge on the impacts of COVID-19, the associated movement restrictions, and value chain disruptions, on reduced agricultural production and food and nutrition security for regions, such as Sub-Saharan Africa (Ayanlade and Radeny, 2020), Caribbean (Blazy and Guyader, 2021), Pacific Islands (Iese et al., 2021), or individual countries, such as Bangladesh (Mandal et al., 2021), China (Pu and Zhong, 2020), Peru (Vargas et al., 2021), Myanmar (Boughton et al., 2021; Fang et al., 2021), or Nepal (Adhikari et al., 2021). As study objectives were mainly to provide rapid assessments and viewpoints, evidence based on rigorous analyses on livelihood outcomes and household coping mechanisms are scant.

While there is overwhelming evidence regarding the negative effects on agricultural production and food and nutrition outcomes, other impacts are more complex and heterogenous in nature

(Amjath-Babu., 2020). Take the example of labor effects. Urban workers who lost their employment and migrant workers from abroad returned home to their rural villages creating a labor surplus. At the same time, would-be migrant workers were restricted to travel to village communities creating labor shortages (Kabir et al., 2020; Karim et al., 2020; Kumar et al., 2021). COVID-19 and movements restriction effects are gendered, too. A study using data from 6 countries found that women were more severely affected in terms of job losses and resulting loss in income compared to men. As a coping mechanism, women more often reduced food consumption but increased savings (Dang and Nguyen, 2021). The pandemic created setbacks for women but also creates economic opportunities (Ragasa and Lambrecht, 2020). Another study from Bangladesh showed that women disproportionately more frequently left the house, mainly for grocery shopping, than men, despite movement restrictions (Hamadani et al., 2020). Women may thus be more exposed to the risk of infection. On the other hand, this casts doubt about the effectiveness of lockdown regulations. The existing literature is limited in terms of evidence regarding the heterogenous effects of COVID-19 and the associated movement restrictions.

The objectives of this paper are twofold. First, we provide rigorous evidence of the impacts of COVID-19 on several aspects of rural livelihoods. Particularly, we analyze how households cope with the COVID-19 impacts in terms of changes in agricultural production, gender-differentiated labor allocation, household expenditures, off-farm incomes, and consumption. The second objective is to analyze heterogenous effects of COVID-19 on rural livelihoods. Here, we examine differences between (fear of) sickness and movement restrictions on livelihood outcomes.

We use Bangladesh as a study case, in particular 2 districts in the southwest of the country. Bangladesh was in national lockdown from March-May 2020, which disrupted value chains and restricted movement of people and commodities (Islam et al., 2020). This, in turn, negatively affected agricultural production and undermined food and nutrition security (Kundu et al., 2020; Hamadani et al., 2020; Zabir et al., 2021).

We use two rounds of datasets collected from 450 farming households from Satkhira and Khulna districts in 2018 and 2020. This allows us to compared outcomes from pre-COVID (2018) with outcomes amid-COVID (2020). Data for 2020 was collected in December after the lockdown. Methodologically, we utilize the panel nature of our data and use simple difference-in-difference analysis techniques with fixed effects.

BACKGROUND

On March 8, 2020, Bangladesh recorded the first person infected with COVID-19. Since then infection rates climbed quickly which was accompanied by a high fatality rate. At the end of 2020, in Bangladesh a total of 510,000 people was infected by COVID-19 and 7,500 died (WHO, 2020). The Khulna division, our study region, ranks third in terms of number of infections (25,000) only after Chattogram division (63,000) and Dhaka division (350,000) (idem). In an attempt to slow the spread of the disease, the Bangladeshi government imposed a lockdown (March 24 – May 30) which drastically restricted movements of people and goods (Islam et al., 2020).

Both, disease and lockdown, had severe direct and indirect effects on the population, penetrating several aspects of people's livelihoods. In addition to the reported number of death, an increasing number of studies have been published on the effects of COVID-19 on mental health (Banna et al., 2020; Bodrud-Doza et al., 2020; Bhuiyan et al., 2020), especially for children (Yeasmin et al., 2020), the garment industry and the resulting internal migration of more than 10 million of workers to rural areas (Brydges and Hanlon, 2020; Kabir et al., 2020), migration, reduced levels of remittances, and food insecurity for this vulnerable group (Barker et al., 2020; Karim et al., 2020), and education (Dutta and Smitta, 2020).

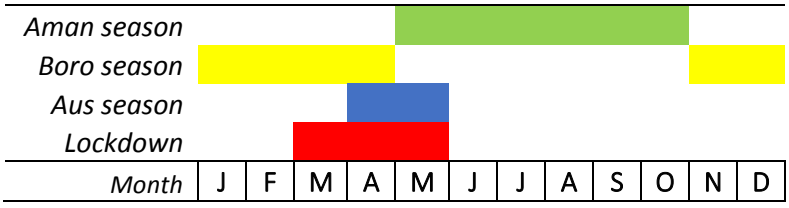
The agricultural sector has also been severely affected by the impact of COVID-19 resulting in disruptions in agricultural value chains and wide-spread food shortages. Disruptions, for example, left daily wage workers, who constitute 1/3 of Bangladesh's total labor force, with reduced incomes and extensively food insecure (Mottaleb et al., 2020). Labor shortages reduced agricultural production and movement restrictions limited access to markets for both sellers and buyers (Zabir et al., 2020). Prices for agricultural goods spiked at first but then quickly dropped sharply due to absence of buyers and traders in local markets, especially for perishable goods, such as vegetables and fish (Alam and Khatun, 2021; Sunny et al., 2021). In turn, in urban centers, prices for major food commodities drastically increased (Khatun et al., 2021; Mandal et al., 2021). The combination of reduced agricultural production and limited market access severely undermined food security and diet diversity (Kundu et al., 2020; Hamadani et al., 2020; Zabir et al., 2021).

Perceived compliance with government regulations were high (>90%) for adherence to social distancing, washing hands, and wearing of a mask (Ferdous et al., 2020). However, impost

movement restrictions, were much less adhered to. Households members, mainly women, did substantially leave the house to purchase groceries for the family. This begs the question about the effectiveness of lockdown regulations, especially for movement restrictions (Hamadani et al., 2020).

In Bangladesh, there are 3 main agricultural seasons, aman (May-Oct), boro (Nov-April), and aus (April-May). COVID-19 started in the end of March and before the government-imposed lockdown and travel restrictions were in effect, much of the boro production in 2020 had already been harvested (see Figure 1). For the boro harvest, such as boro rice or potato, the challenge was further downstream in the value chain. Traders were restricted to pick up the potatoes, farmers were limited to travel to markets to sell the produce. In turn, the aman planting, mainly rice, was severely affected by the government-imposed movement restrictions.

Figure 1. *Agricultural seasons and lockdown 2020 in Bangladesh*



MATERIALS AND METHODS

DATA

For this study, we use two rounds of a panel dataset for the years 2018 and 2020. In December 2018, a baseline survey was conducted in two districts - Satkhira and Khulna – in the Southwest of the country. These districts which are increasingly affected by salinity intrusion were part of

a project to “Strengthen food systems resilience with salt tolerant potato and sweetpotato varieties”. In line with project objectives, six upazilas – the next lower administrative level- were purposively selected along a salinity gradient (i.e., high, medium, and low levels of salinity intrusion). To increase the likelihood to sample potato- and sweetpotato-farming households, and households with pregnant/lactating women as well as infants (under 2 years of age), 9 unions – the next lower administrative level – were purposively selected using secondary data on the prevalence of those selection criteria. A total of 19 villages were randomly selected in those unions from complete village lists. Sampling proportional to size was used to randomly sample 450 households, oversampling in larger villages in terms of population.

In December 2020, the endline survey was implemented with 2018 sample. Attrition was low, as only 10 households could not be identified. The total number of households interviewed in 2020 was thus 440.

In both rounds, the same standardized questionnaire was used. In 2020, the questionnaire was amended with questions about the effects of COVID-19 in particular. The survey was implemented using tablets and preceded by intensive enumerator training and piloting of questionnaire in the field.

MODELLING EFFECTS OF COVID-19

The primary objective of this research is to analyze the impact of COVID-19 on several household livelihood aspects. We harness the panel nature of our dataset for two years 2018

and 2020. The year 2018 refers to a 'before COVID-19' scenario, while the year 2020 corresponds to a 'after COVID-19 hit' scenario. Formally, we can write:

$$D_{it} = \alpha + \beta 2020_i + \gamma X_{it} + \varepsilon_i + \mu_{it} \quad (1)$$

Where D is one of the dependent variables of interest of household i in time t. For each dependent variable a separate equation is estimated. Variables all represent key aspects of rural households, such as agricultural production, share of production sold at markets, labor allocation, expenditures, and consumption. Consumption is proxied by the household diet diversity score (HDDS). Rather than amount or frequency of consumption, this score measures the number of food groups – diversity – that a household consumed over a reference period, in our case during the past 24 hours. The HDDS is also often used as a proxy for household's economic access to food (Swindale & Bilinsky, 2006). We established HDDS following the FAO guidelines (Kennedy et al., 2010). See Table 1 (Descriptive Stats) for more details on all dependent variables. X is a vector of control variables of household i in time t. Control variables are age of household head, years of education, marital status, number of household members, agricultural area, off-farm income, expenditures and district dummy for Khulna.[1] ε is the time-invariant unobserved factor for household i that may affect the dependent variable(s). We control for this source of unobserved heterogeneity by including household fixed effects. μ is the idiosyncratic error term that varies across households and time. The time trend is controlled for including a year dummy for 2020, which is zero for the year 2018. As such, to investigate the impact of COVID-19, the year2020 dummy variable will be the observed changed between the a before COVID-19 and after COVID-19 scenario.

[1] Some control variables are also dependent variables. In these cases, they are dropped from the list of controls.

MODELING HETEROGENOUS EFFECTS OF COVID-19

We model heterogenous effects of COVID-19 by using three categories of farmer self-reported main COVID-19 impacts. These are (1) sickness or fear or sickness, (2) travel restrictions which include shops being closed and social distancing, and (3) loss of income and unemployment. These categories are not mutually exclusive. For instance, sickness and/or travel restrictions may result in loss of income or unemployment and, as such, the latter is a direct outcome of COVID-19 impacts. Following equation (1) we write:

$$D_{it} = \alpha_1 + \beta_1 2020_i + \gamma_1 X_{it} + \delta_1 H_i + \varepsilon_i + \mu_{it} \quad (2)$$

where the specifications are the same as denoted in equation (1), with the exception of H which is a vector of dummy variables representing if a household i experienced sickness or fear of sickness (=1) or zero otherwise; travel restrictions (=1) or zero otherwise; or unemployment or loss of income (=1) or zero otherwise. As discussed, we acknowledge that loss of income/unemployment is likely a result of the combined/single effect associated with COVID-19. Rather than interpreting the results, this dummy is used as a control variable which allows us to use the full sample. All regressions are estimated using robust standard errors.

We predict that each category has a different effect on livelihood outcomes. For instance, if a household member is sick is arguably the most severe case, as potentially all household members cannot work anymore and unable to travel to work, markets, etc. A coping strategy would be to employ more hired labor to perform essential on-farm tasks. There is thus a risk of

crop losses and thus reduced incomes from agricultural production with expected negative implications for household consumption and expenses. Depending on the course and severity of the infection, household could be affected for short or longer terms. In contrast, travel restrictions theoretically restrict access to markets and movement of labor. On-farm activities, performed by the households, however, remain possible, if the farm is in proximity to the household. Reductions in agricultural production thus largely depend on the availability of hired and family labor. Movement restriction may hinder labor to be hired while off-farm income may hinder involvement of family labor. Overall, the impact and adopted coping mechanisms are largely empirical questions. Add to this that enforcement of movement restrictions were weak, especially in rural area. In many rural areas, movement of labor and access to markets may thus be restricted only on paper.

RESULTS

DESCRIPTIVES

The average household in our sample was 47.7 years old in 2018 and, thus, about 2 years older in 2020 (Table 1). Almost all household heads (0.98) were male and married (0.96). The number of household members were, on average, 4.42 in 2018 with no significant increase in 2020. The total years of education were 5.65 in 2018 with also no significance difference in 2020. Interestingly, the total area was significantly reduced from 172 ha in 2018 to 135 ha in 2020. This might be a result of COVID-19's impact on agricultural production. To what extent agricultural production of main crops was affected will be analyzed in the regression analysis.

Finally, some 50% of the sample was located in Khulna district while the other half in Satkhira district. Interestingly, a higher share of households which experienced travel restrictions (78%) were located in Khulna district.

Table 1. *Descriptive statistics of selected household characteristics*

	Total (N=876)		**Sickness (N=226)**		**Travel restriction (N=340)**		**Unemployment (N=310)**	
	2018	**2020**	**2018**	**2020**	**2018**	**2020**	**2018**	**2020**
	Mean	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Age	47.7**	49.2	48.6	50.3	47.8	49.3	46.9	48.1
Male	0.98*	0.97	0.97	0.96	1	1	0.99**	0.97
Married (0/1)	0.96	0.96	0.93	0.94	0.97	0.98	0.96	0.95
Household members	4.42*	4.57	4.45	4.63	4.56	4.42	4.39	4.55
Years of education	5.65	5.74	6.11	6.24	5.69	5.83	5.26	5.28
Total area (ha)	172.3***	135.3	177.2***	120.1	199.7**	162.6	138.8*	117.2
Khulna district	0.52	0.52	0.44	0.44	0.78	0.78	0.3	0.3

Notes: T-test by year 2018 and 2020 for each category; *significance at 10%-level; **significance at 5%-level; ***significance at 1%-level.

In terms of consumption, the HDDS for all 12 HDDS groups was significantly reduced by 0.45 groups (Table 2), possibly as a result of changing household consumption pattern due to COVID-19. Staple commodities, such as cereals (mainly rice) and vegetables were consumed by almost all respondents in both years. Next, an additional 4% of respondents increased consumption of oil and fats. Potatoes were the 4th most important food item in 2018. A clear reduction in potato consumption by almost 12 percentage points was observed for the year 2020. In contrast, fish consumption increased by some 8 percentage points between 2018 and 2020. Fish production is commonplace in our study region and an increased consumption allows household member to stay at home rather than going to market to buy potatoes, for instance. On a positive note, between 2018 and 2020 cigarette and consumption of sugars were reduced

by 11% and 13%, respectively, likely because scarce funds were needed to purchase other more essential consumables. Consumption of other important and nutritious food item, such as legumes (-6.6%) and fruits (-9.0%), however, were also significantly reduced. The consumption of other food items which are important sources of micronutrients, such as meat, milk, and eggs, remained unchanged.

Table 2. *Descriptive statistics of Household Diet Diversity Score (HDDS) by year*

		2018 (N=440)	2020 (N=440)	
HDDS group	**Food item group**	**Mean (1)**	**Mean (2)**	**Change (2)-(1)**
HDDS	All	6.69	6.25	-0.45***
HDDS_1	Cereals	100	100	0
HDDS_3	Vegetables	97.1	97.2	0.1
HDDS_10	Oil and fats	90.7	94.8	4.09***
HDDS_2	Potatoes	85.1	73.4	-11.7***
HDDS_7	Fish	74.2	82.1	7.89***
HDDS_12	Cigarettes and other	60.7	49.5	-11.2***
HDDS_6	Eggs	30.9	31.1	0.2
HDDS_11	Sweets (sugar and sodas)	30.7	17.3	-13.4***
HDDS_8	Legumes	30.2	23.6	-6.6**
HDDS_4	Fruits	29.6	20.6	-9***
HDDS_9	Milk and products	20.9	18.8	-2.1
HDDS_5	Meat	19.1	16.3	-2.8

Notes: ***significant at the 1%-level; **significant at the 5%-level.

The accumulated total annual harvest for all crops amounted to an average of 4.3 tons in 2018 (Table 3). This was about 1 t less compared with total harvest in 2020 and a likely result of the effects of the pandemic. Interestingly, harvest reductions from 2018 to 2020 were not observed for rice, the staple crop in Bangladesh. Other crops, such as potato, however, experienced significant reductions, from 1.49 t in 2018 to 1.14 t in 2020. Despite same levels of rice harvest

after the pandemic hit and the government- imposed lockdown and travel restrictions, the share of aman and boro rice which was sold in the markets increased by 15% and 7%, respectively. Selling more agricultural products was likely a coping strategy to compensate for income losses from other household activities. In case of households perceived sickness as the most severe COVID-19 impact, strikingly, those households did not increase the share of crops sold to markets. Food was needed at home. Household that 'only' experienced travel restrictions, did increase the share of rice and potato sold in markets.

Between 2018 and 2020, household expenditure increased significantly from some 132k to 150k Taka. Whereas no significant differences were observed for sickness and travel restrictions, households that experienced unemployment increased expenditure by 25%. In more detail, food and health expenditures increased significantly between 2018 and 2020 by some 9% and 13.5%, respectively. Food expenditure, however, remained unchanged for households that experienced sickness, likely, because these households were unable to leave the house and were thus not affected by increasing prices. Expenditure on education dropped by some 54%, from 12.7k to 6.8k Taka, between 2018 and 2020.

In terms if labor allocation, households used slightly more male (4%) and female (3%) labor, probably to compensate for the reduction in male family labor (-8%). Female family labor, in contrast, did not increase significantly between 2018 and 2020. Female and male family labor, in turn, was used more off-farm: between 2018 and 2020, off-farm income increased by some 20%. Households affected by sickness and unemployment significantly increased off-farm incomes while households that experienced travel restrictions, did not.

Table 3. *Descriptive statistics of dependent variables*

	Total (N=876)		Sickness (N=226)		Travel restriction (N=340)		Unemployment (N=310)	
	2018	2020	2018	2020	2018	2020	2018	2020
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Total harvest (t)	4.32***	3.28	4.92***	2.94	4.41**	3.69	3.54**	2.69
Aman harvest (t)	1.82	1.78	1.66	1.65	2.22	2.52	1.39	1.23
Boro harvest (t)	2.15	2.19	2.27	2.37	2.49	2.95	1.54	1.41
Potato harvest (t)	1.49*	1.14	1.55	1.27	0.91	0.85	1.95	1.37
Aman % sold	0.34***	0.48	0.36	0.33	0.42***	0.61	0.26***	0.43
Boro % sold	0.4**	0.47	0.44	0.44	0.43**	0.53	0.34*	0.39
Potato % sold	0.6	0.58	0.44	0.44	0.43**	0.53	0.34	0.39
Expenditure (Tk)	132,001**	150,776	131,765	137,487	133,401	144,284	126,398**	168,307
Food expenditure (Tk)	56,291***	61,369	56,487	52,180	57,218**	65,505	54,173***	63,383
Health expenditure (Tk)	8,270***	13,508	8,605	12,119	7,109***	13,563	8,841**	14,451
Education expend. (Tk)	12,727***	6,856	14,558**	9,017	11,707***	6,775	12,348***	4,964
Male hired (% of total)	0.29***	0.33	0.28***	0.37	0.31**	0.36	0.25	0.25
Female hired (% of total)	0.06***	0.09	0.05*	0.07	0.05***	0.08	0.05***	0.1
Male family (% of total)	0.51***	0.43	0.51***	0.43	0.48***	0.4	0.54***	0.46
Female family (% of total)	0.14	0.15	0.14	0.11	0.14	0.14	0.13**	0.17
Off farm income (Tk)	83,041**	103,811	82,615**	100,365	86,546	87,284	90,610**	113,085

Notes: ***significant at the 1%-level; **significant at the 5%-level; *significant at the 10%-level.

REGRESSION RESULTS

TOTAL EFFECTS OF COVID-19

We now turn to the panel regression results with fixed effects. The Hausman test statistics generally suggest the use of fixed effects over random effects, considering all regressions. For those regressions the Hausman test cannot be rejected, and the random effects model is preferred, the coefficient results do not change in terms of significance for the variables of interest. Regression results in this section are summarized in Table 4.

Table 4. *Fixed effects panel regression results for COVID-19 impacts on selected livelihood outcomes*

	Total		**Aman rice**		**Boro rice**		**Potato**	
Harvest (kg)	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**
Year 2020	*-208.8*	*167.5*	*13.82*	*147.4*	*477.3****	*175.2*	*3.611*	*202.9*
R-squared	0.592		0.675		0.109		0.00	
Hausman Chi2 (7)	16.7**		46.7***		5.01		9.42	
Observations	878		603		585		395	
	Female hired		**Male hired**		**Female family**		**Male family**	
Labor share (%)	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**
Year 2020	*0.029****	*0.007*	*0.044****	*0.016*	*0.019*	*0.013*	*-0.093****	*0.017*
R-squared	0.037		0.068		0.03		0.06	
Hausman Chi2 (7)	16.7**		46.7***		5.01		9.42	
Observations	853		853		853		853	
	Total		**Food**		**Health**		**Education**	
Expenditure (log)	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**
Year 2020	*0.067**	*0.035*	*0.046*	*0.044*	*0.544****	*0.078*	*-0.709****	*0.098*
R-squared	0.587		0.687		0.10		0.12	
Hausman Chi2 (7)	16.7**		46.7***		5.01		9.42	
Observations	878		877		855		604	
	Aman rice		**Boro rice**		**Potato**			
Sold at market (%)	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**		
Year 2020	*0.079***	*0.036*	*0.008*	*0.039*	*-0.082*	*0.069*		
R-squared	0.348		0.057		0.003			
Hausman Chi2 (7)	16.7**		46.7***		5.01			
Observations	501		537		346			
	HDDS		**Off-farm income (log)**					
	Coeff.	**Std. err.**	**Coeff.**	**Std. err.**				
Year 2020	*-0.573****	*0.021*	*0.009*	*0.068*				
R-squared	0.054		0.009					
Hausman Chi2 (7)	16.7**		46.7***					
Observations	878		624					

Notes: *significance at the 10%-level; **significance at the 5%-level; ***significance at the 1%-level; control variables included: age, education, number of household members, total expenditure, off-farm income, total area.

In terms of total agricultural production, no significant difference between 2018 and 2020 was found, as the coefficient for year 2020 reveals. Aman production was not significantly impacted

while boro production increased by some 477 kg, on average. Compared to 2018, more hired male and female labor were utilized to support agricultural production. In more detail, the share of female hired labor of total household labor increased by some 3 percentage points, while the increase for male hired labor was 4.4 percentage points. In contrast, the share of male household labor of total labor was reduced by 9.3 percentage points in 2020, while female involvement did not significantly change. Increased selling of agricultural production was found to be the case for aman rice. On average, household's share of aman rice that was sold increased by some 8 percentage points in 2020, compared to 2018.

For other major crops no significant difference between 2018 and 2020 was found. In terms of household expenditures, overall, these increased slightly and significantly at the 10%-level in 2020. Moreover, while food expenditure did not change, health expenditure did increase and expenditure on education did decrease between 2018 and 2020. Next, we further found that HDDS was reduced by 0.57 categories, on average, in 2020 compared with 2018. This suggests that households changed food consumption significantly. Regarding off-farm income, we did not find a significant difference between 2018 and 2020.

HETEROGENOUS EFFECTS OF COVID-19

As for the reduced form of regression, Hausman test statistics are shown, mostly suggesting the use of fixed effects over random effects. Regression results in this section are summarized in Table 5.

Overall agricultural production was significantly lower and negative for households primarily affected by (fear of) sickness. However, looking only at individual crops, harvests were not significantly different for households primary affected by (fear of) sickness or travel restrictions.

Table 5. *Fixed effects panel regression results for heterogenous livelihood outcomes*

	Total		**Aman rice**		**Boro rice**		**Potato**	
Harvest (kg)	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**
Year 2020	130.9	217.5	16.37	147.4	590.6***	223.6	354.1	249.9
COVID: sickness	-842.3*	451.3	253.3	262.1	210.8	598.6	-371.6	424.4
COVID: unemployed[1]	-386.9*	236.1	-128.4	174.4	-324.6	208.7	-487.9**	238.6
R-squared	0.587		0.687		0.096		0.00	
Hausman Chi2 (7)	16.7**		46.7***		5.01		9.42	
Observations	878		603		585		395	
	Female hired		**Male hired**		**Female family**		**Male family**	
Labor share	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**
Year 2020	0.027**	0.011	0.043*	0.025	0.012	0.017	-0.086***	0.024
COVID: sickness	-0.017	0.017	0.055	0.035	-0.026	0.023	-0.012	0.034
COVID: unemployed[1]	0.015	0.015	-0.031	0.034	0.025	0.022	-0.011	0.032
R-squared	0.038		0.089		0.036		0.061	
Hausman Chi2 (7)	4.31		24.9***		7.99		19.2***	
Observations	853		853		853		853	
	Total		**Food**		**Health**		**Education**	
Expenditure (log)	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**
Year 2020	0.052	0.053	0.188***	0.046	0.546***	0.105	-0.627***	0.142
COVID: sickness	-0.074	0.086	-0.591***	0.105	-0.005	0.159	-0.047	0.197
COVID: unemployed[1]	0.082	0.071	-0.019	0.067	-0.001	0.147	-0.183	0.169
R-squared	0.12		0.01		0.10		0.119	
Hausman Chi2 (7)	33.1***		13.3*		9.67		17.5**	
Observations	878		877		855		604	
	Aman rice		**Boro rice**		**Potato**			
Sold at market (%)	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**	**Coeff.**	**Std. err.**		
Year 2020	0.108***	0.042	0.042	0.051	0.012	0.088		
COVID: sickness	-0.094	0.069	-0.042	0.067	-0.133*	0.078		
COVID: unemployed[1]	-0.023	0.065	-0.057	0.056	-0.098	0.061		
R-squared	0.367		0.07		0.01			
Hausman Chi2 (7)	13.2*		12.6*		8.21			
Observations	501		537		346			
	HDDS		**Off-farm income (log)**					
	Coeff.	**Std. err.**	**Coeff.**	**Std. err.**				
Year 2020	-0.866***	0.143	-0.169	0.137				

COVID: sickness	0.416**	0.202	0.301*	0.181
COVID: unemployed[1]	0.523***	0.201	0.264*	0.163
R-squared	0.057		0.01	
Hausman Chi2 (7)	8.13		15.6**	
Observations	878		624	

Notes: *significance at the 10%-level; **significance at the 5%-level; ***significance at the 1%-level; [1] used as control variable only and results are not interpreted; control variables included: age, education, number of household members, total expenditure, off-farm income, total area.

Regarding marketing of agricultural production, a significantly lower and negative effect was observed for the share of potato sold at markets for households that were primarily affected by (fear of) sickness. In contrast, the coefficients for aman and boro rice sold at markets did not enter significantly into the model, despite the coefficients have the expected negative direction. Heterogenous COVID-19 effects were only found for food expenditure. Here, we can observe that households which were primarily affected by (fear of) sickness had lower food expenditures compared with those households that were primarily affected by travel restrictions. Also, off-farm incomes were significantly different between household primarily affected by (fear of) sickness and travel restriction. While (fear of) sickness was associated with positive off-incomes, travel restrictions had the opposite negative effect.

DISCUSSION

We found that COVID-19 had a significant impact on rural livelihoods in Bangladesh and that affected households put several coping mechanisms in place to mitigate the impacts of the pandemic and associated government restrictions. In terms of agricultural production, harvests were not significantly reduced, as a research extensively suggests (Zabir et al., 2020). On the contrary, we found that production increased between 2018 and 2020 for specific crops, such

as boro rice. While higher rice prices incentivized farmers to allocate more area to rice production, productivity gains were also realized as a result of government agricultural support programs, which provide inputs, such as improved varieties (The Daily Star, 2020). Nevertheless, total harvests were significantly lower (and negative) for households that were primarily affected by (fear of) sickness. This was expected as infection and the fear thereof prevent households to perform agricultural work of travel to markets to sell produce.

We further found that households adopted several mechanisms to cope with or mitigate the impacts of COVID-19 and the associated government-imposed lockdown. First, households' overall expenditure did increase, as we predicted. Especially, health-related expenditures increased due likely to testing costs or more frequent doctor visits (Cousins, 2020). These additional costs in 2020 were compensated for by, in particular, reduced education expenditure.

Note that it is note clear if the reduction in education expenditure was due to costs-savings caused by government-imposed schools closures (Begum et al., 2020) or if children of school age had to (temporarily) drop out of school to support the household, as other research has found (Rahman et al., 2020), or both. Despite food expenditure did not increase overall, households that were primarily affected by (fear of) sickness had significantly lower (and reduced) food expenditure compared with households affected by travel restrictions. While (fear of) sickness appeared to bound people to their houses and not travel to markets, travel restrictions appear to not fully prevent people from leaving the house. Those who did were affected by higher prices for key staples (see Supplementary Table 1A). Price increases, however, are commodity and location dependent. For instance, the price for perishable goods

such as vegetables, fish, and chicken declined sharply due to lack of buyers and traders in local markets, or rumors regarding food safety concerns (Alam and Khatun, 2021; Zabir et al., 2021); in urban areas, in turn, prices for major food commodities, such as rice and fish, have spiked (Khatun et al., 2021; Mandal et al., 2021). The implicit finding that household primarily affected by travel restrictions and with higher food expenditure did leave the house more often is in line with other research that found that mainly women left the house, particularly, to buy groceries for the family (Hamadani et al., 2020). This means that women were more exposed to the thread of infection than men. More gender-disaggregated data is needed to confirm this.

The second coping mechanism households adopted was to increase the amount of agricultural production that was sold at local markets. This was the case for Aman rice but not Boro rice or potato. This seems to be surprising because total household expenditure, on average, did not increase. Possibly, households were oblivious to the total actual costs of the pandemic, which appear to not have been more compared to pre-COVID times, and thus sold more at markets pre-emptively. Another explanation is that higher rice prices incentivized households to sell agricultural surplus (see Supplementary Table 1; Khatun et al., 2021). Here, we also observe heterogenous COVID-19 effects. (Fear) of sickness was associated with significant lower share of potatoes sold at markets compared to household primarily affected by travel restrictions. The coefficients for aman and boro rice sold at markets are also negative but not significant which is due likely to small sample size. Overall, the results suggest that (fear) of sickness prevents households from traveling to markets to sell their produce.

A third coping mechanism households applied was to increase the household share of hired labor, both for male and female labor. This finding is in line with the 'internal migration'

hypothesis stating that due to substantive job losses in urban areas, mainly in the garment industry, people returned to their villages which has a positive effect on labor availability in rural areas. As a result, wages for day laborers may have experienced a drop, as research suggests for our study districts (Mottaleb et al., 2020). At the same time, the share of male family labor was reduced. Both (fear of) sickness and off-farm opportunities did not play a significant role explaining the drop in male family labor. We therefore argue that the observed reduction in male family labor was associated, as cause or effect, with the increased share of hired labor.

Fourth, off-farm income did not significantly increase between 2018 and 2020. This may be a result of the government-imposed travel restrictions and market closures – disrupted value chains – reducing chances to reach or being employed in off-farm opportunities. But why are 'disrupted value chains' reducing off-farm opportunities while increasing availability of rural labor at the same time? It is very likely, that rural areas experienced a positive labor shock because of the millions of workers from the garment industry who returned to their home villages (Kabir et al., 2020) in need of employment. As the garment industry gradually reopened after lockdown, it is not clear if workers return to urban centers again, or if they stay in rural areas. We further found a heterogenous COVID-19 effect: households primarily affected by (fear of) sickness had higher (and positive) off-farm incomes than households affected by travel restrictions. This seems puzzling but may be explained by the endogenous nature of the COVID-19 categories. Households that were mainly experiencing reductions in off-farm incomes were more likely to self-select into the travel restriction group than those households that self-selected into (fear of) sickness category.

Fifth, another coping mechanism households applied was the reduction in food consumption. Our mean HDDS of 6.25 observed for 2020 and the reduction by 0.57 categories is in line with other recent studies on food diversity and insecurity due to COVID-19 in Bangladesh (Kundu et al., 2020; Hamadani et al., 2020). We further showed several consumption adjustments. On a positive note, households reduced consumption of cigarettes and other 'luxury' items and sugary products, such as sodas or sweets. But likewise, the consumption of nutritious food items, such as legumes, potatoes, and fruits were reduced. More households, in turn, used more oil and fats and fish. With the fish value chain also being severely affected by disruptions (Zabir et al., 2021), fish was abundantly available, especially in our coastal study districts. A deeper analysis that examines if the increases in some consumption items were able to offset the nutritional content of items that were reduced, will be an important avenue of future research. We further found that diet diversity was reduced more for households primarily affected by travel restrictions than (fear of) sickness which. This, again, seems puzzling as we predicted that travel restrictions will allow household to access food more than those household that likely stay at home because of (fear of) sickness. On the other hand, the size of the effect should not be over-interpreted which was less than 0.5 categories.

CONCLUSIONS

In this study, we present rigorous evidence of the impacts of COVID-19 on several livelihood outcomes using panel data from pre-COVID (2018) and after COVID hit (2020). The secondary

objective was to analyze differences in livelihood outcomes depending on household perception regarding the importance of (fear of) sickness and travel restrictions, respectively.

For the total sample, we found that total agricultural production was not reduced. Productivity increases were observed for boro rice likely as a result of the dissemination of improved varieties. More aman rice was sold at markets after COVID-19 hit and more hired labor – both male and female – was used while male family labor was reduced. In terms of consumption, dietary diversity was reduced while total expenditure, in particular for health-related costs, were increased.

We found significant evidence of a heterogenous COVID-19 effect. In most of the cases, (fear of) sickness reduced the households' willingness, probably and ability, to leave the house compared to household primarily affected by travel restrictions. As such, agricultural tasks are abundant or significantly reduced resulting in lower agricultural production, a lower share of produce sold at markets, or lower food expenditures.

Our research contributes to the growing evidence base of impacts of COVID-19 on rural livelihoods. Agricultural production could be supported by labor-saving farming practices and productivity enhancing technologies. The Bangladesh government, for instance, has rolled-out a mechanization support program to help farmers with the aman rice harvest (Dhaka Tribune, 2020). In other areas, improved (boro) rice varieties were disseminated to increase yields (The Daily Star, 2020). These rapid government interventions are important but need to be scaled to other areas and crops. As households that experienced sickness are likely to be affected most by the inability to move to plots or markets, prioritizing households with infected household

members could be an avenue of effective policy-making. Other 'infection safe' policy interventions could aim at reducing value chains by shortening the marketing channels (Amjath-Babu et al., 2020). For instance, producer organizations in Bangladesh have created online fish marketplaces where fish can directly be sold and bought from the nearest farm (Mandal et al. 2021). Buyers and sellers do not need to travel to crowded wet markets which reduces the risk of infection drastically. In a similar vein, further localizing food production and exchange of food by introducing community marketing schemes could effective (Lioutas and Charatsari, 2021). Another effective intervention to reduce the need to travel to markets is the use of improved storage which has been found to contribute to food security (Huss et al., 2021).

Every crisis produces winners and losers. Producing rigorous evidence of the impact of global threads, such as a pandemic, is key to support or refute anecdotal evidence, much of which was produced especially in the beginning. In addition, acknowledging that specific groups of people, such as those that have already been infected by COVID or have relative more fear of being infected (possibly due to existing comorbidities) behave in such a way that results in higher vulnerabilities, is crucial for designing and targeting effective interventions, whatever they may be.

ACKNOWLEDGEMENT

This work received financial support from the German Federal Ministry for Economic Cooperation and Development (BMZ) commissioned and administered through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) Fund for International Agricultural

Research (FIA), contract number: 81219432. This research was undertaken as part of, and funded by, the CGIAR Research Program on Roots, Tubers and Bananas (RTB) and supported by CGIAR Trust Fund contributors.

REFERENCES

Adhikari, J., Timsina, J., Khadka, S. R., Ghale, Y., & Ojha, H. (2021). COVID-19 impacts on agriculture and food systems in Nepal: Implications for SDGs. Agricultural Systems, 186, 102990.

Alam, G. M., & Khatun, M. N. (2021). Impact of COVID-19 on vegetable supply chain and food security: Empirical evidence from Bangladesh. PLoS One, 16(3), e0248120.

Amjath-Babu, T. S., Krupnik, T. J., Thilsted, S. H., & McDonald, A. J. (2020). Key indicators for monitoring food system disruptions caused by the COVID-19 pandemic: Insights from Bangladesh towards effective response. Food security, 12(4), 761-768.

Ayanlade, A., & Radeny, M. (2020). COVID-19 and food security in Sub-Saharan Africa: implications of lockdown during agricultural planting seasons. npj Science of Food, 4(1), 1-6.

Banna, M. H. A., Sayeed, A., Kundu, S., Christopher, E., Hasan, M. T., Begum, M. R., ... & Khan, M. S. I. (2020). The impact of the COVID-19 pandemic on the mental health of the adult population in Bangladesh: a nationwide cross-sectional study. International Journal of Environmental Health Research, 1-12.

Barker, N., C. A. Davis, P. López-Peña, H. Mitchell, A. M. Mobarak, K. Naguib, M. E. Reimão, A. Shenoy & C. Vernot (2020). Migration and the labour market impacts of COVID-19, WIDER Working Paper, No. 2020/139, ISBN 978-92-9256-896-2, The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki, http://dx.doi.org/10.35188/UNU WIDER/2020/896-2

Barrett, C. B. (2020). Actions now can curb food systems fallout from COVID-19. Nature Food, 1(6), 319-320.

Begum, M., Farid, Md. S., Alam, M. J., Barua, S. (2020). COVID-19 and Bangladesh: Socio-Economic Analysis towards the Future Correspondence. Asian Journal of Agricultural Extension, Economics & Sociology38(9): 143-155, 2020; Article no.AJAEES.61005ISSN: 2320-7027. DOI: 10.9734/AJAEES/2020/v38i930417

Bhuiyan, A. I., Sakib, N., Pakpour, A. H., Griffiths, M. D., & Mamun, M. A. (2020). COVID-19-related suicides in Bangladesh due to lockdown and economic factors: case study evidence from media reports. International Journal of Mental Health and Addiction, 1-6.

Blazy, J. M., Causeret, F., & Guyader, S. (2021). Immediate impacts of COVID-19 crisis on agricultural and food systems in the Caribbean. Agricultural Systems, 190, 103106.

Bodrud-Doza, M., Shammi, M., Bahlman, L., Islam, A. R. M., & Rahman, M. (2020). Psychosocial and socio-economic crisis in Bangladesh due to COVID-19 pandemic: a perception-based assessment. Frontiers in public health, 8, 341.

Boughton, D., Goeb, J., Lambrecht, I., Headey, D., Takeshima, H., Mahrt, K., & Diao, X. (2021). Impacts of COVID-19 on agricultural production and food systems in late transforming Southeast Asia: The case of Myanmar. Agricultural Systems, 188, 103026.

Brydges, T., & Hanlon, M. (2020). Garment worker rights and the fashion industry's response to COVID-19. Dialogues in Human Geography, 10(2), 195-198.

Cousins, S. (2020). Bangladesh's COVID-19 testing criticised. The Lancet, 396(10251), 591. DOI:https://doi.org/10.1016/S0140-6736(20)31819-5

Dang, H. A. H., & Nguyen, C. V. (2021). Gender inequality during the COVID-19 pandemic: Income, expenditure, savings, and job loss. World Development, 140, 105296.

Dhaka Tribune (2020). https://www.dhakatribune.com/business/economy/2020/06/11/govt-takes-tk3-198-crore-farm-mechanization-project-to-support-farmers; accessed March 2021

Dutta, S., & Smita, M. K. (2020). The impact of COVID-19 pandemic on tertiary education in Bangladesh: students' perspectives. Open Journal of Social Sciences, 8(09), 53.

Egger, D., Miguel, E., Warren, S. S., Shenoy, A., Collins, E., Karlan, D., ... & Vernot, C. (2021). Falling living standards during the COVID-19 crisis: Quantitative evidence from nine developing countries. Science advances, 7(6), eabe0997.

Elleby, C., Domínguez, I. P., Adenauer, M., & Genovese, G. (2020). Impacts of the COVID-19 pandemic on the global agricultural markets. Environmental and Resource Economics, 76(4), 1067-1079.

Fang, P., Belton, B., Zhang, X., & Win, H. E. (2021). Impacts of COVID-19 on Myanmar's chicken and egg sector, with implications for the sustainable development goals. Agricultural Systems, 190, 103094.

Ferdous, M. Z., Islam, M. S., Sikder, M. T., Mosaddek, A. S. M., Zegarra-Valdivia, J. A., & Gozal, D. (2020). Knowledge, attitude, and practice regarding COVID-19 outbreak in Bangladesh: An online-based cross-sectional study. PloS one, 15(10), e0239254.

Hamadani, J. D., Hasan, M. I., Baldi, A. J., Hossain, S. J., Shiraji, S., Bhuiyan, M. S. A., ... & Pasricha, S. R. (2020). Immediate impact of stay-at-home orders to control COVID-19 transmission on socioeconomic conditions, food insecurity, mental health, and intimate partner violence in Bangladeshi women and their families: an interrupted time series. The Lancet Global Health, 8(11), e1380-e1389.

Huss, M., Brander, M., Kassie, M., Ehlert, U., & Bernauer, T. (2021). Improved storage mitigates vulnerability to food-supply shocks in smallholder agriculture during the COVID-19 pandemic. Global Food Security, 28, 100468.

Iese, V., Wairiu, M., Hickey, G. M., Ugalde, D., Salili, D. H., Walenenea Jr, J., ... & Ward, A. C. (2021). Impacts of COVID-19 on agriculture and food systems in Pacific Island countries (PICs): Evidence from communities in Fiji and Solomon Islands. Agricultural Systems, 190, 103099.

International Labor Organization (2021). ILO Monitor: COVID-19 and the world of work. Seventh edition. https://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/documents/briefingnote/wcms_767028.pdf; accessed March 2021.

Islam, M. T., Talukder, A. K., Siddiqui, M. N., & Islam, T. (2020). Tackling the COVID-19 pandemic: The Bangladesh perspective. Journal of public health research, 9(4).

Kabir, H., Maple, M., & Usher, K. (2020). The impact of COVID-19 on Bangladeshi readymade garment (RMG) workers. Journal of Public Health.

Karim, M. R., Islam, M. T., & Talukder, B. (2020). COVID-19' s impacts on migrant workers from Bangladesh: In search of policy intervention. World Development, 136, 105123.

Kennedy, G., Ballard T., & Dop, M. (2010). Guidelines for measuring household and individual dietary diversity. Food and Agriculture Organization (FAO). ISBN 978-92-5-106749-9. http://www.fao.org/3/i1983e/i1983e.pdf; accessed March 2021.

Khatun, M. M., Rahmatullah, Md. N., Afrin, S., Hoque, F., Afrin, T., Fatema-tuz-Zohura. (2020). Analysis of Consumer Perceptions on Food Purchasing During COVID-19 Pandemic in Bangladesh. International Journal of Agricultural Economics 5(6): 243-250. doi: 10.11648/j.ijae.20200506.13

Kumar, P., Singh, S. S., Pandey, A. K., Singh, R. K., Srivastava, P. K., Kumar, M., ... & Drews, M. (2021). Multi-level impacts of the COVID-19 lockdown on agricultural systems in India: The case of Uttar Pradesh. Agricultural Systems, 187, 103027.

Kundu, S., Al Banna, M. H., Sayeed, A., Sultana, M. S., Brazendale, K., Harris, J., … & Khan, M. S. I. (2020). Determinants of household food security and dietary diversity during the COVID-19 pandemic in Bangladesh. Public Health Nutrition, 1-28.

Lioutas, E. D., & Charatsari, C. (2021). Enhancing the ability of agriculture to cope with major crises or disasters: What the experience of COVID-19 teaches us. Agricultural Systems, 187, 103023.

Mandal, S. C., Boidya, P., Haque, M. I. M., Hossain, A., Shams, Z., & Mamun, A. A. (2021). The impact of the COVID-19 pandemic on fish consumption and household food security in Dhaka city, Bangladesh. Global Food Security, 100526.

Mottaleb, K. A., Mainuddin, M., & Sonobe, T. (2020). COVID-19 induced economic loss and ensuring food security for vulnerable groups: Policy implications from Bangladesh. PloS one, 15(10), e0240709.

Pu, M., & Zhong, Y. (2020). Rising concerns over agricultural production as COVID-19 spreads: Lessons from China. Global food security, 26, 100409.

Ragasa, C., & Lambrecht, I. (2020). COVID-19 and the food system: setback or opportunity for gender equality? Food security, 12(4), 877-880.

Rahman, M. S., Lassi, Z. S., & Islam, S. M. S. (2020). Risks to Bangladeshi children and young people during covid-19 outbreak. BMJ, 369.

Sunny, A. R., Sazzad, S. A., Prodhan, S. H., Ashrafuzzaman, M., Datta, G. C., Sarker, A. K., ... & Mithun, M. H. (2021). Assessing impacts of COVID-19 on aquatic food system and small-scale fisheries in Bangladesh. Marine Policy, 126, 104422.

The Daily Star, 2020. Tk 5,000cr for farmers. https://www.thedailystar.net/frontpage/news/tk-5000cr-farmers-1892389; accessed March 2021.

Vargas, R., Fonseca, C., Hareau, G., Ordinola, M., Pradel, W., Robiglio, V., & Suarez, V. (2021). Health crisis and quarantine measures in Peru: Effects on livelihoods of coffee and potato farmers. Agricultural Systems, 187, 103033.

World Health Organization. (2020). WHO Bangladesh COVID-19 Morbidity and Mortality Weekly Update (MMWU). 27 December 2020/Vol. No44. https://cdn.who.int/media/docs/default-source/searo/bangladesh/covid-19-who-bangladesh-situation-reports/who_covid-19-update_44_20201227.pdf?sfvrsn=bffee8db_7; accessed March 2021

World Bank. (2020). COVID-19 to Add as Many as 150 Million Extreme Poor by 2021. Press Release. Oct 7, 2020. https://www.worldbank.org/en/news/press-release/2020/10/07/covid-19-to-add-as-many-as-150-million-extreme-poor-by-2021#:~:text=The%20COVID%2D19%20pandemic%20is,severity%20of%20the%20economic%20contraction; accessed March 2021.

World Bank. (2021). Global Economy to Expand by 4% in 2021; Vaccine Deployment and Investment Key to Sustaining the Recovery. Press Release. Jan 5, 2021. https://www.worldbank.org/en/news/press-release/2021/01/05/global-economy-to-expand-by-4-percent-in-2021-vaccine-deployment-and-investment-key-to-sustaining-the-recovery; accessed March 2021.

Yeasmin, S., Banik, R., Hossain, S., Hossain, M. N., Mahumud, R., Salma, N., & Hossain, M. M. (2020). Impact of COVID-19 pandemic on the mental health of children in Bangladesh: A cross-sectional study. Children and youth services review, 117, 105277.

Zabir, A. A., Mahmud, A., Islam, Md. A., Antor, S. C., Yasmin, F., & Dasgupta, A. (2021). COVID-19 and Food Supply in Bangladesh: A Review. South Asian Journal of Social Studies and Economics 10(1): 15-23, 2021; Article no.SAJSSE.63010 ISSN: 2581-821X

SUPPLEMENTARY MATERIALS

Table 1A. *Prices for selected key agricultural goods in 2018 and 2020*

	2018	2020	Difference	
	Price (Tk)	Price (Tk)	(2020)-(2018)	
Crop	Mean	Mean		(%)
Aman rice	20.8	24.2	3.4	16.35
Boro rice	21.4	23.9	2.5	11.68
Jute	34.7	56.8	22.1	63.69
Bringal	17.7	23.6	5.9	33.33
Potato	11.2	13.7	2.5	22.32
Sweetpotato	7.5	16.7	9.2	122.67