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Short- and Long-Term Effects of the 1998 Bangladesh Flood on Rural Wages

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ABSTRACT

Natural disasters have particularly devastating impacts on economic growth in developing countries because they impede the accumulation of capital. The resilience of labor markets is crucial especially for the poor who rely only on labor to diversify their income portfolio and buffer against risk. Such a risk management strategy may become more challenging as global climate change increases the frequency of natural disasters. We use the Bangladesh Flood Impact panel household survey to evaluate how the 1998 “flood of the century” affected wages in Bangladesh. We find long-term declines in wages where nonagricultural labor markets are more severely affected. We also evaluate how soil quality and proximity to auxiliary labor markets cushion labor markets against the disaster. The most compelling evidence shows that workers in areas further from centers of economic activity are more vulnerable to flood-induced wage losses. Our findings suggest that future emergency relief and climate change programs should consider the protection of labor markets by improving infrastructure to facilitate job searches in alternative locations or reduce migration costs.

Keywords: disasters, flood, wages, Bangladesh

JEL codes: Q54, O13

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1. INTRODUCTION

Natural disasters can have devastating long-term impacts because they can impede the accumulation of physical and human capital stock (Skoufias 2003; Yamauchi, Yohannes, and Quisumbing 2008a, 2008b). It is now widely accepted that climate change will not only increase the frequency of two types of natural disasters that affect agriculture and rural households—droughts and floods—but also alter rainfall patterns, thereby changing farming practices, household behavior, and welfare. According to the IPCC *Fourth Assessment Report,* anthropogenic emissions may be responsible for at least a 40-centimeter sea-level rise by the end of the 21st century (IPCC 2007). Such increases in sea levels cause the salinization of groundwater and surface water sources, jeopardizing the supply of drinking water and the capacity to produce crops and displacing populations.

Examining the relationship between severe weather events and wages is particularly relevant for the design of future development and climate change strategies. Households migrate or seek labor in rural agricultural and nonagricultural markets to diversify their portfolio and buffer against risk (Kochar 1999; Rose 2001; Cameron and Worswick 2003; Takasaki, Barham, and Coomes 2010). It therefore is crucial to understand how resilient those markets are to shocks and the extent to which the markets can absorb the excess labor induced by shocks. Policies aimed at improving the reallocation of labor aftershocks (e.g., by protecting or facilitating migrant labor markets) may be a lower-cost alternative to other investment-heavy candidates.

In Bangladesh, annual flooding is considered a normal part of the agricultural cycle. However, severe floods, such as the one that occurred in 1998, can have devastating short- and long-term impacts. Unlike the "normal" floods that occur annually, the 1998 flood lasted until mid-September in many areas, covering more than two-thirds of the country and causing more than 2 million metric tons of rice crop losses (equal to 10.45 percent of target production in 1998–1999) (del Ninno et al. 2001). Using district-level data, a recent study evaluates the impact of riverine floods on agricultural wages in Bangladesh (Banerjee 2007). Banerjee finds that agricultural wages decline by 5 percent in flood-prone areas and by 14 percent in severely exposed areas during "extreme" floods in the short term. We build upon that work by evaluating both the short-term and long-term effects of the most severe flood experienced by households in Bangladesh, using a household panel survey that was specifically collected for this purpose.[1] In addition to using a household panel, our data extend beyond the time period used in Banerjee to account for the long-term impacts of the 1998 flood. Our paper also makes an additional contribution by measuring the flood effect on nonagricultural wages and identifying specific mechanisms that dampen damages in the short and long term.

We estimate reduced-form wage regressions using the Bangladesh Flood Impact household panel survey spanning immediately after the September flood to five and a half years postflood. Our identification strategy depends on the inclusion of district and time fixed effects to control for unobserved spatial and time heterogeneity, as well as reported preflood wage information to control for the initial labor market conditions of each village. We find that for every one-foot deviation from the usual flood depth, daily wages on average declined approximately 2 percent. Upon distinguishing between short- and long-term effects on wages, we find that the long-term impacts dominate. In particular, variations in wages a year after the event are not attributable to the deviations in the flood depth that occurred in 1998. However, we do find a statistically significant impact of the magnitude of the 1998 flood on the variation of wages after five and a half years. The persistence of damages five years past the natural disaster is consistent with findings related to drought effects on labor markets in Brazil (Mueller and Osgood 2009) and on growth patterns in Ethiopia (Dercon 2004). Wages declined between 4 and 5 percent for every one-foot increase from the usual flood depth more than five years after the major flood. Further distinguishing between agricultural and nonagricultural labor markets, we find that agricultural markets

[1] The survey has been used to account for immediate (del Ninno, Dorosh, and Smith 2003; del Ninno et al. 2001) and long-term 1998 flood damages with a specific focus on asset losses, consumption declines, reductions in nutritional status, and human capital accumulation (Quisumbing 2005a, 2005b; Yamauchi, Yohannes, and Quisumbing 2008a, 2008b).

experienced a wage loss of 4 percent for every one-foot increase, which remains constant over time. In contrast, nonagricultural labor markets experienced a greater decline in wages of around 7 percent per one-foot increase in the flood depth from normal conditions, with greater losses over time. The persistent negative impact of the flood on credit dependence in Bangladesh may be partially responsible for the negative long-term impact on investment in labor and other related markets (del Ninno, Dorosh, and Smith 2003). Our findings also corroborate the limitations of the food assistance programs in Bangladesh, which enhanced food availability in the short term but had no bearing on long-term household purchasing power (Quisumbing 2005a).

We also evaluate the roles of factors that can cushion labor markets from severe flood damages. In particular, we measure how soil drainage capacity and proximity to markets and bazaars may dampen the impact of floods on wages. Nearby markets and bazaars may provide surplus workers access to additional outlets for employment. Our results indicate that labor markets in predominantly clay-soiled areas (with low drainage capacity) were more severely affected than other areas in the short term. We also find that labor markets closer to the weekly market or bazaar were less affected than those further away. This suggests that the lack of auxiliary labor markets for workers exacerbated the impact of floods on wages. Although the analysis is representative of a modest number of villages in Bangladesh, our work suggests that future development and disaster relief policies might consider increasing workers' access to additional labor markets through investments in infrastructure and transportation.

In what follows, we provide a theoretical framework and a review of the literature describing why wages may be affected by natural disasters in the long term (Section 2). In Section 3, we describe the household panel survey. We present our empirical model, identification strategy, and empirical results in Section 4. Our concluding remarks are discussed in Section 5.

2. THEORETICAL INSIGHTS ON NATURAL DISASTERS AND THEIR WAGE EFFECTS

Studies in the risk-coping literature lend support to imminent wage effects from natural disasters in the short term. Natural disasters jeopardize production, affecting the marginal productivity of labor and thereby reducing on-farm labor demand. If workers' movement across sectors is relatively costless, some will seek employment off the farm. The impact of the shock ex post on off-farm labor supply will depend on the relative importance of the income and substitution effects. Rose (2001) demonstrates that the income effect is such that the household will increase its labor supply off the farm to maintain a minimum level of income when a damaging shock is realized. The substitution effect depends on the relationship between the shock and productivity in the own-farm production and labor market. Under certain conditions, Rose shows that the substitution reinforces the income effect of risk on off-farm labor market participation. The empirical evidence corroborates the aforementioned theoretical predictions. Households tend to diversify income risk ex post by shifting labor supply to off-farm activities (Kochar 1999; Rose 2001; Cameron and Worswick 2003; Takasaki, Barham, and Coomes 2010). Where labor supply adjustments are the primary means of coping with covariate risk, we would expect a decline in agricultural wages as the shock lowers the returns to agriculture and workers lay idle or seek employment in an alternative sector. What remains unclear is the extent to which off-farm or nonagricultural wages will be affected. If switching employment is costless, then we can infer from previous work that labor supply will increase in the nonagricultural sector. What remains unclear is the extent to which labor demand is satiated in the short term. Therefore, we evaluate the impact of the 1998 flood on wages first by pooling the sample of agricultural and nonagricultural workers, and then by differentiating effects across sectors.

Next, we are interested in assessing the long-term ramifications of a widespread, severe covariate shock on wages. This constitutes an important gap in the literature, because there may be several reasons why a short-term climate shock would affect factor markets in the long term. Community risk sharing prevalent in other settings (e.g., Townsend 1994) may be limited in the context of a severe short-term shock and informal credit systems may be overburdened. A lack of credit institutions could lead low-income households to invest in less-risky portfolios with lower average returns (Eswaran and Kotwal 1990; Rosenzweig and Binswanger 1993; Zimmerman and Carter 2003). Some households cope with climate shocks in the short term by selling their productive assets to obtain a minimum level of consumption (Rosenzweig and Binswanger 1993; Rosenzweig and Wolpin 1993; Fafchamps, Udry, and Czukas 1998; Kazianga and Udry 2006). Since the occurrence of climate shocks can trigger an underinvestment in capital, labor markets may also be affected in the long term. As long as farmers cannot replenish their productive assets, agricultural labor demand will decline. The scope of this problem will depend on farmers' credit access and the complementarity of labor and capital. Moreover, the surplus of agricultural labor may seek employment in the nonfarm rural sector. Depressed wages in the local nonfarm labor market may ensue if any or all of the following obtain: (i) migration is costly, (ii) demand for rural nonfarm services or products declines in response to the reduction in farmer purchasing power parity, or (iii) demand from the rural nonfarm sector is insufficient to accommodate the surplus labor induced by the shock. It is of interest to understand over what period the decline in nonagricultural labor demand may take place and for how long. Using our unique dataset, we will study the timing of the wage effects and their duration.

With respect to the timing of the wage effects, it is possible that we observe impacts only in the long term. The government of Bangladesh responded to the 1998 flood by providing food assistance through two programs. The Gratuitous Relief (GR) program, initiated in August 1998, was designed to provide food aid to households living in flood-affected areas. The Vulnerable Group Feeding (VGF) program was a larger-scale program targeting flood-affected areas as well as relatively poor segments of the population. Participation in the programs dwindled over time. Among the households sampled by our survey, the percentage of villages receiving GR dropped from 66 percent at the time of the flood in 1998 to 8 percent in January–April of 2004 compared with the 69 percent of villages receiving VGF dropping to 18 percent over the same period (Quisumbing 2005b). The direct transfers provided by these available programs may have dampened the anticipated effect of the shock on labor supply responses, which precludes observing a wage effect in the short term, particularly in the nonagricultural sector.

3. DATA

The Bangladesh Flood Impact panel household survey collected by the International Food Policy Research Institute was designed to evaluate the impact of the most severe natural disaster of the century. Bangladesh experiences annual flooding, ranging for days or weeks in July or August, that covers 30 percent of the country (del Ninno et al. 2001). Because farmers are accustomed to these floods, production losses attributable to them are uncommon. Severe floods are also part of Bangladesh's history, with specific cases occurring in 1954, 1974, 1987, and 1988. The 1998 flood achieved similar dangerous depths as the 1988 flood; however, households sustained these levels for 25 more days (del Ninno et al. 2001). The flooding began in early July and did not end until mid-September, affecting 68 percent of the country at various times (del Ninno et al. 2001).

The survey covers a large sample of households spatially over time: 757 households in 126 villages spanning November 1998 to May 2004. Seven *thanas* were selected based on the severity of flooding (according to the Bangladesh Water Development Board), the district level of poverty, representation in previous studies, and geographical variation (del Ninno et al. 2001).[2] Households were randomly selected based on a probability sampling technique involving several stages (see del Ninno et al. 2001 for more details). The panel consists of four rounds: (i) November–December 1998 (two months after the peak of the flood), (ii) April–May 1999, (iii) November–December 1999, and (iv) April–May 2004. The survey collects an array of household (and community) information including demographics, consumption, assets, employment, agricultural production practices, and borrowing.

The labor modules of the survey provide information on three types of employment: salaried workers, business and cottage activities (which primarily include self-employed workers), and the casual labor market (day laborers). The casual labor market had the greatest percentage of workers (33.5 percent) in 1998 and suffered the greatest losses immediately following the flood (del Ninno et al. 2001). Because we expect the casual labor market to be particularly vulnerable to a flood shock (since households use the labor market to diversify risk and as an additional source of income and since the market lacks contractual arrangements committing employers to hiring workers for a fixed period of time), we concentrate on this market to analyze the labor market impacts of the 1998 flood.

Two forms of daily wages (which include the value of food) are documented in the survey: wages in the last month prior to the survey, and wages in the three months before the last month prior to the survey. For instance, in the first round, wage data are collected for October 15–November 14, 1998, and July 15–October 14, 1998. The first round also asks workers to report their preflood wages for the same three-month period in 1997, specifically July 15–October 14, 1997. In our regression, the dependent variable consists of the previous-month wage data to reduce measurement error. One consequence of using this variable is that we are making wage comparisons, where the baseline is the wage one month after the flood rather than before the flood. We exploit the preflood self-reported data by constructing a variable that takes the averages of the individual preflood wages in each village to control for the initial labor market conditions in the regression.

Our 1998 flood variable is created from data collected in the first round of the household survey. Data on the usual flood depth and the depth of the flood in 1998 (in feet) were collected for all household plots that were owned and used. We first subtract the value of the normal flood depth for each plot from the realized depth value in 1998. We then construct a 1998 flood shock variable that consists of the village means of all the individual plot shock values. The construction of the shock variable captures the covariate nature of the shock and allows for variation in the damages caused by the flood. It must be noted that because the 1998 flood shock was a onetime event, the flood shock variable does not vary over time, which affects our empirical identification strategy.

Table 1 presents the means, standard deviations, and number of observations for each variable included in our wage regressions. We convert the wages from all rounds into 2004 terms using the

[2] A *thana* is an administrative unit that is smaller than a subdistrict and larger than a village.

consumer price indexes provided by the Bangladesh Bureau of Statistics. We evaluate two types of village-level characteristics that can alter vulnerability to flood exposure: whether the land consists of more than 50 percent clay soil, and the distances from the weekly market and bazaar. The distance variable was taken from round four of the community questionnaire. The clay variable was constructed from the household surveys and varies by village and over time.

Table 1. Summary statistics

Variable	Mean	Standard Deviation	Observations
Wages (2004 Taka)	72.94	26.55	1470
1998 Flood shock (feet)	3.48	1.39	1470
Female dummy	0.08	0.27	1470
Age	36.3	12.89	1470
Agricultural labor dummy	0.60	0.49	1470
Village mean wages 1997 (2004 Taka)	71.23	17.43	1470
April dummy	0.53	0.50	1470
Year 1999 dummy	0.52	0.50	1470
Year 2004 dummy	0.23	0.42	1470
Madaripur dummy	0.15	0.36	1470
Mohammedpur dummy	0.13	0.33	1470
Muladi dummy	0.13	0.33	1470
Saturia dummy	0.13	0.33	1470
Shibpur dummy	0.14	0.35	1470
Sharasti dummy	0.12	0.33	1470
Land over 50 percent clay dummy	0.05	0.21	1470
Distance from weekly market (km)	2.46	2.03	1329
Distance from bazar (km)	2.03	2.14	1302

Note: The Derai thana is omitted from the table.

4. EMPIRICAL STRATEGY AND RESULTS

We estimate a pooled ordinary least squares (OLS) regression to measure the impact of the deviation in the flood depth in 1998 from normal conditions during the wet season on daily wages:

$$w_{ijmt} = \beta_0 + \beta_1 X_{it} + \beta_2 F_i + \beta_3 F_i \times \delta_m + \beta_4 A_{it} + \beta_5 F_i \times A_{it} + \beta_6 w^{1997} + \alpha_j + \delta_m + \lambda_t + \varepsilon_{ijmt} \quad (1)$$

The dependent variable w_{ijmt} is the natural logarithm of the wage for individual *i* in *thana j* in month *m* of year *t;* X_{it} are variables that control for individual labor supply characteristics; F_i is the 1998 deviation in depth from normal flood conditions; A_{it} are various labor supply or demand characteristics that mitigate the losses incurred during the 1998 flood; w^{1997} is the natural logarithm of the preflood village wages; α_j, δ_m, and λ_t are *thana,* month, and year fixed effects; and ε_{ijmt} is the error term. For robustness, we also estimate a variant of equation (1) that includes a household random effect (RE) to account for unobserved heterogeneity, substituting $\varepsilon_{ijmt} = \mu_i + u_{ijmt}$.[3] Though the random effects model can be more efficient, it also strongly assumes that unobservable household characteristics are independent of the covariates. In both pooled and random effects versions of equation (1), we allow for clustering at the *thana* level, allowing for arbitrary spatial correlation of the flood impacts (Wooldridge 2003).

We focus on the impacts of the 1998 flood on the growing season relevant to most rural households without irrigation, the wet season. Harvesting crops during the wet season typically takes place in November and December (del Ninno et al. 2001). Because some of the rounds were collected after the wet season, we interact our April-month dummy variable with the flood variable to difference out the seasonal effect. For the purpose of our study, the parameter on the flood variable β_2 is of particular importance. The flood variable is a proxy for the loss of productive outputs or assets, or both, in the agricultural and nonagricultural sectors. Though farmers account for normal flooding conditions prior to the agricultural production season, the 1998 flood was unique in its scope, scale, and duration. Therefore, we expect the severity of the flood to at least have ramifications on labor demand, $\beta_2 \leq 0$.[4]

The market's dependence on environmental conditions and the availability of mechanisms to mitigate losses determine the extent of the impact of the disaster on labor demand. We allow the effect of the 1998 flood to differ by labor market (agricultural/nonagricultural) and land quality (whether the soil was predominantly clay). We expect agricultural labor markets and labor markets in areas with high clay content to experience greater losses in the form of wages, $\beta_5 < 0$. With respect to the latter, whereas clay soil normally provides favorable conditions for agricultural production, it lacks drainage capacity. Thus, the flood can have particularly severe consequences on agricultural labor markets if the farmers most affected are also the ones that have the greatest influence on labor demand since they may be responsible for hiring workers. Moreover, nonagricultural markets may be affected, in addition to the possibility of floods depleting the markets' productive assets, by the surplus labor made available by the decline in agricultural labor markets.

We also evaluate the extent to which proximity to weekly markets or bazaars affects wages. Such venues can provide additional labor market opportunities or outlets for generating income through trade. Where roads and public transportation are lacking, we might expect distant villages to realize greater losses as auxiliary labor markets or outlets for revenue to absorb or occupy unemployed or underemployed workers are absent. Note that it is also possible that we observe the opposite effect if migration is costless. If workers migrate to other labor markets and in-migration is limited, then the ensuing shortage of labor could increase wages.

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[3] Inclusion of the time invariant flood variable precludes the estimation of a household fixed effect version of equation (1).

[4] We note the possibility of no effect because it is possible that the out-migration of labor in response to the flood causes the opposite effect. For example, if workers can freely migrate and in-migration is nonexistent, labor supply may decrease yielding a positive effect on wages.

Our final model allows for distinctions in the severity of the flood over time. To test the impact of floods over time, we modify equation (1) to include variables that interact the severity of the flood variable with the time dummy variables:

$$w_{ijmt} = \beta_0 + \beta_1 X_{it} + \beta_2 F_i + \beta_3 F_i \times \lambda_t + \beta_4 F_i \times \delta_m + \beta_5 A_{it} + \beta_6 F_i \times A_{it} + \beta_7 F_i \times A_{it} \times \lambda_t + \beta_6 w^{1997} + \alpha_j + \delta_m + \lambda_t + \varepsilon_{ijmt}. \quad (2)$$

As discussed in Section 2, the flood may have differential effects on wages in the short and long term for at least three reasons. First, some of the emergency relief programs, particularly those that involved cash transfers, were short-lived. It is interesting to observe how wages evolved particularly in relation to the termination of emergency relief programs. Second, if the flood has long-term impacts on asset accumulation then it is likely that investment declines, further exacerbating labor market prospects. Third, it is possible that the flood affected agricultural and nonagricultural markets differently over time, which will depend on fluidity across markets and the interdependence of agricultural and nonagricultural markets.

We first estimate models (1) and (2) excluding any variables that account for flood mitigation mechanisms *A*. Table 2 reports the results from our baseline regressions. The estimated parameters and standard errors from the pooled OLS regression in column 1 of Table 2 indicate that for each additional foot of water attributable to the 1998 flood (relative to normal flood conditions), wages decline 1.9 percent. The random effects model reported in column 2 produced a smaller decline in wages of 1.7 percent. When distinguishing the effect of the 1998 flood over time, the pooled OLS regression indicates that the negative impact on wages gradually worsened over time. Although the parameters on the short-term flood shock effects are not significant, the parameter on the long-term effect on wages is significant and the magnitude is larger than the previous specification of the model. The pooled OLS regression in column 3 indicates that more than five years after the major flood, wages decreased by 4.7 percent for every additional foot in flood depth. The alternative random effects model specification in column 4 provided a slightly smaller estimate, indicating a 4.4 percent decline in daily wages per additional foot in flood depth.

Our results are consistent with the 5 percent decline in district wages following extreme floods among more flood-prone districts noted in Banerjee (2007). There are a few noteworthy differences in our study that have implications on the interpretation of our results. First, we include agricultural and nonagricultural wages in our regression. Second, our baseline wages (i.e., wages collected in the first round of the household survey) may already reflect a flood-induced decline since the data reflect earnings one month after the flood. Although we do account for preflood wages at the village level, this could possibly explain why we do not observe a similar short-term effect on wages. Additionally, this also suggests that our findings may underestimate the true impact since we are not comparing long-term wages to preflood wages. Third, we distinguish between short-term and long-term effects on wages. Our 5 percent decline in wages reflects a long-term effect rather than an immediate effect. The long-term effect may exceed that of the short term if there is a history of emergency relief programs that dampen immediate effects but fail to protect assets and related markets.

Table 2. 1998 flood impact on individual wages

	(1) Pooled OLS	(2) RE GLS	(3) Pooled OLS	(4) RE GLS
1998 flood shock	-0.019*	-0.017*	-0.009	-0.007
	(0.009)	(0.009)	(0.010)	(0.012)
1998 flood shock × year 1999 dummy			-0.021	-0.02
			(0.018)	(0.019)
1998 flood shock × year 2004 dummy			-0.047*	-0.044*
			(0.022)	(0.026)
April dummy	0.004	0.002	-0.078	-0.073
	(0.089)	(0.091)	(0.072)	(0.078)
1998 flood shock × April dummy	0.032*	0.032*	0.054***	0.054***
	(0.016)	(0.018)	(0.016)	(0.018)
Year 1999 dummy	0.080***	0.082***	0.153*	0.154*
	(0.022)	(0.027)	(0.075)	(0.083)
Year 2004 dummy	0.049	0.048	0.212**	0.202**
	(0.043)	(0.042)	(0.069)	(0.086)
Female dummy	-0.708***	-0.680***	-0.709***	-0.682***
	(0.138)	(0.132)	(0.138)	(0.132)
Age	0.022***	0.023***	0.022***	0.023***
	(0.005)	(0.005)	(0.005)	(0.005)
Age-squared (divided by 100)	-0.028***	-0.029***	-0.028***	-0.028***
	(0.008)	(0.007)	(0.008)	(0.007)
Agricultural labor dummy	-0.097	-0.089*	-0.096	-0.088*
	(0.052)	(0.050)	(0.052)	(0.050)
Ln(village mean wages 1997)	0.227***	0.221***	0.230***	0.223***
	(0.060)	(0.058)	(0.060)	(0.058)
Constant	2.935***	2.926***	2.892***	2.887***
	(0.287)	(0.280)	(0.283)	(0.278)
Sigma_u		0.15		0.15
Sigma_e		0.31		0.31
Rho		0.20		0.20
Observations	1,470	1,470	1,470	1,470
R-squared	0.30	0.30	0.30	0.30

Notes: *Thana* clustered standard errors are reported in parentheses.
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.10$.
Thana fixed effects are included in all models.
OLS (GLS) refers to ordinary (generalized) least squares regression. RE indicates a random household effect is included.

The empirical findings suggest that the consequences of the 1998 flood on the daily and casual labor market were more severe in the long term than the short term. As mentioned previously, this could be an artifact of the design of our regression specification where comparisons are being made with wages one month after the flood rather than preflood wages. Another possible explanation for the differential impacts on wages over time may be the influence of emergency relief programs on labor market dynamics. First, emergency relief programs might have protected asset depletion in the short term. In her analysis of the impact of the food assistance programs on assets, Quisumbing (2005a) finds that the GR program (rather than the VGF program, which predominantly distributed transfers in kind) was more successful at protecting the assets of the poor. Those programs were short-lived and, being targeted to the poor, did not enable most wealthy households to protect their investments. Second, emergency relief programs might have shifted labor supply upward, offsetting the impact the decline in labor demand would have had on short-term wages. Households might substitute leisure for consumption in response to the income gain in the short term. Skoufias, Unar, and Gonzalez-Cossio (2008) do not find an effect of cash or in-kind transfers on labor market participation in Mexico. Instead, transfers affected the allocation of time spent between agricultural and nonagricultural activities. Their findings suggest that it may be important to distinguish flood impacts by the type of labor market (e.g., agricultural versus nonagricultural). A third possible explanation for the differences in wage impacts over time may be the dwindling of informal credit sources. Following the flood, the majority of loans were financed by relatives (23 percent) and neighbors (31 percent) (del Ninno et al. 2001). Those sources might have reached their capacity in the years following the flood. In spite of the number of formal financial options provided by nongovernmental organizations, banks, or cooperatives, the limited availability of low-interest loans might have affected households' ability to borrow.

Table 3. 1998 flood impact on wages by labor market

	(1) Pooled OLS	(2) RE GLS	(3) Pooled OLS	(4) RE GLS
1998 flood shock	-0.009	-0.009	0.014	0.014
	(0.013)	(0.013)	(0.014)	(0.014)
1998 flood shock × year 1999 dummy			-0.036	-0.036
			(0.023)	(0.025)
1998 flood shock × year 2004 dummy			-0.069**	-0.065***
			(0.023)	(0.025)
Year 1999 dummy	0.080***	0.082***	0.151*	0.153*
	(0.022)	(0.027)	(0.073)	(0.086)
Year 2004 dummy	0.049	0.048	0.226**	0.214***
	(0.042)	(0.041)	(0.072)	(0.086)
Agricultural labor dummy	-0.047	-0.044	-0.038	-0.038
	(0.050)	(0.044)	(0.045)	(0.035)
1998 flood shock × agricultural labor dummy	-0.015	-0.013	-0.038**	-0.036***
	(0.018)	(0.018)	(0.014)	(0.015)
1998 flood shock × year 1999 dummy ×			0.027	0.027
agricultural labor dummy			(0.017)	(0.017)
1998 flood shock × year 2004 dummy ×			0.034***	0.032***
agricultural labor dummy			(0.006)	(0.007)
Observations	1,470	1,470	1,470	1,470
R-squared	0.30	0.30	0.31	0.31

Note: All models include season and *thana* fixed effects, a variable that interacts the shock and season variables, the log of village mean wages in 1997 variable, a female dummy, and age and age-squared variables.
Thana clustered standard errors are reported in parentheses.
*** p ≤ 0.01, ** p ≤ 0.05, * p ≤ 0.10.
OLS (GLS) refers to ordinary (generalized) least squares regression.
RE indicates a random household effect is included.

Our next regression specification allows for the distinction of the 1998 flood impacts by labor market. Estimates from the pooled OLS and random effects versions of model (1), where we include variables that interact the flood shock variable with a dummy indicating whether the worker participated in an agricultural task, are reported in the first two columns of Table 3. The results indicate that agricultural wages were more negatively affected by the 1998 flood, but the parameter estimates are not statistically significant at the 10 percent critical level.

We further distinguish the flood impacts by labor market and time following specification (2). The third and fourth columns of Table 3 report the pooled OLS and random effects estimates. The pooled OLS and random effects model estimates suggest that agricultural wages experienced a decline immediately following the shock of 2.4 and 2.2 percent ($\beta_2 + \beta_6$ in model [2]), respectively, for every one-foot increase in flood depth. For the same increase in flood depth in 1998, a statistically significant decline in nonagricultural wages was observed only five years after the event. Additionally, the magnitude of the decline was more severe than in the agricultural market (6.9 and 6.5 percent in the pooled OLS and random effects regressions). The loss in agricultural wages increased only slightly five years later from 2.4 to 3.5 percent (in the pooled regression) and from 2.2 to 3.3 percent (in the random effects regression) per each additional foot of flood depth. The results suggest that the decline in agricultural wages remained relatively stable, in contrast with the nonagricultural labor market, which was more deeply affected in the long term. Several factors may contribute to the greater decline in nonagricultural markets. A greater level of asset depletion may have influenced the labor demand of this market. The nonagricultural labor market may be more vulnerable to the flood consequences of related markets. For example, Quisumbing (2005a) found declines in nonfood per capita expenditures particularly among the wealthier household participants of food assistance programs. Thus, the decline in the demand in nonfood markets, for example, may have severe repercussions on the nonagricultural labor market. Finally, the surplus of workers from the agricultural labor market may have switched their employment to the nonagricultural labor market, further exacerbating wage declines.

The next set of regression specifications allows for distinctions in flood impacts by labor demand and supply characteristics that may mitigate flood impacts on wages. Table 4 includes the estimates from the pooled OLS and random effects models that allow for the flood impacts to vary by soil quality. To understand the relevance of drainage on the flood impact, we focus on distinguishing flood effects across areas with and without greater than 50 percent of their land consisting of clay soil. The estimates from model (1) are reported in columns 1 and 2 of Table 4. One possible interpretation is that clay soil increases the marginal productivity of labor yet also increases vulnerability to the flood impacts due to the lack of drainage. We also provide estimates of model (2), which further differentiates the flood effects by type of soil and elapsed time, in columns 3 and 4 of Table 4. The long-term impact of the flood on wages remains consistent with previous estimates reflecting a long-term decline of around 5 percent. Accounting for time differentiation of the effects, we now observe that areas with clay soil are severely affected immediately following the shock; however, they recover a year after the flood in the random effects model.

Table 4. 1998 Flood impact on wages accounting for soil quality

	(1) Pooled OLS	(2) RE GLS	(3) Pooled OLS	(4) RE GLS
1998 flood shock	-0.016	-0.014	-0.003	-0.002
	(0.010)	(0.011)	(0.014)	(0.016)
1998 flood shock × year 1999 dummy			-0.026	-0.025
			(0.019)	(0.021)
1998 flood shock × year 2004 dummy			-0.053*	-0.049*
			(0.024)	(0.027)
Year 1999 dummy	0.080**	0.082***	0.167*	0.166*
	(0.024)	(0.030)	(0.081)	(0.091)
Year 2004 dummy	0.050	0.048	0.232**	0.218**
	(0.045)	(0.044)	(0.078)	(0.094)
Land more than 50% clay dummy	0.167*	0.143**	0.167*	0.138*
	(0.073)	(0.069)	(0.080)	(0.078)
1998 flood shock × land more than 50% clay dummy	-0.036*	-0.033**	-0.039*	-0.035**
	(0.017)	(0.015)	(0.017)	(0.017)
1998 flood shock × year 1999 dummy × land more than 50% clay dummy			0.035	0.043*
			(0.026)	(0.026)
1998 flood shock × year 2004 dummy × land more than 50% clay dummy			0.006	0.004
			(0.017)	(0.017)
Observations	1,470	1,470	1,470	1,470
R-squared	0.30	0.30	0.30	0.30

Note: All models include season and *thana* fixed effects, a variable that interacts the shock and season variables, the log of village mean wages in 1997 variable, a female dummy, an agricultural labor dummy, and age and age-squared variables. *Thana* clustered standard errors are reported in parentheses.
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.10$.
OLS (GLS) refers to ordinary (generalized) least squares regression. RE indicates a random household effect is included.

Our final model allows the flood impact to vary by distance to auxiliary labor markets. We use two measures of distance to labor markets: the distance to the weekly market and the distance to the bazaar. The results from the pooled OLS and random effects versions of models (1) and (2) using both measures of distance to auxiliary labor markets are reported in Table 5. The estimates of model (1) are presented in columns 1, 2, 5, and 6. They show a severe impact on wages in villages that are more distant from the areas of economic activity. These findings are robust and significant (at the 10 percent critical level) in all model specifications and to measurement of distance to auxiliary labor markets. The estimates of model (2) are presented in columns 3, 4, 7, and 8 in Table 5. We observe that the flood shock has significant and increasing consequences on wages over time. Moreover, villages that are further away from weekly markets or bazaars suffer more immediately after the shock but are in a better position one year and five years after the flood. One possible explanation for the change in the impact of distance over time is that the migration response of workers is not immediate. This is plausible especially in distant areas where workers need to mobilize a sufficient amount of financial resources prior to migrating. The shortage of labor that ensues following the out-migration of workers may benefit those that remain behind.

Table 5. 1998 flood impact on wages accounting for distance to the nearest market

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Credit Variable	Distance from weekly market				Distance from bazar			
Model	Pooled OLS	RE GLS	Pooled OLS	RE GLS	Pooled OLS	RE GLS	Pooled OLS	RE GLS
1998 flood shock	0.006	0.006	0.027	0.029	0.005	0.007	0.018	0.020
	(0.019)	(0.018)	(0.021)	(0.022)	(0.019)	(0.019)	(0.024)	(0.026)
1998 flood shock × year 1999 dummy			-0.037*	-0.039**			-0.023	-0.024
			(0.019)	(0.020)			(0.020)	(0.022)
1998 flood shock × year 2004 dummy			-0.067***	-0.065**			-0.057**	-0.058**
			(0.026)	(0.027)			(0.021)	(0.024)
Year 1999 dummy	0.088**	0.095***	0.159*	0.165*	0.077**	0.084***	0.133	0.140
	(0.025)	(0.031)	(0.082)	(0.088)	(0.025)	(0.030)	(0.081)	(0.092)
Year 2004 dummy	0.061	0.063	0.247***	0.239***	0.042	0.049	0.213**	0.220***
	(0.045)	(0.042)	(0.067)	(0.081)	(0.035)	(0.037)	(0.072)	(0.084)
Distance	0.031**	0.027***	0.031**	0.027**	0.032**	0.030***	0.032**	0.030***
	(0.012)	(0.010)	(0.013)	(0.011)	(0.011)	(0.011)	(0.049)	(0.011)
1998 flood shock × distance	-0.009**	-0.008***	-0.014**	-0.014***	-0.007*	-0.007**	-0.010**	-0.010***
	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
1998 flood shock × year 1999 dummy × distance			0.007***	0.008***			0.003***	0.003***
			(0.001)	(0.001)			(0.001)	(0.001)
1998 flood shock × year 2004 dummy × distance			0.005*	0.006***			0.004	0.004
			(0.002)	(0.002)			(0.003)	(0.003)
Observations	1,329	1,329	1,329	1,329	1,302	1,302	1,302	1,302
R-squared	0.31	0.31	0.31	0.31	0.29	0.29	0.29	0.29

Note: All models include season and *thana* fixed effects, a variable that interacts the shock season variables, the log of village mean wages in 1997 variable, a female dummy, an agricultural labor dummy, and age and age-squared variables.
Thana clustered standard errors are reported in parentheses.
*** p ≤ 0.01, ** p ≤ 0.05, * p ≤ 0.10.
OLS (GLS) refers to ordinary (generalized) least squares regression. RE indicates a random household effect is included

5. CONCLUSION

Five years after the 1998 flood in Bangladesh, according to our findings, the real wages of rural workers in the casual labor market declined between 4 and 5 percent for each one-foot deviation in flood depth from the normal conditions. Wages in the short term were not affected perhaps due to the assistance provided by emergency relief programs. Such programs provided mostly food assistance, with a small distribution of cash transfers in the initial months following the flood. Mechanisms for the protection of assets were quite limited in the long term, and outstanding debts prevailed. It is possible that the programs also provided incentives for workers to reduce their labor effort, which also prevented wages from declining in the short term.

Previous studies that evaluate the impacts of disasters on labor markets focus on the agricultural sector (Banerjee 2007; Jayachandran 2006). Our findings suggest that agricultural labor markets experience declines in the short term that stabilize over time. In contrast, nonagricultural markets are more severely affected in the long term. Nonagricultural markets may be more vulnerable to natural disasters due to their dependence on the recovery of other markets. For example, nonfood expenditures declined after the flood as a greater share of household income was spent on food because purchasing power was low and food prices were high (del Ninno, Dorosh, and Smith 2003). The vulnerability of the nonagricultural labor market to severe floods has implications on the role of rural nonfarm employment to help households diversify and cope with risk. Workers that switched sectors and remained employed in the nonagricultural sector in response to the flood were worse off in the long term.

We explore how the vulnerability of labor markets was affected by soil type. We distinguish the flood impacts by whether the land predominantly consisted of clay soil, which is suitable for agricultural production but lacks drainage potential. Our estimates suggest that the benefits of clay soil in terms of enhancing the marginal productivity of labor likely outweigh the losses from poor drainage in the short term.

Lastly, migration to other labor markets can mitigate the effects of a severe flood on local labor markets. Migration calls for the mobilization of financial resources to transport migrants elsewhere, which may be difficult for the poor. In spite of this limitation, access to alternative labor markets after the flood can diversify future income risk and reduce the supply of labor, preserving wages in local labor markets. Helping workers find employment elsewhere after a severe flood or providing household incentives to migrate by reducing the transaction costs may be a temporary solution to help labor markets recover years after a major flood.

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