Effect of flood on agricultural wages in Bangladesh: An empirical analysis*

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Summary

This paper analyzes the effects of riverine floods on agricultural wages in Bangladesh. Drawing upon the district-wise monthly real agricultural wage data, over January 1979 to December 2000, for the twenty districts in the country, we model wages as a dynamic process (an autoregressive distributed lag process [ADL[4,4]]), and explain wage formation in terms of crop yield, real prices of crops, past wages and flood occurrences. The results of our analyses show that, floods have positive implications for wages in the long-run. In flood months, however, wages decline in the districts that are inundated. We explain these results in terms of the effects of flood on productivity, and therefore the demand for labor. We obtain difference-in-difference estimates to show that the magnitude of impact of flood on wages depends on the relative flood-proneness of a district and the relative severity of flood-conditions. Our results indicate that improvement in demand and supply conditions in agricultural labor market (including increased productivity and favorable terms-of-trade in agriculture) can mitigate the negative impact of disasters on wages in Bangladesh.

Key words: Asia, Bangladesh, flood, agricultural wages
JEL Classifications: J31, J43, O13, O18, O53, Q19

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Dis-as-ter (di zas'ter) ***n.*** [[<L. *dis-,* away + *astrum,* a star]] any happening that causes great harm or damage, calamity.
Webster's New World™ Dictionary (New York, London, Toronto, Sidney, Singapore: Pocket Books, 1995).

Disaster: The phenomenon that causes damage (natural or man made) to human populations and their settlements
Ludvic van Essche (1986). "Planning and Management of Disaster Risks in Urban and Metropolitan Regions". International Seminar on Regional Development for Disaster Prevention, UNDRO, Geneva.

"A disaster is not a physical happening, it is a social event…(it is) in one sense the manifestation of the vulnerabilities of a social system (and) prime attention should be given to doing something about such vulnerabilities…[T]hinking disasters as social phenomena (allow) them to be seen as something which can be reacted to as part of ongoing policies and programmes of national and social development– which could reduce societal vulnerabilities in the first place."
Enrico Quarantelli (1986). "Planning and management for the prevention and mitigation of natural disasters, especially in a metropolitan context: Initial questions and issues which need to be addressed". Planning for Crisis Relief International Seminar, UNCRD, Nagoya.

1. INTRODUCTION

That economic deprivation increase vulnerability to disaster is neither profound nor perplexing. On one hand, a poor household faces greater difficulties in adjusting to a given loss of income (Ravallion, 2000); on the other, the poor are less capable of taking protective measures against hazards (Varley, 1994; Islam, 2001). This paper explores one of the channels through which disasters affect the poor by analyzing the effects of riverine floods on wages of agricultural workers in Bangladesh.[1]

The unique geomorphologic and climatic conditions of the country have made Bangladesh vulnerable to monsoon riverine floods. Since her independence in 1971, the country has experienced floods of different magnitude in 1971, 1974, 1978, 1984, 1986, 1987, 1988, 1989, 1991, 1993, 1995, 1996, 1997, 1998, 1999, 2000 (Asiatic Society of Bangladesh, various years), and more recently in 2004. Floods are capricious benefactor to the agrarian regime of Bangladesh. While they enrich soil with nutrients and supply water for irrigation, they destroy crops when assuming extreme proportions. It is intuitively obvious that as severe flooding disrupts the normal agricultural activities in the fields, the agricultural workers are rendered jobless. What, however, is not immediately clear is how wage rates of these workers are affected in these periods.[2] The present paper examines this issue. We draw upon the district-wise monthly data over 1979-2000 to model real agricultural wages in Bangladesh as a dynamic process and analyze the effect of flood.

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1. There are 6.21 million agricultural workers in Bangladesh (BBS, 2000), constituting 74.9% of the rural poor in the country (Rahman and Islam, 2003). 33% of the income of rural households in the country is generated by agricultural wages and the number of families depending on wages as their principal source of income is increasing over time (BBS, 2002).
2. Hossain (1990) writes that impact of flood on demand and supply of agricultural laborers is rather uneven, and there is nothing predetermined in the way floods affect their wages.

Rest of the paper is organized as follows: Section 2 examines the antecedents in literature and explains how this paper relates to it. Section 3 discusses the different ways in which floods may affect agricultural wages. Section 4 specifies our dynamic wage model. It also describes the data and the methodology of our analysis. Section 5 identifies the trend and seasonality in data, and describes the cross-district variations in wages. The main analyses of the paper are presented in the next three sections. Section 6 estimates how wages are affected in flood months. Section 7 examines how this effect varies across districts that differ in geomorphic terms in their relative flood-proneness. Section 8 develops the analysis further to examine whether or not the magnitude of impact of flood depends on the relative severity of flood conditions. Section 9 presents the conclusions of this paper. The appendix has five tables: Tables A.1 and A.2 respectively describe how the series on real agricultural wage and agricultural productivity are generated for analysis. Table A.3 presents a crop calendar for the country and describes the relative flood-vulnerability of crops. Table A.4 describes the relative flood-proneness of districts in Bangladesh. Table A.5 presents a chronology of flood occurrences in Bangladesh for 1979-2000.

2. RELATED LITERATURE

Monsoon (late June to early October) is the season of riverine floods in Bangladesh. Flooding occurs with heavy rainfall and with discharges in rivers exceeding their carrying capacity (Rasid and Paul, 1987). Bangladesh experiences two forms of riverine floods: high frequency but localized floods that are considered normal and are identified with the monsoon season itself; and low frequency floods of extreme proportion (Rasid and Paul, 1987; Rogers *et al*, 1989; Boyce, 1990).[3] These two types of flood are identified as 'normal' (or 'minor') and 'extreme' (or 'major') floods respectively. While there is an extensive body of literature analyzing the impact of flood on Bangladesh agricultural production, not many of them focus on the effects of floods on agricultural wages. An obvious starting point to review the latter is Hossain *et al* (1988). The authors describe that agricultural wages declined in the inundated regions, in the flood months of the extreme flood year 1988. This decline was, however, less in districts where greater proportion of land is devoted to labor-intensive, high-yielding-varieties (HYV) of crops. The authors also observe that wages decline less in regions that are proximate to Dhaka, the capital city.

The other important study in this area is by del Ninno and Roy (1999a, 1999b, 2001a) and del Ninno, Roy and Mukherjee (1999). The authors analyze the impact of extreme flood of 1998 on rural labor market, specifically, household employment in Bangladesh. They find that, in the flood months of 1998, average income of Bangladeshi rural laborers declined 60% below their monthly income in the preceding flood-free year, 1997. Also, the income did not recover to the original pre-flood level even one year after the floods. Earlier, Ravallion (1987) has found that the

3. Floods assume extreme proportion when discharges in Ganges, Brahmaputra and Meghna peak simultaneously and the natural catchment areas of these mighty rivers fail to drain this heavy flow (Rogers *et al*, 1989). Economic losses in four extreme floods since 1971 are as follows: $600 million dollars in 1974, $2.2 billion in each of the two consecutive floods of 1987 and 1988 (Regional Cooperation of Flood Information Exchange in the Hindu Kush Himalayan Range, 2002) and $3.5 billion in 1998 (Shehabuddin, 2000).

1974 floods caused a structural break in the temporal pattern of wage formation in the country. Hossain (1990) finds a similar result and shows that wages in Bangladesh decline in the disaster months.[4]

A more comprehensive analysis of the impact of flood on agricultural wage is presented in Azam (1993). The author uses the country-wide data, over July 1981-June 1989, to generate a series on rice-equivalent of wages for Bangladesh, and explain the fluctuations in the series in terms of past wages, growth rate of rice price and severity of flood conditions (measured in terms of the extensiveness of area flooded). The results show that, given the price of rice, floods have significant negative impact on real wages. Azam, however, cautions against the latent endogenity in data, as he theorizes that rice price and real wages are simultaneously determined. Azam also notes that the limited data, covering a relatively short period (91 months), prevents him from including other potentially important explanatory variables.

In the present paper, we examine a much richer panel of data, extending over a longer time period (January 1979-December 2000), across twenty districts in Bangladesh.[5] This enables us to address the potential problem of omitted variables in earlier models. In addition, we try to discern the differential impact of floods across regions that vary in their relative exposure to flooding. We compare the fluctuations in wages in a 'more' flood-prone district vis-à-vis a 'less' flood-prone district. As a final point, we try to distinguish the differential impact of floods of varying severity and estimate how the effects of 'extreme' floods differ from that of 'normal' floods.

3. EFFECTS OF FLOOD ON AGRICULTURAL WAGES: A DISCUSSION

Acuity tells that the effects of flood on agricultural wages will depend on how floods affect the determinants wages, in other words, the demand and supply conditions in agricultural labor market. The effects of flood on productivity, and therefore labor demand, are largely determined by the timing of flood surges (Hossain, 1990; Rasid and Paul, 1987). Traditionally, there have been two peak seasons in agricultural wages in Bangladesh. The first continues from mid-April to mid-September and the second continues from mid-November to mid-February (Ahmed, 1981; Datta, 1998). The former is the period of harvest of dry-season crops and the sowing/transplantation of wet-season crops; while the later is the period of harvest of wet-season crops and sowing/transplantation of dry-season crops (BBS[a], various years).[6] Monsoon riverine floods have direct bearings on how wages fluctuate in mid-April to mid-September. The floods may also have indirect implications for post-flood wages in mid-November to Mid-February.

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4. Hossain (1990) defines the periods of disaster as periods when real wages declined by 10% or more below their level in the previous quarter. Azam (1993:2) points out that this approach suffers from identification problem.

5. Bangladesh is divided into six *bibhag* or Administrative Divisions: Dhaka, Chittagong, Khulna, Rajshahi, Barisal and Sylhet. The Divisions are subdivided in 20 'greater' (the erstwhile 'old'). In this paper, these 'greater' or 'old' districts are the unit of analysis and are referred to as 'districts'.

6. In terms of the nature of irrigation, crop calendar in Bangladesh consists of two somewhat overlapping seasons: (a) Wet (monsoon) season or *kharif* crop season (mid March-early January) and (b) dry-season or *rabi* crop season (mid-November-August). *Aman* variety of rice is the principal wet-season (*kharif*) crop. Jute, the main cash crop (an annual crop), is also harvested in this season. The dry (*rabi*) season consists of (i) winter (mid November-May) and (ii) summer (mid March-August). *Boro* variety of rice is the main winter crop, while *aus* variety of rice is the main summer crop. The common practice for Bangladeshi peasants is to cultivate *aman* rice in monsoon, followed by *boro* or *aus* in dry season (Hossain, 1990; Datta, 1998; BBS[a], various years).

Hossain (1990:35) writes that floods in May and June destroy the dry-season crops and lower the demand for labor for harvest and post-harvest operations. Floods in July are, however, propitious, as they assist the sowing of wet-season crops by watering the fields. The arid lands that would otherwise have been left fallow are now planted; the fertile lands are now more intensively cultivated with mixed cropping and intercropping practices (Quasem, 1992; Islam *et al*, 2004). August floods destroy the newly planted seedlings, but may increase the demand for labor after the floodwater recede as farmers re-plant their fields (Hossain, 1990; Ahmad *et al*, 2001). Floods in September and early October are, however, devastating. On one hand, they destroy the wet-season harvest; on the other, they depress the labour demand for sowing the post-flood dry-season crops. Hossain *et al* (1988:16) explains that in the post-disaster periods, land-owning households, that have suffered crop-loss in flood months, may try to cope with their loss by replacing the hired-labor with family-labor. This decline in demand for hired-labor may keep the wages depressed in post-flood months.

Agricultural wages in flood months and post-flood months may further be depressed with increased in distress sale of labor. Labor supply increases as floods destroy assets (homestead, cattle and so forth) and reduce the already meager wealth of the workers (Islam, 2001). In their effort to deal with this income loss, the workers may be willing to accept lower wages to remain employed.

The magnitude of impact of flood on wages may also depend on geomorphologic characteristics of the inundated region (Paul and Rasid, 1993). The relatively low-lying districts in Bangladesh are more frequently submerged. Intuition suggests that the peasant life in these districts would systematically adapt to flood hazards over time (Fafchamps, 2003). We can argue that the effects of flood shocks would be comparatively less in a 'more' flood-prone district than a 'less' flood-prone one. As a result, agricultural wages would deviate less from their normal non-flood monthly patterns, when a 'more' flood-prone district gets inundated, than when a 'less' flood-prone district gets inundated.

Bradnock (1984) writes that the magnitude of impact of flood further depends on relative severity of flood conditions. 'Extreme' floods affect extensive areas of Bangladesh, including lands that are at a higher elevation and lands that are normally draught-prone (Rasid and Paul, 1987). Unlike 'normal' floods, they can cause extended periods of water-logging, continuing over two months or more.[7] Crop loss in times of 'extreme' flooding is therefore more severe than that in times of 'normal' floods (Brammer, 1990a, 1990b). We can argue that, wages would deviate more from their normal non-flood monthly patterns, in times of 'extreme' floods than in times of 'normal' flood.

4. A DYNAMIC MODEL OF WAGE FORMATION

Our objective in this paper is to empirically investigate the effects of flood on real agricultural wages in Bangladesh. A theoretical motivation for a dynamic wage model, however, can readily be offered. We invoke Osmani (1991) to specify a non-competitive model of agricultural labor market in Bangladesh. In this specification, the nature of

7. Bangladesh experienced 'extreme' flood situations in: late June to early August in 1987, July to September-early October in 1988 and late July-early October in 1998.

wage-employment contract between workers and landlords play a crucial role in determining wages, together with other demand and supply determinants of labor. Typically, contracts are renegotiated at the onset of each crop season to effect the wage changes and past wages set the benchmark for negotiation for new wages (Dutta, 1998; Dutt and Olmsted, 2004). The contractual employments ensure a closed structure of agricultural labor market, where landlords hire workers with whom they have previous experience.[8] In absence of flood, our model specifies that labor demand in the t^{th} period (L^d_t) depends on current nominal wage (W_t) and a set of non-wage determinants (say, X). Labor supply in the t^{th} period (L^s_t) depends on current nominal wage (W_t), past wages (W_{t-k}) and a set of non-wage factors (say, Z). In the existing literature, the important non-wage determinants of labor demand are identified as agricultural productivity (in terms of yield per unit of land) and crop prices; the important non-wage determinants of labor supply are food prices, prices of other non-food items that workers consume and their alternative non-farm sources of income (Ahmed, 1981; Bardhan, 1984; Khan, 1984; Hossain, 2004). The nominal wage rate (W_t*) realized in the t^{th} period is then given by:

$$W_t{}^* = W_t{}^*(W_{t-k}, X, Z) \qquad [1]$$

Khan (1984) explains that increase in agricultural productivity increases wages by stimulating the demand for labor. The effect of an increase in price of crops, however, can be ambiguous. On one hand, higher crop prices encourage production and raise labor demand; on the other, these higher prices increase workers' consumption expenditure on food and induce higher labor supply. The latter effect is more severe on landless workers who are net-buyers of food (Ravallion, 1990; Boyce and Ravallion, 1991). The ultimate effect of increase in crop prices, therefore, depends on the relative strength of the demand-generating effect and the cost-of-living or supply-generating effect of price rise. [9]

In addition, changes in crop prices may change the terms-of-trade between agriculture and industrial sectors. Agricultural workers consume such non-food industrial products as clothing and footwear, fuel and other household requisites (BBS[b], various years). Khan (1984) explains that improvement in terms-of-trade in agriculture vis-à-vis industrial sector enables the agricultural sector to absorb higher real wage rates in long-run. In short-run, however, increased crop price reduces the real wages (Boyce and Ravallion, 1991). Once again, the ultimate outcome of terms-of-trade effect on wages will depend on the relative strength of the long-run effect and the short-run effect.

Finally, expansion of alternative means of livelihood, including non-farm employment, that reduces the workers' dependence on land, will also increase their real wages (Hossain, 2004).

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8. Bardhan (1984) finds that there are serious incentives in rural South Asia for territorial affinities. Labour markets oftentimes do not extend beyond the confines of the villages (Bardhan, 1984: 71). Bardhan and Rudra (1981) explain this phenomenon in terms of the employers' effort to minimize the following two costs: costs of imperfect information on characteristics of the worker and costs of contract enforcement with unfamiliar people. Datta (1998) observes that labour recruitments are also greatly influenced by the social ties and political affiliations of employers and employees. These factors segregate the rural agricultural labor market in Bangladesh.

9. Effect of flood on rural CPI in Bangladesh has not always been uniform. While the 1974 floods caused massive increase in food prices, leading to famines (Ravallion, 1987), in later years, the adverse effects of flood on prices have been mitigated through appropriate public policy, including import of food (del Ninno *et al*, 2003). Boyce (1990) writes that large-scale import of food grain in response to 1988 floods actually led to a decline in market prices of food.

We now explicitly specify our empirical model. We start by linearizing [1]. We find that our nominal wage model is homogenous of degree zero in prices. [10] We deflate all the variables in our model by rural CPI to obtain an equation of real wage. [11] Our wage equation has a fairly general (m^{th}-order) autoregressive distributive lag formulation, with lags in levels in both the dependent and the independent variables (ADL(m,m)). It is given by:

$$w_{d,t} = \alpha_0 + \sum_{k=1}^{m} \alpha_k w_{d,t-k} + \sum_{k=0}^{m} \pi_k^R p_{d,t-k}^R + \sum_{k=0}^{m} \pi_d^J p_{d,t-k}^J + \sum_{k=0}^{m} \theta_k^R q_{d,t-k}^R + \sum_{k=0}^{m} \theta_k^J q_{d,t-k}^J \quad [2]$$

$$+ \psi\ \Phi + \tau_1 t + \tau_2 t^2 + \sigma_2 S_2 + \sigma_3 S_3 + \delta D + u_{d,t}$$

where d = 1,2, ..,20 for the twenty districts, and t =1 for January 1979, 2 for February 1979,.. for the successive month-years over January 1979–December 2000; $w_{d,t}$ is the natural log of current real wage for male agricultural workers (without food) (in terms of rural CPI) in district d at time t; $u_{d,t}$ is the stochastic error process. The non-flood explanatory variables in [2] are as follow (measured in natural log):

- $w_{d,t-k}$: past real wage;
- $p^R_{d,t-k}$: real price of rice (nominal price deflated by rural CPI);
- $p^J_{d,t-k}$: real price of jute (nominal price deflated by rural CPI);
- $q^R_{d,t-k}$: per acre yield of rice in terms of rural CPI;
- $q^J_{d,t-k}$: per acre yield of jute in terms of rural CPI;
- t: linear trend
- t^2: quadratic trend
- S_2: dummy indicating summer season, taking the value of 1 for the months March-June and zero otherwise;
- S_3: dummy indicating winter season, taking the value of 1 for the months November-February and zero otherwise;
- D: a vector of district dummies, where d = 1 for Chittagong, 2 for Comilla etc.

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10. Nominal wage is homogenous of degree zero in prices if $\sum_k \alpha_k + \sum_k \gamma_k + \sum_k \zeta_k + \sum_k \lambda_k = 1$. We fail to reject the null hypothesis on the basis of chi-squared test for homogeneity ($p < 0.01$).

11. Note, as we deflate nominal wages by rural CPI to generate our variable of interest and, at the same time, include real prices of crops as explanatory variables, our specification of wage function opens itself to the potential problem of endogenity. To examine this issue, we carry out the 'Hausmann-Wu' tests (Hausman, 1978; Wu, 1973). The results of a likelihood ratio test ($p<0.001$) indicate that our model does not suffer from this endogeneity bias. Also, on the basis of an F-test ($p<0.01$), we fail to reject the hypothesis that, for our data, real prices of crops are exogenous. In addition, we examine the problem of multicollinearity in rural CPI data to examine whether or not prices of food items and non-food items are perfectly collinear. Invoking Farrar and Glauber (1967) we find that multicollinearity is not serious for our data, as the R^2 between the prices of food items and non-food items (R^2=0.51) do not exceed the R^2 of our regression models (presented in tables 3 and 4).

The rational for considering only two crops for our analysis is that rice and jute are respectively the principal food and cash crops in Bangladesh.[12] We include trend variables to capture the effects of time-dependent variables such as population size and land-man ratio. We also introduce district-dummies to capture the district-specific effects (such as proportion of landless workers in rural population, nature of land distribution, levels of infrastructure, proximity to city) not explicitly considered in our model.[13]

Φ in [2] is a vector of all flood-related variables and may include the following:

- F^2 : dummy indicating flood occurrence in harvest period of dry-season crops, taking the value of 1 if flood occurs anywhere in Bangladesh in months May and June, and zero otherwise;
- F^3 : dummy indicating flood occurrence in growing period of wet-season crops, taking the value of 1 if flood occurs anywhere in Bangladesh in months July and August, and zero otherwise;
- $I_{d,t}$: district inundation dummy, taking the value of 1 if flood occurs in district *d* in month-year *t*, and zero otherwise;
- M_d : district flood-proneness dummy, taking the value of 1 when district *d* is a 'more' flood-prone district, and zero otherwise;
- E_t : dummy indicating 'extreme' flood, taking the value of 1 if 'extreme' flood occurs anywhere in Bangladesh in month-year *t*, and zero otherwise.

(a) Description of data

We put together the series on real agricultural wage in the following manner: Average daily nominal wage data for male agricultural workers (without food) are obtained for each month for January 1979-December 2000 for the twenty districts in Bangladesh.[14] The nominal wages are then deflated by rural CPI.[15] The real wage series thus obtained is used to generate a series on monthly wage indices. Table A.1 in appendix discusses how the series is generated. We use the least-squares-with-dummy-variables (LSDV) method of pooling data to generate our continuous series on real wage.[16] The pooled series has 3675 observations. The series is serially correlated but stationary. The effects of past values of wages on their current values die out after a lag of four periods.[17]

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12. In 2000, 75% of the total cultivable area in Bangladesh was under rice production, and 2.86% was under jute production. Of the area under rice cultivation, 53.28% (almost 40% of the total cultivable area) was under wet-season *aman* rice, 34.1% area was under dry-season *boro* rice and 12.62% was under *aus* rice (BBS[a], 2002).

13. The limited availability of data prevents us from explicitly analyzing the role of alternative non-farm sources of income as determinant of agricultural wages.

14. Source: BBS[a], various years. The nominal wage series has missing data for January 1990-November 1990 and for January 1991-June 1992.

15. Source: (1) BBS[c], various years; (2) BBS[b], various years. Data on CPI for agricultural workers are not available for Bangladesh. We therefore use rural CPI as a proxy. The data on rural CPI is available for four Divisions: Dhaka, Chittagong, Khulna and Rajshahi. The series is available from July 1978, and has missing data for December 1987-October 1988.

16. We follow Maddala (1977) to pool our cross-section and time-series data in the following manner: Defining $w_{d,t}$ as the real agricultural wage rate and $A_{d,t}$ as the vector of explanatory variables in district *d* in month-year *t* (where *d* = 1,..,20 and *t* = 1 for January 1979, 2 for February 1979,..) we postulate separate regression for each district *d*: $w_{d,t} = \alpha_d + \beta_d A_{d,t} + u_{d,t}$. Next, we test the hypothesis that H_1: $\beta_1 = \beta_2 = \ldots = \beta_{20} = \beta$ and estimate the common regression equation: $w_{d,t} = \alpha_d + \beta A_{d,t} + u_{d,t}$. Our *F* ratio (p<0.01)

We generate the series on real prices of crops in the following manner: First, the series on nominal rice price is generated as a simple average of prices of coarse quality and medium quality rice in each district, for January 1979-December 2000.[18] Similarly, the series on nominal jute price is generated as a simple average of prices of *white* type and *tossa* type of jute.[19] Next, the two series are deflated by rural CPI to generate our series on real prices of rice and jute.

The series on per acre yield of rice and jute, in terms of rural CPI, are generated in the following manner: First, we generate the series on per acre yield of crops. Towards this we divide the series on each variety of rice (*aus*, *aman*, and *boro*) (in metric tons) and each variety of jute (*white* and *tossa*) (in bales), in each district in each month, by area under cultivation (in acres) for the respective crops in each district.[20] Next, we take a weighted average of the yield rate of different varieties of rice to generate the series on monthly rice (all types) yield (in metric tons per acre) for January 1979-December 2000. Likewise, we generate the series on monthly jute (all types) yield (in metric tons per acre). The relevant weights are determined using the crop calendar for the country (presented in Table A.3 in appendix). Columns 2 and 3 in appendix Table A.2 describes how the series on per acre yield of rice and jute are generated. Finally, we deflate the two series by rural CPI.

We followed Bangladesh Ministry of Irrigation, (1986) and Rogers *et al* (1989) to classify the districts in Bangladesh according to their relative flood-proneness. Table A.4 in appendix presents this classification. The 'more' flood-prone districts in Bangladesh are the districts with 50% or more area vulnerable to inundation to flood-depth of 90cm or above in a 'normal' flood-year. These are also the more frequently flooded districts. All other districts are considered 'less' flood-prone.

The data on relative severity of flood conditions in each flood-year is collected from various sources.[21] 'Extreme' floods are distinguished from 'normal' floods in terms of their long duration, extensiveness of area affected, and depth of standing water. In a normal year, 35% of *net cultivated* area of Bangladesh (constituting almost 55% of the total area) experiences 'shallow' floods (of depth 30-90cm), 16% experiences 'moderate' floods (of depth 90-180cm); and 12% experiences 'deep' floods (of depth over 180cm). The remaining 37% is not affected by floods (Bangladesh Ministry of Irrigation, 1986). In years of extreme floods 35% or more of *total* area of the country experience 'moderate' to 'deep' flooding (of flood-depth 90cm or more) (Rogers *et al*, 1989; Zaman, 1993). Table A.5 in appendix presents a chronology of flood occurrence in Bangladesh for 1979-2000.

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is not significant and we fail to reject the hypothesis. As there are no significant differences in the coefficients in the district-wise regression equations, we pool the data and use a single equation for our regression analysis.

17. The lag specification is on the basis of the lowest value of the Akaike criterion and the Schwarz criterion.
18. Sources: (1) BBS[c], various years; (2) BBS[a], various years.
19. Source: BBS[a], various years.
20. Source: BBS[a], various years.
21. Source: DHA, various years; Asiatic Society of Bangladesh, various years; Hossain *et al*, 1988; Khalequzzaman, 1994; del Ninno *et al*, 1999a, 1999b; Ahmed *et al*, 2001; BAPA, 2000.

(b) Methodology of analysis

We start our analysis by asking the following questions: (I) do floods cause any significant fluctuations in agricultural wages in Bangladesh? (II) If yes, then what role do favorable demand and supply conditions in the agricultural labor market play in mitigating the impact of floods? (III) Does the magnitude of impact of flood depend on whether or not a district is 'more' flood-prone? And finally, (IV) Is the impact of 'extreme' flood significantly different from that of 'normal' flood? Towards answering these questions we follow the so called 'simple to general' approach of analysis (Johnston and DiNardo, 1997). Equation [2] presents the most general form our model. As we proceed in our analysis, we consider various versions of this model to discern the role that different explanatory variables play in explaining fluctuations in wages in flood months. We apply the OLS method to estimate our model.[22]

5. TREND, SEASONALITY AND CROSS-DISTRICT VARIATIONS IN WAGES

We start by examining the trend and seasonality in our data. Our relevant equation is:

$$w_{d,t} = \beta_0 + \beta_1 t + \beta_2 t^2 + \delta_2 S_2 + \delta_3 S_3 + \varepsilon_{d,t} \qquad [3]$$

Table 1 presents the estimation results for this model. The table shows that agricultural wage in Bangladesh has a significant negative linear trend and a significant positive quadratic trend. Hossain (2004) explain that, the downward trend in agricultural wages in Bangladesh in earlier years has been replaced by an upward trend in the recent past. The authors write that the increase in non-farm activities in rural Bangladesh has somewhat reduced the pressure on land and generated a positive affect on agricultural wages. Table 1 also shows that wages in winter are significantly higher (by almost 7%) than that in monsoon. Wages in summer are lower (by approximately 5%) than that in monsoon. Table 2 describes the seasonal variations in agricultural wage indices in Bangladesh in flood years and non-flood years over 1979-2000.

22. The presence of lagged endogenous variable in our model poses the latent problem of biased OLS estimates. OLS estimates in such models are, however, consistent and asymptotically efficient for large samples (Johnston and DiNardo, 1997). We therefore apply OLS as we have a considerably large data set.

Table 1
Trend and seasonality in (log) real agricultural wage indices (in terms of RCPI) in Bangladesh [a]

Explanatory variable	**Estimated value of coefficient**
Constant of regression	0.93
	*(210.098)**
Linear trend (*t*)	-8.12
	*(-16.22) **
Quadratic trend (t^2)	1.01
	*(7.63)**
Seasonal dummy indicating Summer (S_1)	-0.0047
	*(-1.75)****
Seasonal dummy indicating Winter (S_2)	0.0068
	*(2.51)***
Number of observations	3675
R-squared	0.264
Adjusted R-squared	0.263

[a] *t statistics in the parenthesis*
** Significant at 1%*
*** Significant at 5%*
****Significant at 10%*

Table 2

Seasonal fluctuations in real agricultural wage indices (in terms of RCPI) in districts in Bangladesh, 1979-2000 [a]

Seasons	**All years**	**Non-flood years**	**All flood years**	**Normal flood years**	**Extreme flood years**	**All flood years when district is inundated**[b]	**Normal flood years when district is inundated**[b]	**Extreme flood years when district is inundated**[b]	**All flood years when district is not inundated**	**Normal flood years when district is not inundated**	**Extreme flood years when district is not inundated**
Monsoon (Jul-Oct)	0.866 *(0.042)*	0.832 *(0.05)*	0.886 *(0.066)*	0.881 *(0.031)*	0.875 *(0.058)*	0.852 *(0.038)*	0.861 *(0.241)*	0.846 *(0.066)*	0.898 *(0.043)*	0.856 *(0.331)*	0.904 *(0.043)*
Winter (Nov-Feb)	0.876 *(0.043)*	0.845 *(0.06)*	0.88 *(0.047)*	0.88 *(0.039)*	0.883 *(0.056)*	0.863 *(0.045)*	0.881 *(0.155)*	0.866 *(0.067)*	0.904 *(0.048)*	0.876 *(0.292)*	0.845 *(0.048)*
Summer (Mar-Jun)	0.864 *(0.047)*	0.844 *(0.064)*	0.894 *(0.071)*	0.88 *(0.035)*	0.903 *(0.06)*	0.869 *(0.048)*	0.893 *(0.248)*	0.866 *(0.07)*	0.902 *(0.05)*	0.856 *(0.327)*	0.9 *(0.05)*

[a] *standard deviations across district in the parenthesis*

[b] Districts are inundated in late summer and/or monsoon seasons. No riverine flood takes place in winter. The post-flood effects of inundation in late summer and/or monsoon, however, may continue in winter, especially in years of 'extreme' floods.

Table 2 shows that, in all the three crop seasons (monsoon, winter and summer), wages are higher in flood-years than in non-flood years. Wages, however, decline in monsoon flood months in the inundated districts. In years of 'extreme' floods, wages continue to remain depressed in the winter following the monsoon floods. In years of 'normal' floods, wages increase in the post-flood winter and summer seasons. Wages also increase in the monsoon flood season in districts that are not inundated. Post-flood seasonal wages continue to remain high in these districts.

Figure 1 presents the 11-month lagged moving-average in real agricultural wages in Bangladesh and the 'more' flood-prone districts of the country, for January 1979-December 2000. The series has missing data for December 1987-October 1988, January-November 1990 and January 1992-June 1993. The figure shows that average real wages in the 'more' flood-prone districts has, in general, been higher than the country-wide average wages. The figure also shows that monthly real wages in the country has increased over 1983-1987, but declined over 1987-1989. Two 'extreme' floods have taken in the latter period, in June-August of 1987 and July-October of 1988. Real wages showed a steady increase over 1994-2000. In this period, moving-averages in real wages in the 'more' flood-prone districts have declined sharply in November 1998-October 1999. 'Extreme' floods have taken place in the country in July-October 1998.

Figure 1
11-Month Moving Average in Real Agricultural Wages in Bangladesh and its More Flood-prone Districts, January 1979-December 2000

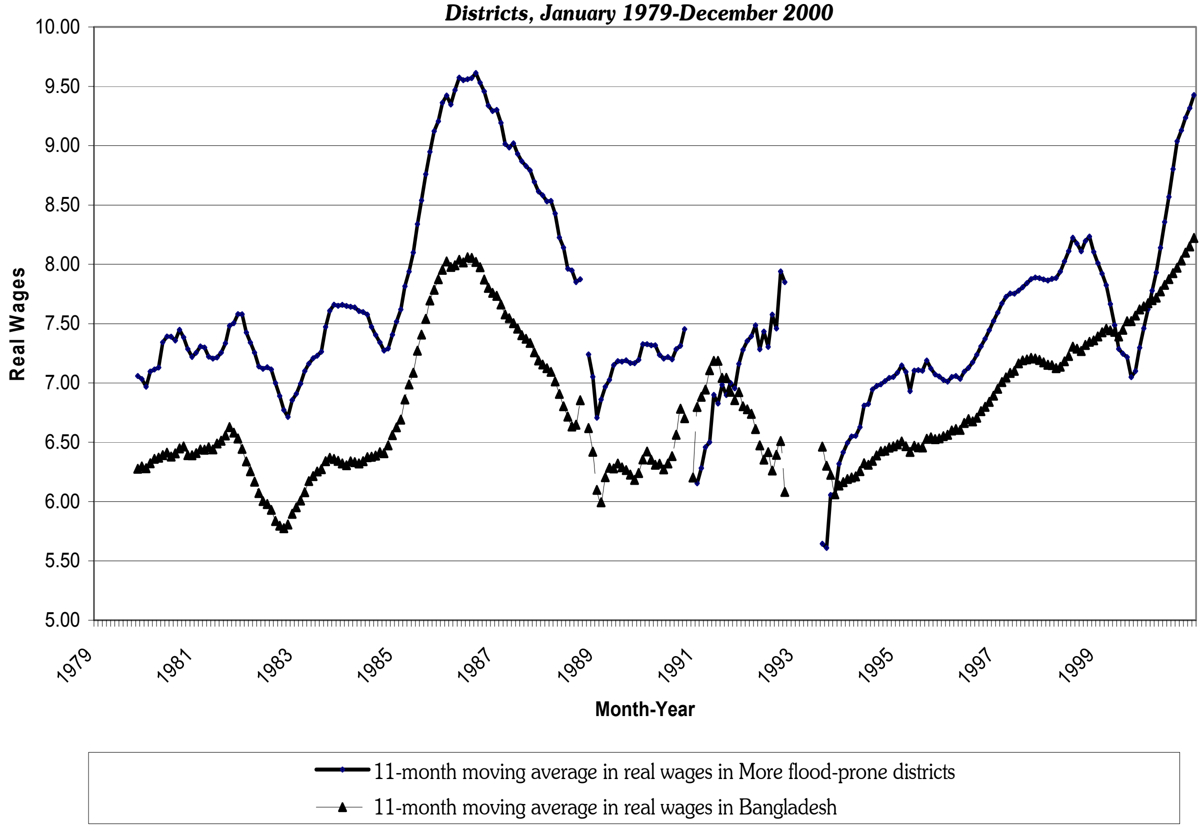

Table 3
Annual average real agricultural wage indices (in terms of RCPI) in 'more' and 'less' flood-prone districts in Bangladesh, 1979-2000 [a]

Districts	All years	Non-flood years	All flood years	Normal flood years	Extreme flood years	All flood years when district is inundated	Normal flood years when district is inundated	Extreme flood years when district is inundated	All flood years when district is not inundated	Normal flood years when district is not inundated	Extreme flood years when district is not inundated
More Flood-prone	0.878 *(0.029)*	0.855 *(0.049)*	0.9 *(0.03)*	0.874 *(0.028)*	0.899 *(0.031)*	0.868 *(0.015)*	0.87 *(0.019)*	0.848 *(0.034)*	0.917 *(0.057)*	0.916 *(0.037)*	0.888 *(0.026)*
Less Flood-prone	0.825 *(0.014)*	0.823 *(0.005)*	0.875 *(0.015)*	0.855 *(0.014)*	0.887 *(0.01)*	0.859 *(0.028)*	0.887 *(0.01)*	0.805 *(0.015)*	0.887 *(0.012)*	0.865 *(0.014)*	0.889 *(0.005)*

[a] *standard deviations across district in the parenthesis*

Table 3 describes the cross-district variations in wage indices and presents the annual average agricultural wages in 'more' and 'less' flood-prone districts in flood years and non-flood years. The table shows that, over 1979-2000, annual average wages in Bangladesh have been higher in 'more' flood-prone districts than in 'less' flood-prone districts. Wages are also higher in flood-years than in non-flood years across all districts. In years of 'normal' flood, average annual wages are low in 'more' flood-prone districts that are inundated, but high in 'less' flood-prone districts that are inundated. In years of 'extreme' flood, however, average annual wages decline in all the districts that are inundated. For districts that are not inundated, annual average wages remain high even in years of 'extreme' flood.

6. WAGE FLUCTUATIONS IN TIMES OF FLOOD

To examine how floods affect agricultural wages in Bangladesh, we draw out a rather naïve model from [2]. The model explains fluctuations in wages in terms of their past values, flood occurrences in different months, trend and seasonality. It is given by:

$$w_{d,t} = \alpha_0 + \sum_{1}^{4} \alpha_k w_{d,t-k} + \psi_2 F^2 + \psi_3 F^3 + \tau_1 t + \tau_2 t^2 + \sigma_2 S_2 + \sigma_3 S_3 + \delta D + u_{d,t} \quad [4]$$

In the above equation, the effect of flood in May-June in Bangladesh on wages in district *d* is captured by Ψ_2; the effect of flood in July-August is captured by Ψ_3; and the effect of flood in September-October is captured by α_0. Estimates of equation [4] are reported in column 2 of Table 4. We shall interpret the estimation results later in this section, together with that of an extended version of [4].

In the extended version of [4] we explicitly introduce agricultural productivity and real prices of crops as explanatory variables, to discern the role of demand and supply conditions in agricultural labor market in mediating the impact of flood on wages. Our extended model is:

$$w_{d,t} = \alpha_0 + \sum_{k=1}^{4} \alpha_k w_{d,t-k} + \sum_{k=0}^{4} \pi_k^R p_{d,t-k}^R + \sum_{k=0}^{4} \pi_k^J p_{d,t-k}^J + \sum_{k=0}^{4} \theta_k^R q_{d,t-k}^R + \sum_{k=0}^{4} \theta_k^J q_{d,t-k}^J$$
$$+ \psi_2 F^2 + \psi_3 F^3 + \tau_1 t + \tau_2 t^2 + \sigma_2 S_2 + \sigma_3 S_3 + \delta D + u_{d,t} \quad [5]$$

The interpretations of α_0 and Ψ coefficients in [5] are similar to that in [4]. π_k^R and π_k^J respectively capture the price elasticity of wage with respect to real prices of rice and jute; θ_k^R and θ_k^J respectively capture the productivity elasticity of wages with respect to rice and jute yield. Estimates of equation [5] are reported in column 3 of Table 4.

Table 4
Effect of flood on agricultural wage in Bangladesh: Summary of regression models [6] and [7] [a]

Explanatory Variable	Estimated value of coefficient	
	Model given by [6] Wage fluctuations explained in terms of flood occurrences and past wages	**Model given by [7]** Wage fluctuations explained in terms of flood occurrences, past wages, agricultural productivity and real prices
Regression coefficient		
α_0	-0.093 *(-2.77)****	-0.091 *(-2.6)****
Flood occurrence		
F_2	-0.092 *(-2.68)****	-0.09 *(-2.59)****
F_3	0.098 *(3.02)****	0.116 *(3.18)****
Past values of log real wages		
$w_{d,t-1}$	0.558 *(35.7)****	0.564 *(33.8)****
$w_{d,t-2}$	0.172 *(4.5)****	0.184 *(4.8)****
$w_{d,t-3}$	0.138 *(3.5)****	0.107 *(3.1)****
$w_{d,t-4}$	0.088 *(2.36)****	0.086 *(2.28)***
Log real price of rice (nominal price deflated by rural CPI)		
$p^R_{d,t}$		-0.15 *(-3.92)****
$p^R_{d,t-1}$		0.0097 *(1.37)*
$p^R_{d,t-2}$		0.0085 *(1.29)*
$p^R_{d,t-3}$		0.0063 *(1.01)*
$p^R_{d,t-4}$		0.00071 *(0.9)*
Log real price of jute (nominal price deflated by rural CPI)		
$p^J_{d,t}$		0.00033 *(0.364)*
$p^J_{d,t-1}$		0.0097 *(1.37)*
$p^J_{d,t-2}$		0.0085 *(1.29)*
$p^J_{d,t-3}$		0.0063 *(1.01)*
$p^J_{d,t-4}$		0.00071 *(0.9)*
Rice productivity (log of per acre rice yield in terms of rural CPI)		

$q^{R}_{d,t}$		0.129
		*(3.12)****
$q^{R}_{d,t-1}$		0.095
		*(2.99)****
$q^{R}_{d,t-2}$		0.038
		*(1.7)**
$q^{R}_{d,t-3}$		0.00068
		(0.87)
$q^{R}_{d,t-4}$		0.00037
		(0.371)
Jute productivity (log of per acre jute yield in terms of rural CPI)		
$q^{J}_{d,t}$		0.088
		*(2.4)***
$q^{J}_{d,t-1}$		0.087
		*(2.3)***
$q^{J}_{d,t-2}$		0.0080
		(1.18)
$q^{J}_{d,t-3}$		0.0071
		(1.07)
$q^{J}_{d,t-4}$		0.00041
		(0.43)
Number of observations	3675	3675
R-squared	0.729	0.765
Adjusted R-squared	0.727	0.763

[a] *t statistics in the parenthesis*
** Significant at 1%*
*** Significant at 5%*
****Significant at 10%*

Our results show that, real agricultural wages in Bangladesh decline (by 9%) when flood occurs in harvest period of dry-season crops in May-June; while they increase (by approximately 10%) with flood occurrence in growing period of wet-season crops in July-August. Wages also decline (by 9%) with flood in September-October. Our results further shows that, when we include productivity and real prices of crops as explanatory variables to explain wage fluctuations, the coefficient estimate on May-June flood dummy (F^2) declines in value and that on July-August flood dummy (F^3) increases. These results suggest that improvement in demand and supply conditions of labor can alleviate the negative impact of flood and magnify the positive impact.

In addition, Table 4 shows that real agricultural wages are positively and significantly affected by their past values. A high wage in the past will lead to higher current wages. This result is indicative of the downward rigidity in wages in Bangladesh, even in presence of widespread involuntary unemployment in agriculture (Ahmed, 1981; Bardhan, 1984; Osmani, 1991).

Table 4 also shows that the estimated coefficient on current real rice price ($p^{R}_{d,t}$) is negative and statistically significant. This suggests that the cost-of-living effect of rice prices on wages outweigh their demand-generating effect, at least in the short-run. This result is comparable to that obtained by Boyce and Ravallion (1991). The authors explain that as price of rice, the staple food grain, rise relative to other goods, the rice-purchasing power of agricultural wages, and therefore the real wages, fall. The present model, however, also finds that the estimated coefficients on past rice prices ($p^R_{d,t-k}$) are positive, suggesting that, over the time, real wages increase to adjust to any past increases in rice price. The estimated coefficients on current and past real price of jute are positive, though statistically insignificant. Table 4 further shows that the estimated coefficients on current productivity of rice ($q^R_{d,t}$) and jute ($q^J_{d,t}$) are positive and significant. The coefficient estimates of past productivity of rice and jute ($q^R_{d,t-k}$ and $q^J_{d,t-k}$ respectively) are also positive. This result is consistent with that obtained by Khan (1984). A rise in productivity increases real wages by stimulating demand.

7. WAGE FLUCTUATIONS IN 'MORE' FLOOD-PRONE DISTRICTS

Not all districts in Bangladesh are similarly affected by flooding. Heavy rainfall and river surges that inundate the low-lying districts, may leave other high-elevation districts unaffected. In this section, we examine how the relative flood-proneness of a district can explain the variations in its wages in the flood months. We introduce a district flood-proneness dummy (M_d) to indicate that district *d* is 'more' flood-prone; and a district-inundation dummy ($I_{d,t}$) to indicate inundation in district *d* in month-year *t*; and develop [5] as:

$$w_{d,t} = \alpha_0 + \sum_{k=1}^{4}\alpha_k w_{d,t-k} + \sum_{k=0}^{4}\pi_k^R p^R_{d,t-k} + \sum_{k=0}^{4}\pi_k^J p^J_{d,t-k} + \sum_{k=0}^{4}\theta_k^R q^R_{d,t-k} + \sum_{k=0}^{4}\theta_k^J q^J_{d,t-k}$$
$$+\psi_4 I_{d,t} + \psi_5 M_d + \psi_6 (I_{d,t} {}^* M_d) + \tau_1 t + \tau_2 t^2 + \sigma_2 S_2 + \sigma_3 S_3 + \delta D + u_{d,t} \qquad [6]$$

In [6], ($\Psi_5 + \Psi_6$) captures any variation in wages in district *d* on account of its 'more' flood-proneness; ($\Psi_4 + \Psi_6$) captures the variations caused by inundation in period *t*. Ψ_6 captures the effect of inundation in 'more' flood-prone district *d* in month-year *t*. We can also interpret ($\Psi_5 + \Psi_6$) as indicative of the long-term effects of repeated flooding in district *d*, while ($\Psi_4 + \Psi_6$) and Ψ_6 as indicative of the immediate impact of current-period inundation. Estimates of equation [6] are reported in column 2 of Table 5.

Table 5.
Wage fluctuations in 'more' flood-prone districts and in times of 'extreme' floods in Bangladesh: Summary of regression model [8] and [9] [a]

Explanatory Variable	Estimated value of coefficient	
	Model given by [8] Wage fluctuations in 'more' flood-prone districts	**Model given by [9]** Wage fluctuations in 'extreme' flood years
Regression coefficient		
α_0	-0.00034 *(-0.369)*	-0.00030 *(-0.352)*
Flood related variables		
$I_{d,t}$	-0.060 *(-1.98)***	-0.044 *(-1.96)***
$M_{d,t}$	0.089 *(2.54)****	0.088 *(2.5)****
$(I_{d,t}*M_{d,t})$	-0.0077 *(-1.13)*	-0.041 *(-1.89)**
E_t		0.083 *(2.04)****
$(I_{d,t}*E_t)$		-0.084 *(-2.16)****
$(M_{d,t}*E_t)$		0.00036 (*0.62*)
$(I_{d,t}*M_{d,t}*E_t)$		-0.052 *(-1.96)***
Past values of log real wages		
$w_{d,t-1}$	0.561 *(33.75)****	0.564 *(33.79)****
$w_{d,t-2}$	0.186 *(4.82)****	0.179 *(4.74)****
$w_{d,t-3}$	0.109 *(3.11)****	0.099 *(3.08)****
$w_{d,t-4}$	0.085 *(2.26)****	0.084 *(2.17)****
Log real price of rice (nominal price deflated by rural CPI)		
$p^R_{d,t}$	-0.174 *(-4.52)****	-0.168 *(-4.34)****
$p^R_{d,t-1}$	0.097 *(3.01)****	0.096 *(2.99)****
$p^R_{d,t-2}$	0.082 *(2.01)***	0.083 *(2.01)***
$p^R_{d,t-3}$	0.027 *(1.5)*	0.029 *(1.55)*
$p^R_{d,t-4}$	0.0097 *(1.37)*	0.0098 *(1.37)*
Log real price of jute (nominal price deflated by rural CPI)		
$p^J_{d,t}$	0.00032 *(0.362)*	0.00031 *(0.359)*

$p^{J}_{d,t-1}$	0.00052 *(0.56)*	0.00048 *(0.45)*
$p^{J}_{d,t-2}$	0.00028 *(0.26)*	0.00028 *(0.26)*
$p^{J}_{d,t-3}$	0.0090 *(1.34)*	0.0089 *(1.33)*
$p^{J}_{d,t-4}$	0.04 *(1.89)**	0.039 *(1.78)**
Rice productivity (log of per acre rice yield in terms of rural CPI)		
$q^{R}_{d,t}$	0.145 *(3.64)****	0.136 *(3.496)****
$q^{R}_{d,t-1}$	0.097 *(2.99)****	0.095 *(2.99)****
$q^{R}_{d,t-2}$	0.037 *(1.68)**	0.015 *(1.43)*
$q^{R}_{d,t-3}$	0.00061 *(0.84)*	0.00068 *(0.87)*
$q^{R}_{d,t-4}$	0.00034 *(0.367)*	0.00031 *(0.359)*
Jute productivity (log of per acre jute yield in terms of rural CPI)		
$q^{J}_{d,t}$	0.089 *(2.5)***	0.089 *(2.5)***
$q^{J}_{d,t-1}$	0.088 *(2.31)***	0.085 *(2.27)***
$q^{J}_{d,t-2}$	0.0078 *(1.17)*	0.0081 *(1.19)*
$q^{J}_{d,t-3}$	0.0071 *(1.07)*	0.0070 *(1.06)*
$q^{J}_{d,t-4}$	0.00041 *(0.43)*	0.00040 *(0.428)*
Number of observations	3675	3675
R-squared	0.76	0.77
Adjusted R-squared	0.757	0.766

[a] *t statistics in the parenthesis*
** Significant at 1%*
*** Significant at 5%*
****Significant at 10%*

Our results show that wages tend to be higher (by 8%) if the district-concerned is 'more' flood-prone. A plausible explanation of this result can be in terms of the long-term positive impact of floods on land-productivity. Fields in a frequently flooded district are better irrigated and more fertile (Boyce, 1989; Hossain, 1990). Brammer (1988) explains that floodwater breed nitrogen-fixing blue-green algae, and decompose the submerged weeds and leaves. These stimulate the alternating cycles of oxygen-reduction and oxidization in the inundated fields. Periodic flooding increases the moisture content of soil. Over the time, the minerals deposited on the fields by river alluvium erode and further enrich the soil. Improved soil conditions augment agricultural productivity. Rogers *et al* (1989) compare the yield rates of different crops in 'more' and 'less' flood-prone districts in Bangladesh. The authors find that, the average annual agricultural productivity and the value added per hectare of cultivated land, in the 'more' flood-prone districts, are respectively 1.4 and 1.1 times higher, than that in the 'less' flood-prone districts. The authors also find that, agricultural productivity per rural person is 1.35 times higher in 'more' flood-prone districts than that in 'less' flood-prone districts. The higher productivity generates higher demand for labor and positively affects wage formation over long-run in the 'more' flood-prone districts. [23]

Column 2 of table 5 also shows that, during the flood-months, agricultural wages decline significantly (by 6%) in all the districts that are inundated (irrespective of their relative flood-proneness). The decline, however, is less (by only .08%) when we consider inundation in only the 'more' flood-prone districts. The impact of flood shocks is less severe on wage formation in areas that have been repeatedly exposed to disaster (Fafchamps, 2003). Agrarian practices, including crop culture and crop calendar, in 'more' flood-prone districts have adapted to the normal monsoon flood regime over time (Rasid and Paul, 1987). Accordingly, wages decline less when a 'more' flood-prone district is inundated.

8. WAGE FLUCTUATIONS IN TIMES OF 'EXTREME' FLOOD

In the final part of our analysis, we examine how the impact of 'normal' flood differs from that of 'extreme' flood. Towards this, we exploit the panel characteristic of our data further, and extend [6] to include a dummy variable (E_t) to indicate occurrence of 'extreme' flood in month-year *t* in Bangladesh. Our model is now given by:

$$w_{d,t} = \alpha_0 + \sum_{k=1}^{4} \alpha_k w_{d,t-k} + \sum_{k=0}^{4} \pi_k^R p_{d,t-k}^R + \sum_{k=0}^{4} \pi_k^J p_{d,t-k}^J + \sum_{k=0}^{4} \theta_k^R q_{d,t-k}^R + \sum_{k=0}^{4} \theta_k^J q_{d,t-k}^J$$
$$+ \psi_4 I_{d,t} + \psi_5 M_d + \psi_6 (I_{d,t} * M_d) + \psi_7 E_t + \psi_8 (I_{d,t} * E_t) + \psi_9 (M_{d,t} * E_t)$$
$$+ \psi_{10} (I_{d,t} * M_d * E_t) + \tau_1 t + \tau_2 t^2 + \sigma_2 S_2 + \sigma_3 S_3 + \delta D + u_{d,t} \qquad [7]$$

In [7], (Ψ_7 + Ψ_8 + Ψ_9 + Ψ_{10}) captures the total effect of 'extreme' flood on wages. (Ψ_8 + Ψ_{10}) captures the effect of 'extreme' floods in any inundated district, irrespective of its relative flood-proneness; while Ψ_{10} captures the effect of 'extreme' floods in only those inundated districts that are 'more' flood-prone. (Ψ_5 + Ψ_6 + Ψ_9 + Ψ_{10}) explains the variations in wages caused by 'more' flood-proneness of the district. Estimates of equation [7] are reported in column 3 Table 5.

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23. An alternative explanation for the higher wages in the 'more' flood-prone districts can be the following: Many of the districts near Dhaka, the capital, are flood-prone. Proximity to Dhaka and linkages to its urban labor market may account for the higher wages, in at least those 'more' flood-prone districts that are in the neighborhood of the city. To examine this issue, we include a dummy variable indicating proximity to Dhaka in our regression equation. The dummy takes the value 1 for all the 'more' flood-prone districts sharing common boundary with Dhaka, and zero otherwise. The estimated coefficient on this dummy is 0.0094 (t-statistics=1.36). Accordingly, we fail to accept the hypothesis that proximity to Dhaka plays a significant role in explaining high wages in 'more' flood-prone districts.

Our results show that, though the estimated coefficient on E_t is positive, the total effect of 'extreme' flood on wages is negative. Agricultural wages in Bangladesh decline in 'extreme' flood months. We find that, the coefficient estimates on 'extreme' flood (E_t), and the coefficient estimate on the interaction variable indicating district inundation during 'extreme' flood ($E_t*I_{d,t}$), are nearly equal in absolute value and standard deviation, but opposite in sign. This suggests that there may be a high correlation between these two variables. The fact that almost all the districts in Bangladesh are inundated in an 'extreme' flood year can possibly explain this high correlation.

Our results also show that, in 'extreme' flood months, wages decline significantly (by 14%) in all districts that are inundated (irrespective of their relative flood-proneness); but, this decline is less severe (by 5%) when the district-concerned is 'more' flood-prone. We compare the coefficient estimates on the interactive dummy indicating inundation in 'more' flood-prone districts ($I_{d,t}*M_{d,t}$) in models [6] and [7] (presented in columns 2 and 3 respectively in Table 5). We find that, 'extreme' flood conditions will cause a more sever decline in wages (by 4%) in the inundated districts, than would otherwise have happened (.08% decline in wages) had only 'normal' flood conditions prevailed.

9. CONCLUSION

In this concluding section, we summarize our main results. We have argued that, the impact of flood on wages is realized through the impact of flood on demand and supply conditions in agricultural labor market. Delving into the antecedents in literature, we find that agricultural productivity and price of crops are important determinants of agricultural wages in Bangladesh. By analyzing the data, we also find that past wages, past agricultural productivity and past crop prices play important roles in determining wages. We therefore model wages as a dynamic process and estimate the effects of flood on the series.

Our results indicate that, over the long-term, flood as a phenomenon has positive impact on agricultural wage rates in Bangladesh. Boyce (1990) writes that for the rice farmers in the country, too little water is a greater threat than too much water. Draught has lead to more serious production shortfalls than flooding (Montgomery, 1985; Ahmed and Bernard, 1989). Important still, years of abnormally high floods have produced above-normal harvest of post-flood dry season crops in Bangladesh (Rogers *et* al; Brammer, 1990a and b; Boyce, 1990; Paul and Rasid, 1993). Our results, however, also show that, during the flood months, wages decline in the inundated districts; more so in times of 'extreme' floods, but less so in districts that are 'more' flood-prone. Other empirical studies have shown that the labor employment in agricultural decline significantly in these periods (del Ninno and Roy, 2001a, 2001b). The decline in income of the workers causes a severe decline in their consumption level and increases the incidence of illness and morbidity (del Ninno *et al*, 1999). These negative effects can continue in the post-flood months through the lingering nutritional consequences and increased household debt (del Ninno and Roy, 2001b).

The results in this paper further indicate that the factors that cause increase in demand for labor in flood-free periods can mitigate the negative impact of disasters in the flood-months. Increased agricultural productivity, that increases real wages, will reduce the vulnerability of the exposed population to potential short-fall in income level in times of disasters. In this regard, the need for long-term investment in agricultural, that facilitate intensive cultivation of high-yielding-variety and labor-intensive crops in the dry-season and that of flood-resistant variety of rice in the wet-season, has been emphasized (Rasid and Paul, 1987; del Ninno *et al*, 2003). The positive benefits of increased productivity, however, can be translated to increased welfare of agricultural workers only in presence of adequate social transfer mechanism (Montgomery, 1985). Agricultural wages in Bangladesh are also affected by such factors as land-distribution and bargaining power of workers. In presence of such structural and institutional constraints of wage determination, the issues of disaster responses in the country cannot be separated from the processes of rural development, and have to be embedded in the long-term, ongoing process of poverty reduction and social welfare.

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APPENDIX

Table A.1
Formula used for generating series on real agricultural wage indices for different districts in Bangladesh, by months, 1979-2000

$WI^d_{m,y} = w^d_{m,y} / \overline{w}^d_y$ where,

$WI^d_{m,y}$ = real agricultural wage index in district d in month m in year y; d = Chittagong, Comilla, Noakhali,.., Rangpur; m = January, February,.., December; y = 1979,1980,..,2000;

$w^d_{m,y}$ = real agricultural wage rate in district d in month m in year y;

w^d_y = annual average real agricultural wage rate in district d in year y, the average being taken over months

Table A.2
Formula used for generating series on rice and jute productivity in Bangladesh by month [a]

Month Column 1	**Rice productivity = q^R_m** Column 2	**Jute productivity = q^J_m** Column 3
Jan	$1*q^{BORO}_{jan} + 0*q^{AUS}_{jan} + 0*q^{AMAN}_{jan}$	$0*q^W_{jan} + 0*q^T_{jan}$
Feb	$1*q^{BORO}_{feb} + 0*q^{AUS}_{feb} + 0*q^{AMAN}_{feb}$	$0*q^W_{feb} + 0*q^T_{feb}$
Mar	$0.75*q^{BORO}_{mar} + 0.25*q^{AUS}_{mar} + 0*q^{AMAN}_{mar}$	$1*q^W_{mar} + 0*q^T_{mar}$
Apr	$0.5*q^{BORO}_{apr} + 0.5*q^{AUS}_{apr} + 0*q^{AMAN}_{apr}$	$0.75*q^W_{apr} + 0.25*q^T_{apr}$
May	$0.25*q^{BORO}_{may} + 0.75*q^{AUS}_{may} + 0*q^{AMAN}_{may}$	$0.5*q^W_{may} + 0.5*q^T_{may}$
Jun	$0*q^{BORO}_{jun} + 1*q^{AUS}_{jun} + 0*q^{AMAN}_{jun}$	$0.5*q^W_{jun} + 0.5*q^T_{jun}$
Jul	$0*q^{BORO}_{jul} + 0.75*q^{AUS}_{jul} + 0.25*q^{AMAN}_{jul}$	$0.5*q^W_{jul} + 0.5*q^T_{jul}$
Aug	$0*q^{BORO}_{aug} + 0*q^{AUS}_{aug} + 1*q^{AMAN}_{aug}$	$0.5*q^W_{aug} + 0.5*q^T_{aug}$
Sep	$0*q^{BORO}_{sep} + 0*q^{AUS}_{sep} + 1*q^{AMAN}_{sep}$	$0*q^W_{sep} + 0*q^T_{sep}$
Oct	$0*q^{BORO}_{oct} + 0*q^{AUS}_{oct} + 1*q^{AMAN}_{oct}$	$0*q^W_{oct} + 0*q^T_{oct}$
Nov	$0.25*q^{BORO}_{nov} + 0*q^{AUS}_{nov} + 0.75*q^{AMAN}_{nov}$	$0*q^W_{nov} + 0*q^T_{nov}$
Dec	$0.5*q^{BORO}_{dec} + 0*q^{AUS}_{dec} + 0.5*q^{AMAN}_{dec}$	$0*q^W_{dec} + 0*q^T_{dec}$

Source: BBS, various years.

[a] The relevant weights are assigned in terms of crop calendar for the country,

In Table A.2 the symbols have the following interpretations:
q^R_m = productivity of rice (all variety: *aus, aman* and *boro*) in month '*m*', where *m* = January, February, etc.
q^{BORO}_m = productivity of *boro* variety of rice in month '*m*', where m = *Jan* for January, *Feb* for February, etc.
q^{AUS}_m = productivity of *aus* variety of rice in month '*m*', where m = *Jan* for January, *Feb* for February, etc.
q^{AMAN}_m = productivity of *aman* variety of rice in month '*m*', where m = *Jan* for January, *Feb* for February, etc.
q^J_m = productivity of jute (all variety: *white* and *tossa*) in month '*m*', where *m* = January, February, etc.
q^W_m = productivity of *white* variety of jute in month '*m*', where m = *Jan* for January, *Feb* for February, etc.
q^T_m = productivity of *tossa* variety of jute in month '*m*', where m = *Jan* for January, *Feb* for February, etc.

Table A.3
Crop calendar in Bangladesh and the relative flood-vulnerability of rice and jute

Crop	Variety	Sowing/ transplant months	Harvest months	Flood-vulnerability
Aus (Pre-monsoon or Summer Rice)	Local Broadcast	mid March-mid April	mid July-early August	*Aus* rice can tolerate only shallow flooding.[a] Harvested prior to peak monsoon floods.
	HYV Transplant	mid March-mid April	July-August	
	HYV Broadcast	mid March-mid April	late July-August	
Aman (Monsoon Rice)	Local Transplant	end June-early September	December-early January	Transplant *aman* can tolerate moderate flooding.[b] Vulnerable to flood all along the growing period and at the time of harvest.
	HYV Transplant	late June-mid August	December-early January	
	Local Broadcast	March-April	mid November -mid December	Local broadcast *aman* can tolerate deep flooding. [c] Exposed to flood all along the growing period.
Boro (Winter Rice)	Local	mid November-mid January	April-May	*Boro* rice is harvested prior to flood seasons.
	HYV	December-mid February	Mid April-June	
Jute	White(Capsularis)	early March-mid April	July-August	Jute can tolerate only shallow flooding .[a] Harvested during peak monsoon floods.
	Tossa (Olitorius)	mid April-early May	August-September	

Source: Crop Calendar: BBS, various years; Flood-vulnerability of crops: Rasid and Paul, 1987
[a] Shallow flood: depth of standing water less than 1m.
[b] Moderate flood: depth of standing water 1m–2m
[c] Deep flood: depth of standing water more than 2m

Table A.4
Classification of districts in Bangladesh terms of relative flood-proneness

'More' flood-prone districts	% area vulnerable, in 'normal' flood year, to flood of depth		'Less' flood-prone districts	% area vulnerable, in 'normal' flood year, to flood of depth	
	0- 90cm	> 90cm		0- 90cm	> 90cm
Bogra	22	78	Rajshahi	60	40
Pabna	25	75	Noakhali	78	22
Comilla	32	68	Barisal	84	16
Faridpur	32	68	Kushtia	87	13
Tangail	38	62	Khulna	91	9
Sylhet	42	58	Rangpur	94	6
Dhaka	43	57	Chittagong	97	3
Mymensingh	45	55	Patuakhali	98	2
Jessore	46	54	Rangamati	100	0
			Bandarban	100	0
			Dinajpur	100	0

Source: Rogers *et al*, 1989

Table A.5
Chronology of flood occurrences, regions affected and estimated flood-losses in Bangladesh, 1979-2000

Flood year	Flood months	Region affected	Estimated flood-losses
1984	May-June[1]	Habiganj, Maulavi Bazaar, Sunamganj and Sylhet	175,000 tons of rice and 80,000 tons of jute destroyed. 2 million people affected. 100,000 rendered homeless.[a]
1986	August[1], September–early October[1]	2890sq miles of area were flooded including Rajshahi, Northeastern parts of the country, Bagerhat, Barguna, Faridpur Jessore, Khulna, Patuakhali and Satkhira	1.3 million acres of crops damaged. 3.4 million people affected. 200,000 people rendered homeless.[a]
1987[b]	July–August[2]	Estimated return period: 30-70 year event. The flood affected about 57,300 sq km of Bangladesh including the western side of the Brahmaputra, the area below the confluence of the Ganges and the Brahmaputra, areas north of Khulna and finally some areas adjacent to the Meghalaya hills.	Cumulative loss of 1987 & 1988 floods worth US $ 2 billion, reducing GDP about 4%.
1988[b]	July[1], August–early September[3], Late September-early October[1]	Estimated return period: 50-100 About 82,000 sq km (about 60% of the area) was inundated. Districts affected in July: Bogra, Habiganj, Netrokona, Maulavi Bazaar, Rangpur, Satkhira and Sunamganj. Districts affected in August-September: Bogra, Chandpur, Comilla, Dhaka, Faridpur, Gaibanda, Habiganj, Jamalpur, Manikganj, Munshiganj, Mymensingh, Pabna, parts of Narshingdi, Sirajganj, Sunamganj, Tangail and western part of Brahmanbaria. Districts affected in October: Barisal, Netrokona, Lakshmipur and Sirajganj.	
1989	Late July–early August[1], Late August[2]	Bandarban, Chittagong, Cox Bazaar and Sylhet Maulavi Bazaar, Sirajganj and Sylhet	200,000 people affected. Seed beds and standing crops in over 9,000 ha partially affected. 600,000 people trapped by water.[a]
1991	July–September[1]	Northwestern part of the country.	1.5 million peoples affected. No significant loss of crops was reported.[a]
1993	June-July[1]	Bandarban, Brahmanbaria, Chittagong, Comilla, Cox's Bazaar, Dhaka, Parts of Feni, Habiganj, Khagrachari, Kishoregonj, Maulavi Bazaar, Netrokona, Pabna, Sherpur, Sunamganj and Sylhet	Approximately 10,373,217 peoples (20% of the total population in affected districts) affected.[a] 958,766 acres of crops damaged. 2,664 educational institutes damaged.
1995	June-July[1]	Bogra, Gaibanda, Jamalpur, Kurigram, , Madaripur, Maulavi Bazaar, Netrokona, Pabna, Rangpur, Shariatpur Sirajganj, Sunamganj and Sylhet	463000 people in Sunamganj and 47000 people in Sylhet and Gaibanda affected.[a] 20% of the houses in the affected districts destroyed.

1996	July[1]	Bogra, Dhaka, Faridpur, Gaibanda, Jamalpur, Kurigram, Lalmonirhat, Manikganj, Madaripur, Narayanganj, Rajbari, Shariatpur, Sherpur, Sirajganj, Tangail	2200357 people affected. [a] 8148 acres of crop fully damaged. 158,0693 acres of crop partially damaged. 49875 houses damaged.
1997	July[1]	Bandarban, Barisal, Chittagong, Cox's Bazaar, Dhaka, Dinajpur, Gopalganj, Khagrachari, Munshiganj, Mymensingh, Netrokona, Rangamati and Thakurgaon	100,000 people homeless, 800,000 people marooned.[a] 300,000 acres of cropland inundated.
1998[b]	Late July–early October[4], [5], [6]	52 of its 64 districts flooded. The severely affected districts were: Barisal, Chandpur, Chandpur, Chapai Nawabganj, Chittagong, Dhaka, Gaibanda, Gopalganj, Kishoregonj, Kurigram, Lakshmipur, Madaripur, Magura, Manikganj, Munshiganj, Narayanganj, Narshingdi, Nawabganj, Rajshahi, Sirajganj, Sunamganj and Sylhet Districts not Affected: Jessore, Bogra, Dinajpur	100,250 sq. km, about 68% of the total area of the country[4], inundated. Total damage worth US $ 3 billion.
1999	July[1]	Bandarban, Chittagong, Comilla, Cox's Bazaar, Khagrachari, Lakshmipur, Manikganj and Rangamati	
2000	Late May–early June[1], September[7]	Magura, Jheniahdah, Barisal, Shariatpur, Dhaka, Kishoregonj, Narayanganj, Bandarban, Chittagong, Maulavi Bazaar, Chandpur, Rajshahi Satkhira, Jessore, Jheniahdah, Chuadanga, Magura, Meherpur, Kushtia, Rajshahi and Chapai-Nawabganj	

Source: [1] United Nations Department off Humanitarian Affairs (DHA), various years
[2] Sifatul Quader Chowdhury *et al*, 2006
[3] Hossain *et al*, 1988
[4] del Ninno *et al*, 1999b
[5] Ahmad *et al*, 2001
[6] BAPA, 2000
[7] Hossain, 2000

[a] Total population in Bangladesh as in 1991 census: 111,456,000
[b] Years of 'extreme' flooding