

# **Effects of flood on agricultural wage formation in Bangladesh: An empirical analysis**

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## **Abstract:**

It is a stylized fact that natural disasters have a profound and increasing impact on the economically deprived communities. This paper explores one of the channels through which disaster affects the poor by analyzing the effects of flood disasters on wages of the agricultural workers in Bangladesh. I use the district-wise monthly data over the period 1979-2000 to model real agricultural wages in Bangladesh as a dynamic process and to estimate the significance of floods in explaining fluctuations in the series. In addition, I explore how the agricultural wages in a repeatedly flooded region adjust to the shock induced by flood disasters. Towards this, I obtain difference-in-difference estimates of interaction effects of the impact of flood in a relatively flood-prone district. I also estimate whether or not the magnitude of this impact varies with the relative severity of flood conditions. The results obtained in this paper show that floods as a phenomenon have an overall positive effect on agricultural wages in Bangladesh even though they cause a decline in wages in the districts that are inundated. The wages in general tend to be higher in a frequently flooded district compared to a less flood-prone district; and extreme floods cause a less dramatic decline in wages when the frequently flooded districts are inundated. I argue that these impacts of floods on agricultural wages are generated through the flood impacts on agricultural productivity and relative price of crops; accordingly, favorable demand conditions in the agricultural labor market will mitigate the negative impacts of floods on agricultural wages.

*Key words:* Asia, Bangladesh, agricultural wages, flood

*JEL Classifications:* J31, J43, O13, O18, O53, Q19

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## 1. Introduction

*A crucial part of the concept of flood hazard is the interface between floods and people. A flood is not hazardous unless humans are sufficiently affected.*

- World Commission on Dams (2000).

*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. Activities of development nature then can be seen as an integral part of disaster prevention and mitigation.*

- 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; United Nations Centre for Regional Development, Nagoya

That economic deprivation increases vulnerability to disaster is neither profound nor perplexing. On one hand, poor households have a greater difficulty in adjusting to a given loss of income than the non-poor ones (Ravallion 2000); on the other, these households are less capable to take protective measures against hazards than rich households (Varley 1994, Islam 2001). This paper explores one of the channels through which disaster affects the poor by analyzing the effects of floods on the wages of agricultural workers in Bangladesh.

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 magnitudes in 1971, 1974, 1978, 1984, 1986, 1987, 1988, 1989, 1991, 1993, 1995, 1996, 1997, 1998, 1999, 2000 (Asiatic Society of Bangladesh 2003) and more recently in 2004. Flood is a capricious benefactor to the agrarian regime of Bangladesh. While floods enrich soil with nutrients and supply water for irrigation thereby supporting agricultural production, they also destroy crops when assuming disastrous proportions. It is intuitively obvious that as heavy floods disrupt the normal agricultural activities in the fields, agricultural workers are rendered jobless. What is however not immediately obvious is how wage rates of these workers are affected in these periods.<sup>1</sup> The present paper examines this issue. It uses the district-wise monthly data over the period 1979-2000 to model real agricultural wages (in terms of rural consumer price index) in Bangladesh as a dynamic process and estimates the

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<sup>1</sup> Hossain (1990a) writes that the impact of the flood on demand and supply of agricultural laborers is rather uneven. As a result, there is nothing predetermined in the way floods affect wages of these workers.

significance of floods in explaining fluctuations in the series. In addition, it examines whether the magnitude of the impact of floods on agricultural wages varies across the regions that are geomorphologically different in terms of their relative flood proneness and whether or not these impacts depend on the relative severity of floods. There are 6.21 million agricultural laborers in Bangladesh (Labor Force Survey 1995-96, BBS 2000). Household surveys show 74.9 per cent of the rural poor in Bangladesh work as agriculture workers (Rahman and Islam 2003). 33 percent of the household income of rural poor is generated by agricultural wages (BBS 2000) and the number of rural families depending on wages as the principal source of their income is increasing over time (Mujeri and Khondker 2002, BBS 2002). By documenting how floods affect agricultural wages, the present paper seeks to understand the implications of disasters for the wellbeing of a very large section of rural poor in Bangladesh.

The rest of this paper is structured as follows: Section 2 reviews how this paper relates to the literature. Section 3 explores the main channels through which floods might affect agricultural wages in Bangladesh. I survey the antecedents in the literature to identify different factors that determine agricultural wage in Bangladesh. I hypothesize that as floods affect the demand and supply conditions in the agricultural labor market, the agricultural wages deviate from their normal patterns as a resultant impact. Section 4 presents the data and describes the methodology of analysis in this paper. Section 5 presents the main empirical results of flood impacts on wages. Section 6 presents the related results on the role of agricultural productivity and real prices of crop in mitigating the impacts of floods on wages. Section 6 concludes. The appendix at the end of this paper briefly reviews the literature on determinants of agricultural wages in Bangladesh, explains the data analyzed and presents the estimates of the models.

## **2. Related literature**

Ward (1978) defined flood as a body of water which rises to overflow land that is not normally submerged. Monsoons (June-early October) are the seasons of riverine floods in Bangladesh. Flooding occurs with heavy rainfall and when the discharges in the rivers peak simultaneously (Rasid and Paul 1987). The country experienced extreme flood situations in 1974, 1987, 1988 and 1998 when 35 per cent or more of its total area was submerged under water of depth 90 cm or more (Rogers et al 1989, Zaman 1993, Asiatic Society of Bangladesh 2003, UNDHA various years). Economic losses in these years were estimated to be \$600 million in 1974, \$2.2 billion in 1987 and 1988 (South Asian Floods 2002) and \$3.5 billion in 1998

(Shehabuddin 2000). The combined losses in the years 1987 and 1988 amounted to approximately 4 per cent of the GDP of the country in 1988 (Hossain et al 1988). The loss in 1998 was about 7 percent of the GDP of the country in 1998 (Ahmed 2001, BBS 2001). Historic records indicate that the frequency, magnitude and duration of floods in Bangladesh are on the rise over the last decades (Khalequzzaman 2000).

While there is an extensive body of literature on the impacts of flood on the agrarian economy of Bangladesh, not many of these studies analyze the impacts of flood on agricultural wage rates. Hossain et al (1988) touched upon this issue as they described the impacts of extreme flood of 1988 in Bangladesh. The authors found that agricultural wages declined in the inundated regions in Bangladesh, but this decline was less severe in the regions where proportionately more land was devoted to labor intensive high yielding varieties (HYV) of crops. Also, wages declined less in the regions that are proximate to the capital, Dhaka. del Ninno and Roy (1999a and b, 2001a and b) and del Ninno, Roy and Mukherjee (2001) studied the impacts of the extreme floods of 1998 on the agricultural labor market of Bangladesh and found that in the flood months of July-October in 1998, the average monthly wage earnings for the daily laborers fell by 60 per cent below what they earned in the same months in 1997. The authors also reported that the wage income did not recover even in July-October of 1999, a year after flood. The above mentioned studies are illuminating as they describe how agricultural wages fluctuated in two specific years of extreme flood in Bangladesh. However, they do not tell us anything about the long run impacts of floods on agricultural wages or how wages fluctuate in the regions that are more frequently flooded compared to the regions that are less flood-prone. Quasem (1992) addressed the later issue when he carried out a comparative study of wages across different agroecological zones in Bangladesh. He found that the agricultural wages was lower in the regions that are extremely flood prone. However, this study did not analyze how floods affect wages in different years.

The long run impact of flood was brought up by Ravallion (1987) when he concluded that the 1974 floods caused a structural break in wage formation over time in Bangladesh. The other temporal analysis on the impact of natural disasters on real wages was presented by Hossain (1990). Hossain used dummy variable to indicate periods of disaster. The dummy took the value of one when the real wages declined 10 per cent or more below its level in the previous quarter. As Azam (1993:2) points out, this study suffers from endogeneity problem.

Azam (1993) proposed an alternative dynamic model where he qualified the flood variable in terms of the area flooded (in acres) and the real wages in terms of price of coarse

quality rice. He used the monthly data for Bangladesh over the period July 1981 to June 1989 to explain the fluctuations in rice-equivalent of wages in terms of its past value, growth rate of rice price and variations in area flooded. The result showed that given the price of rice, floods have significant negative impact on real wages. Azam's principal objective had been to analyze the dynamics of wage adjustment in response to price changes in the times of disaster. This model did not examine the variable impacts of floods across different regions in Bangladesh. Also, the study did not analyze how factors like agricultural productivity and prices of other important crops (like jute) would influence the impact of floods on wages. Azam himself noted that this study had certain limitations. First, the study was carried over a relatively small period of time (91 months). The limited data prevented him from including other potentially important explanatory variables. Second, Azam cautioned about the possible homogeneity problem in data as he theorized that rice price and real wages simultaneously determine each other.

The present paper hopes to contribute to the existing literature in three ways: First, like its precursors, this paper examines how monthly real agricultural wages fluctuate in flood months, but it examines these impacts over a much longer period of time (1979-2000). The richer data set enables me to address the potential problem of omitted variables in earlier models. And second, unlike its predecessors, this paper analyzes why the impacts of flood vary across different districts in Bangladesh.<sup>2</sup> Typically, rural labor markets in Bangladesh are segmented (Datta 1998). By implicitly and explicitly controlling for the relevant regional factors I hope to have a better understanding of the role of these factors in wage determination in the times of floods. I estimate real agricultural wage rate (in terms of rural consumer price index) as a function of its past values, current and past productivity of agricultural crops in different districts, and current and past real prices of crops in different districts to examine how these determinants explain agricultural wages in non-flood and flood periods across Bangladesh. I distinguish between the districts that are more flood-prone from those which are less so and examine whether or not the impacts of flood vary with relative flood proneness of a district. Finally, this paper distinguishes between moderate and extreme flood situations in Bangladesh and examines the significance of relative severity of floods in explaining wage fluctuations.

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<sup>2</sup> Bangladesh is divided into six *bibhag* or Administrative Divisions: Dhaka, Chittagong, Khulna, Rajshahi, Barisal and Sylhet. The Divisions are subdivided into 19 'greater' (the erstwhile 'old') Districts in Bangladesh. In the present paper, these 'greater' or 'old' districts are the unit of analyses and are referred to as 'districts'.

### **3. Impact of flood on agricultural productivity, prices and wages**

To understand why and how floods might affect agricultural wages one needs to understand how floods affect the different determinants of agricultural wages. In this section I try to identify the different factors that explain agricultural wage formation in Bangladesh. Next, I propose hypotheses to explain the impacts of floods on these variables and therefore, on agricultural wages across different districts in Bangladesh. Finally, I try to account for these hypotheses.

#### **3.1 Determinants of agricultural wages in Bangladesh**

A survey of the literature reveals that ‘there is substantial evidence that the (farm) wage rate is quite sensitive to demand and productivity factors’ (Bardhan, 1984:56). Appendix 1 presents a thumbnail sketch of this survey. Within a particular crop season, labor demand is high during the period of sowing/transplantation and the periods of harvest. In these periods agricultural wages rise (Sen Gupta 1974, Ahmed 1981, Masum 1982, Datta 1998). These periods are interspersed with the relatively slack periods when the crops are left growing in the fields. In these periods, the demand for agricultural workers decline and so do agricultural wages.

Apart from the seasonal fluctuations in demand, the demand for labor is also determined by long term trend factors, agricultural productivity and terms of trade in agriculture (Khan 1984). The trend picks up the time-dependent variables such as population size, inequality in landownership, increasing land-man ratio, slow growth of output due to technological and institutional constraints and slow growth of employment per unit of land. Increase in per acre production of agriculture would stimulate demand for labor and therefore would have a positive effect on real wages. Increase in the relative price of agricultural products however would have two opposing effects. First, rise in price of crops lead to an increase in production of agricultural goods and therefore the demand for agricultural workers. Khan (1984) explains that this would increase the ability of the agricultural sector to absorb greater increase in wages in the long run. However, increase in the price of agricultural products would also have a cost of living effect, at least in the short run. Increase in food price would increase the consumption expenditure for the agricultural workers. The effect would be more severe for the landless laborers who are the net buyers of food (Ravallion 1990, Boyce and Ravallion 1991). The workers would then be compelled to work for more hours, and therefore the supply of labor would increase. This would have a negative impact on the wages. The ultimate effect of an increase in the price of agricultural

products would depend on the relative strength of the demand effect vis-à-vis the cost of living effect.

Agricultural wages vary across regions in Bangladesh. These variations have been explained in terms of regional variations in demand and supply conditions of labor (Ahmed 1981, del Ninno and Roy 1999a). The demand for agricultural labor is comparatively higher in the regions where land is more intensely cultivated and multiple crops are produced. The demand for labor is also higher in the regions where proportionately more land is devoted to labor-intensive HYV crops vis-à-vis less labor-intensive crops. In these regions the agricultural wages are expected to be higher. On the other hand, agricultural wages are expected to be lower in regions with higher concentration of landless households. In these regions, the supply of agricultural workers will be high and the agricultural wages are expected to be low (Ahmed 1981, Skoufias 1993, del Ninno and Roy 1999a).

The next subsection explores the different channels through which floods might affect agricultural wages in Bangladesh.

### **3.2 How do floods affect agricultural wages? - Some hypotheses**

There are two peak seasons in agricultural wage pattern 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 latter is the period of harvest of the wet season crop and sowing/transplantation of the dry season crop (BBS 2002).<sup>3</sup> However, in the times of monsoon floods the normal harvest and plantation activities in the fields are disrupted (Hossain et al 1988). The floods can occur in the months of June to early October. The impacts of these floods on the agrarian economy of Bangladesh vary according to the timings of flood surges

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<sup>3</sup> In terms of the nature of irrigation, there are two somewhat overlapping seasons in the crop calendar of Bangladesh: (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 crop of Bangladesh is also grown in this season. The dry (*rabi*) season consists of (i) winter season (mid November-May) and (ii) summer season (mid March-August). *Boro* variety of rice is the main winter crop while *aus* variety of rice is the main summer crop. *Boro* rice and *aus* rice compete with each other for the same cultivable land. The commonly practiced cropping pattern for the peasants in Bangladesh is *aman* rice in the rainy season, followed by *boro* or *aus* or jute in the dry season (Hossain 1990, Datta 1998, BBS 2002). In 2000, 75 percent of the total cultivable area in Bangladesh was under rice production and 2.86 per cent was under jute production. Of the area under rice cultivation, 53.28 percent (almost 40 per cent of the total cultivable area in Bangladesh) was under *aman* rice cultivation, 34.1 percent area was under *boro* rice cultivation and 12.62 per cent was under *aus* rice cultivation (BBS 2002).

and extensiveness of the area inundated (Paul 1984, Rasid and Paul 1987, Paul and Rasid 1993). I propose the following hypotheses regarding the effects of these floods on wage formations in Bangladesh:

***Proposition 1:*** Floods cause fluctuations in the seasonal demand for labor, and thereby affect the agricultural wages across different districts in Bangladesh.

***Proposition 2:*** Agricultural wages in a frequently flooded district would deviate less from their usual pattern when floods occur in the district.

***Proposition 3:*** Decline in wages is expected to be more dramatic in the inundated districts in the years of extreme floods as compared to that in the years of localized floods.

### **3.3 Discussion**

As floods destroy crop, the demand for the workers for harvest and post-harvest activities is reduced. Given the supply of workers, this may lead to a decline in wages. The real wages will fall further if price of the food crops increase in the flood months. The situation will worsen if the supply of labor increases at the same time through distress sale of labor.<sup>4</sup> However, not all the regions in Bangladesh are equally affected in the times of floods. The magnitude of the impact of flood may vary across regions that vary in terms of their topographical characteristics (Rasid and Paul 1993). Intuition suggests that the agricultural workers and peasants in the districts that are more frequently inundated would systematically adapt themselves to flood hazards. This paper therefore postulates that the floods do not generate nonsystemic shocks to the process of wage formation in agricultural sector of a more flood-prone district. Accordingly, the magnitude of impact of a flood on agricultural wages is expected to be comparatively less in a more flooded district.

The magnitude of impact of flood on agricultural wages also depends on the relative severity of floods. Bradnock (1984:40) writes, 'the specific causes of floods [in Bangladesh] vary from region to region, and the implications for agricultural activity also vary according to the origins and the type of flooding that is experienced'. In the years of localized or 'minor' floods,

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<sup>4</sup> The distress sale of labor may occur if floods destroy the assets (homestead, cattle and so forth) of the workers. In a study on the impact of floods on residential houses in rural and urban Bangladesh, Islam (2001) showed that the relative losses of assets (including houses) are more for poor households. On one hand, the poor households have a lesser capacity to take protective measures against prospective flood damages than rich households; on the other hand, the low cost houses (and thus low-income occupants) are relatively more vulnerable to floods as, lower the costs of construction, the higher are the structural damages from flood.

the low-lying districts are most severely affected. However, in the years of extreme or ‘major’, floods even the relatively highland and draught prone areas of Bangladesh are affected (Paul 1984, Rasid and Paul 1987, Paul and Rasid 1993). Major floods usually occur when the surge of water in the three great rivers Ganges, Brahmaputra and Meghna peak simultaneously (Rogers et al, 1989). Since its independence in 1971, Bangladesh has experienced four extreme or ‘major’ floods in 1974, 1987, 1988 and 1998 (Asiatic Society of Bangladesh 2003, United Nations Department of Humanitarian Affairs various years). In addition, different regions in the country has experienced regionally concentrated ‘minor’ floods in 1971, 1978, 1984, 1986, 1989, 1991, 1993, 1995, 1996, 1997, 1999, 2000 and 2004. Abnormal or extreme floods are distinguished from the normal floods (also known as localized or ‘minor’ floods) in the country in terms of their (a) long duration, (b) extensiveness of the area affected and (c) depth of standing water.<sup>5</sup> While the localized floods do not cause a severe set back for the wet season crop production for the entire country, extreme floods do. I argue that the decline in wages is expected to be more dramatic in the inundated districts in the years of extreme floods as compared to that in the years of localized floods. I expect this result for the following two reasons: First, the outside or migration options for agricultural laborers are reduced when extensive regions are inundated simultaneously and the workers may be forced work for lower wages. Second, the wage bargaining power of the workers are compromised in the times of extreme flood disasters, as the fall back options of the workers are compromised. Most of these workers are poor and poverty reduces their capacity to absorb shocks from unexpected variations in income and consumption (Fafchamps 2003). On one hand, the poor tend to put greater value to a given change in consumption than the non-poor; on the other, the poor tend to have fewer access to physical and human resources to buffer their consumption from a loss of income (Ravallion 2000: 297).

#### **4. Data and methodology**

My objective is now to empirically test the validity of the hypotheses proposed in the earlier section. Towards that end, I seek to model real agricultural wage rate in terms of

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<sup>5</sup> In a normal year, 35 per cent of the *net cultivated* area of the country experiences shallow floods (of depth 30-90 cm), 16 per cent experiences moderate floods (of depth 90-180 cm); and 12 per cent experiences deep floods (of depth over 180 cm). The remaining 37 per cent is not affected by floods (Bangladesh National Water Plan, 1986). However, in the years of abnormal floods, 35 per cent or more of the *total* area of the country experience moderate to deep flooding (with the depth of standing water being 90 cm or more) (Rogers et al 1989, Zaman 1993). The abnormal floods can continue for two months or more.

agricultural productivity, prices of agricultural product and long term trend factors to examine how floods affect wages. I start by identifying the exogenous and endogenous variables of our model. Next I explain the strategy of analysis adopted in this paper.

#### 4.1 Identification of variables

The series on real agricultural wages is generated by deflating the nominal wages series by rural consumer price index. I identify the following four flood-related determining variables: (a) flood dummy for Bangladesh to indicate the month when flood has occurred somewhere in the country in a monsoon month of a particular year, (b) district inundated dummy to indicate the district where the flood has occurred in a monsoon month of a flood year, (c) relative flood proneness dummy to indicate whether or not a district is geomorphologically more prone to flooding, and finally (d) flood severity dummy variable to indicate whether or not the flood in a particular year was extreme in nature. I introduce district dummy variables to capture the district-specific effects not explicitly considered in the models. Appendix 2 describes the data and their sources.

#### 4.2 Methodology of analysis

I use the least squares dummy variables (LSDV) method of pooling the data to generate a continuous series on (log) real agricultural wages across the districts and over the months in the time period January 1979-December 2000.<sup>6</sup> The pooled series on wages (across districts and over time) has 3675 observation points. I find that the series on dependent and independent variables are serially correlated, but stationary. The effects of the past values of the variables on their current values die out after a lag of four periods.<sup>7</sup> I start the empirical analysis by examining the presence of trend and seasonality in agricultural wage data. The relevant regression equation is as follows:

$$w_{d,t} = a + b_1t + b_2t^2 + b_3SUMMER + b_4WINTER + \varepsilon_{d,t} \quad (1)$$

In the above equation  $w_{d,t}$  is a three category variable representing the natural log of real agricultural wage rate of the  $d^{th}$  district in the  $t^{th}$  time period,  $d = 1, 2, \dots, 20$  and  $t = 1$  for January

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<sup>6</sup> The justification for pooling the data is that on testing, I had failed to reject the hypothesis that the estimated values of slope coefficients are same across the different districts in Bangladesh and only the intercepts are different.

<sup>7</sup> The lag specification is on the basis of the lowest value of Akaike criterion and Schwarz criterion.

1979, 2 for February 1979, etc.  $t$  and  $t^2$  are the linear and quadratic time trends respectively. *SUMMER* and *WINTER* are the seasonal dummy variables indicating summer and winter crop season respectively. *SUMMER* takes the value of 1 for the months March-July and zero otherwise. *WINTER* takes the value of 1 for the months November-May and zero otherwise. The results of estimation are reported in table 5 in the appendix.

Next I propose dynamic models of agricultural wages in Bangladesh to seek the answers to the following questions: (a) Do floods cause any significant fluctuations in agricultural wage rates in Bangladesh? (b) Do the effects of flood on agricultural wages differ in the districts that are inundated in the flood months from that in districts that have remained flood-free? (c) What role do agricultural productivity and real price of crops play in explaining fluctuations in agricultural wages in a district in the flood months? (d) Does the magnitude of impact of flood on agricultural wages depend on whether or not a district is frequently flooded? (e) Are the effects of moderate floods significantly different from that of the extreme floods? And finally, (f) what role do favorable demand conditions in the agricultural labor market mitigate the impacts of flood on agricultural wages across regions in Bangladesh? I follow the so called ‘simple to general’ approach of analysis (Johnston and DiNardo 1997) and proceed in the following manner:

I start by estimating the significance of floods as an explanatory variable in explaining fluctuations in agricultural wages in Bangladesh. Equation (2) presents univariate model of log real agricultural wages in Bangladesh in terms of its past values, flood dummy for Bangladesh and district dummies:

$$w_{d,t} = \alpha + \sum_{k=1}^4 \beta_k w_{d,t-k} + \xi_1 FLOOD_t + \psi D_d + u_{d,t} \quad (2)$$

$w_{d,t}$  in the above equation once again indicates the natural log of real agricultural wage rate of the  $d^{\text{th}}$  district in the  $t^{\text{th}}$  time period,  $d = 1, 2, \dots, 20$  and  $t = 1$  for January 1979, 2 for February 1979, etc.  $w_{d,t-k}$  indicates the past values of agricultural wages in district  $d$  in periods  $t-k$  where  $k = 1, 2, 3, 4$ .  $FLOOD_t$  is a dummy variable that indicates flood has occurred in some part of Bangladesh in month  $t$ . The variable takes the value one to indicate that period  $t$  is a monsoon flood month in Bangladesh, and is zero for non-flood periods (including winter and summer months as well as the monsoon months in a draught year).  $D_d$  is the vector of district dummies, where  $d = 1$  for Chittagong, 2 for Comilla etc.  $u_{d,t}$  is the random unobserved ‘error’ term. The results of estimation are reported in column 3 of table 6 in the appendix.

To examine whether or not the effects of floods on agricultural wages differ between the districts that are inundated and the districts that had remained flood-free, I extend model (2) and introduce the district inundated dummy ( $INUNDATED_{d,t}$ ). This dummy variable takes the value one to indicate flood occurrence in district  $d$  in period  $t$ , and is zero otherwise. Equation (3) presents the new model:

$$w_{d,t} = \alpha + \sum_{k=1}^4 \beta_k w_{d,t-k} + \xi_1 FLOOD_t + \xi_2 INUNDATED_{d,t} + \psi D_d + u_{d,t} \quad (3)$$

The results of estimation of model (3) are reported in column 4 of table 6 in the appendix. An estimate of the coefficients of district inundated dummy captures the direct effects of flood on agricultural wages in the districts that are inundated. An estimate of the coefficients of flood dummy captures the spillover effects or the externality generated by floods in the neighboring districts on the agricultural wages in the districts that had remained flood-free.

Next, I examine how the favorable demand conditions in the labor market mitigate the effects of flood on agricultural wages in the inundated districts. Towards this I extend equation (3) to introduce such non-flood explanatory variables of agricultural wages as agricultural productivity and real prices of agricultural product. My extended model has an autoregressive distributive lag formulation of 4<sup>th</sup>-order lags in levels in both the dependent and independent variables (ADL(4,4)). Equation (4) presents the model:

$$w_{d,t} = \alpha + \sum_{k=1}^4 \beta_k w_{d,t-k} + \sum_{k=0}^4 \gamma_k RICE_{d,t-k} + \sum_{k=0}^4 \delta_k JUTE_{d,t-k} + \sum_{k=0}^4 \rho_k PRICE^{RICE}_{d,t-k} + \sum_{k=0}^4 \pi_k PRICE^{JUTE}_{d,t-k} + \xi_1 FLOOD_t + \xi_2 INUNDATED_{d,t} + \psi D_d + u_{d,t} \quad (4)$$

In the above equation agricultural productivities are captured in terms of  $RICE_{d,t-k}$  indicating the natural log of rice yield per acre of land in district  $d$  in  $t$ - $k$ <sup>th</sup> period, and  $JUTE_{d,t-k}$  indicating the natural log of jute yield per acre of land in district  $d$  in  $t$ - $k$ <sup>th</sup> period. Crop prices are captured by  $PRICE^{RICE}_{d,t-k}$  indicating the natural log of real price of rice (in terms of rural consumer price index) in district  $d$  in  $t$ - $k$ <sup>th</sup> period and  $PRICE^{JUTE}_{d,t-k}$  indicating the natural log of real price of jute (in terms of rural consumer price index) in district  $d$  in  $t$ - $k$ <sup>th</sup> period. All the other symbols have their earlier interpretations. The results of estimation of model (4) are reported in column 5 of table 2 in the appendix.

To examine the effects of floods on agricultural wages when a more flood-prone district is inundated, I estimate the model given by equation 5:

$$w_{d,t} = \alpha + \sum_{k=1}^4 \beta_k w_{d,t-k} + \xi_1 FLOOD_t + \xi_2 INUNDATED_{d,t} + \xi_3 MORE_d + \xi_4 (INUNDATED_{d,t} * MORE_d) + \psi D_d + u_{d,t} \quad (5)$$

In equation (5),  $MORE_d$  is the district flood-proneness dummy. It takes the value one when district  $d$  is more prone to flood, and is zero otherwise.  $(INUNDATED_{d,t} * MORE_d)$  is the interaction dummy that captures the impact of flood on agricultural wages in a more flood prone district in the flood months when the district is inundated. All the other symbols have their earlier implications. The results of estimation of model (5) are reported in column 6 of table 6 in the appendix. An estimate of the coefficient of the district flood-proneness dummy indicates whether or not the fact that a district has been repeatedly exposed to flooding plays any role in its agricultural wage formation. In others words, this coefficient captures the long tem impact of floods on the agricultural wages. In contrast, an estimate of the coefficient of the interaction dummy captures the short term or immediate impact of flood exposure. It indicates how agricultural wages respond to the flood shocks in the flood month when a repeatedly flooded district is inundated.

I further extend model (5) to examine what role do agricultural productivity and real prices of crops play in mediating the impacts of floods on agricultural wages in the more flood-prone districts. Equation (6) presents the new model:

$$w_{d,t} = \alpha + \sum_{k=1}^4 \beta_k w_{d,t-k} + \sum_{k=0}^4 \gamma_k RICE_{d,t-k} + \sum_{k=0}^4 \delta_k JUTE_{d,t-k} + \sum_{k=0}^4 \rho_k PRICE^{RICE}_{d,t-k} + \sum_{k=0}^4 \pi_k PRICE^{JUTE}_{d,t-k} + \psi D_d + \xi_1 FLOOD_t + \xi_2 INUNDATED_{d,t} + \xi_3 MORE_d + \xi_4 (INUNDATED_{d,t} * MORE_d) + u_{d,t} \quad (6)$$

All the symbols in equation (6) have their earlier interpretations. The results of estimation of model (6) are reported in column 7 of table 6 in the appendix.

Finally I estimate the impact of extreme flood on the agricultural wages in a more flooded district that is inundated. The new model is given by equation (7):

$$\begin{aligned}
w_{d,t} = & \alpha + \sum_{k=1}^4 \beta_k w_{d,t-k} + \sum_{k=0}^4 \gamma_k RICE_{d,t-k} + \sum_{k=0}^4 \delta_k JUTE_{d,t-k} + \sum_{k=0}^4 \rho_k PRICE^{RICE}_{d,t-k} \\
& + \sum_{k=0}^4 \pi_k PRICE^{JUTE}_{d,t-k} + \psi D_d + \zeta E_t + \xi_2 INUNDATED_{d,t} + \xi_3 MORE_d \quad (7) \\
& + \xi_4 (E_t * MORE_{d,t}) + \xi_5 (INUNDATED_{d,t} * MORE_{d,t}) \\
& + \xi_6 (E_t * INUNDATED_{d,t}) + \xi_7 (E_t * INUNDATED_{d,t} * MORE_d) + u_{d,t}
\end{aligned}$$

In equation (7)  $E_t$  is the flood severity dummy that takes the value one to indicate extreme flood situation in Bangladesh in month  $t$ , and is zero otherwise. Given the present data set,  $E_t$  takes the value one only for the monsoon months in years 1987, 1988 and 1989. The coefficient of the interaction dummy ( $E_t * INUNDATED_{d,t}$ ) captures the effect of extreme floods on agricultural wages in all the districts that are inundated in period  $t$ . The coefficient of the meta-variable ( $E_t * INUNDATED_{d,t} * MORE_{d,t}$ ) captures the effect of extreme floods on agricultural wages in a more flood prone district  $d$  that is inundated in period  $t$ . All the other symbols in equation (7) have their earlier interpretations. The results of estimation of model (7) are reported in column 8 of table 6 in the appendix.

## 5. Main results

### 5.1 Trend and seasonality in agricultural wages in Bangladesh

Table 5 in the appendix reports the estimates of trend and seasonality in agricultural wage data. The table shows that that agricultural wage in Bangladesh has a significant negative linear trend and a significant positive quadratic trend. The results also show that wages in the winter are significantly higher compared to that in the monsoon. Wages decline in the summer months but are not significantly different from their levels observed in the monsoon.

### 5.2 Effects of floods on agricultural wages in Bangladesh

Table 6 presents the estimation results of the models (2) to (7). All regressions control for district effects. The results indicate that the effects of flood on agricultural wages in Bangladesh can be studied from three perspectives: (I) the impacts realized all over Bangladesh in the flood months, (II) the impacts realized only in the inundated districts in the flood months, and (III) responses in agricultural wages in the inundated districts to the flood shocks. The response over the long run is indicated by the difference-in-difference estimate of the interaction effect of

inundation in more flood-prone districts. The short term responses in the flood month is indicated by the difference-in-difference estimate of the interaction effect of inundation in more flood-prone districts in the times of extreme flood.

I start by examining fluctuations in agricultural wage rates in Bangladesh in flood months. Column 3 in the table presents the estimates of the main variables of model (2) and shows that estimated coefficient of the flood dummy ( $FLOOD_t$ ) is positive. This implies that agricultural wages increases in the flood months in Bangladesh. This result can be explained in terms of the positive association between flooding, irrigation and increased demand for labor. ‘Although normal floods may cause some damage to crops and properties, they are widely considered a blessing for agriculture because floodwaters provide soil moisture and plant nutrients from both nitrogen fixing blue-green algae and decomposing plant remains’ (Paul and Rasid 1993: 150. See also Brammer 1990b: 164). Boyce (1987) found that moderate floods had a significant positive effect on agricultural performance. Hossain (1990) writes floods early in the season or during the midseason of agricultural production increase the harvest of crops in fertile lands. Bountiful irrigation often encourages multiple cropping and mixed cropping in these fertile lands. Moderate floods also assure the success of crops in the infertile land that are otherwise threatened by erratic precipitation. In addition, the arid tracts of land that are left fallow in the normal flood-free years are cultivated as floods and the accompanying rainfall irrigate the tracts (Asiatic Society of Bangladesh 2003). All these factors cause an overall increase in the seasonal demand for agricultural workers in Bangladesh in the flood months. As a result, agricultural wages in general increase in these months in Bangladesh.

Do the effects of flood on agricultural wages differ across the districts that are inundated and the districts that remain unaffected in the flood months? Column 4 in appendix table 6 shows that the estimated coefficient on the district flooded dummy ( $INUNDATED_{d,t}$ ) is negative. This implies that wages decline by a significant extent in the flood months in the districts that are inundated. This result provides empirical support to the hypothesis presented as proposition 1 in section 3 of this paper. Therefore, even though floods as a phenomenon have positive implications for agricultural wages in Bangladesh, in the districts that are flooded the demand for agricultural labor decline as the agricultural fields get submerged and crops are destroyed (Hossain 1988). As a result agricultural wages fall in the affected district.

Does the magnitude of impact of flood on agricultural wages depend on how frequently a district is flooded? In other words, how do agricultural wages adjust over the long run in a district

that is repeatedly and extensively flooded? To answer these questions, we examine the case of geomorphologically more flood-prone districts. Column 6 in appendix table 6 shows that the estimated value of the coefficient on relative flood proneness dummy ( $MORE_d$ ) is positive, but insignificant. This implies that agricultural wages in the more frequently flooded districts tend to be higher than the less flooded districts, though marginally. A plausible explanation for this result can be in terms of the positive and strong correlation between floods, fertility and agricultural productivity in districts (Boyce 1987). Brammer (1988) emphasized the short term and the long term fertility benefits of flooding. The short term benefits accrue due to nitrogen fixation of the floodwater-bred blue-green algae, the decomposition of the submerged weeds and rice leaves, and the alternating oxygen-reducing and oxidizing conditions of intermittently flooded soils. The long term benefits of flooding accrue due to the weathering of minerals in river alluvium brought on the land that is repeatedly inundated. The short and the long term fertility benefits of repeated flooding would have positive impact on the agricultural productivity and therefore on real wage rates in the more flooded districts.<sup>8</sup> Boyce (1987) found that the districts with higher share of acreage subject to light or moderate flooding experience higher agricultural productivity. As a result, higher rate of agricultural wages evolve over the long run in the more flooded districts.

Column 6 of table 6 in appendix also shows that the estimated value of the coefficient on the interaction dummy ( $INUNDATED_{d,t} * MORE_d$ ) is negative but insignificant, suggesting agricultural wages fall in a more flooded district when the districts are inundated. Also, as we compare the estimated coefficient on the district flooded dummy ( $INUNDATED_{d,t}$ ), we find that the value has decreased in model (4) (column 6) as compared to model (3) (column 5). This result gives credence to the second hypothesis in this paper, presented as proposition 2, that though agricultural wages fall in all those districts that are inundated, this decline is less in a more frequently flooded district. It indicates that wages become more resilient to flood shocks in the frequently flooded districts.

How do agricultural wages respond to the shocks of extreme flooding in the flood months? Does the magnitude of impact of extreme flood on agricultural wages depend on whether or not the district concerned is more frequently flooded? Column 8 in table 6 in appendix presents the estimates of the main explanatory variables in model (7). It shows that the estimated values of the

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<sup>8</sup> In addition, we can also speculate that in a more frequently flooded district, the peasants and the agricultural workers explicitly consider the prospect of floods when entering into wage contracts. However, substantiation of this claim is beyond the scope of this paper. A future paper that studies the impact of floods in Bengal delta from a historical perspective will address this issue.

coefficient on the flood severity dummy ( $E$ ) is positive. However, the estimated coefficients on the district flooded dummy ( $INUNDATED_{d,t}$ ) and that on the interaction term  $E_t * INUNDATED_{d,t}$  are negative. This implies, as we have observed in the case of normal floods, extreme floods also have a general positive effect in agricultural wages in the districts that are not submerged, but a significantly negative effect on wages in the districts that are.

To examine whether or not the effects of extreme floods on wages in the more-flooded districts are any different from the districts that less-flooded, we examine the estimates of the coefficients on the interaction terms  $E * MORE_d$ ,  $INUNDATED_{d,t} * MORE_d$  and  $E_t * INUNDATED_{d,t} * MORE_d$  also presented in Column 8. The estimated coefficient on  $E * MORE_d$  is positive, but those on  $INUNDATED_{d,t} * MORE_d$  and  $E_t * INUNDATED_{d,t} * MORE_d$  are negative. The results indicate that even in the more frequently flooded districts, extreme floods cause an increase in wages in the months when the districts are flood-free, but they cause a decline in wages in the months when the districts are flooded.

Boyce (1990) points out that, in the past two decades, the years of abnormally high floods have produced normal or above-normal harvest. In these years, the above-average rainfalls benefited agricultural production in nonflooded areas. The arid lands that would have otherwise been left fallow are sown, while the fertile lands are more intensively cultivated with mixed cropping and intercropping practices (Md. Abdul Quasem 1992, MJ Islam et al 2004, Akhtar C Ahmed et al 1992, Hossain 1990). These activities increase the demand for agricultural workers in the region. The increased residual moisture and soil fertility conditions benefit the post-flood dry winter crops as well. The bumper harvest in these periods compensate for flood losses. In the aftermath of extreme floods of 1988 and 1998, the winter crops recorded bumper harvest (Boyce 1990, Ahmad et al 2001). Following the line of argument in this paper, the positive impacts of extreme flood on agricultural productivity of a district will also be relayed to the agricultural wage rates in that region. World Bank (1989a:15) reports that the high production of rice crop in 1988, together with large-scale government imports of food grains in response to floods, caused a 25 percent fall in market price below procurement price. In these situations, the real agricultural wages will rise further in the short run. However, as the World Bank further reports, in 1988 the food grain glut and the falling market prices adversely affected the incentives to the farmers. This may cause a post-flood decline in demand for agricultural workers and a reduction in post flood nominal wage income at least in the short run.

We now examine how do wages in agriculture in more flooded districts respond to flood shocks in the times of extreme flood. We examine whether or not the magnitude of fluctuations in wages in extreme flood months differ between the more-flooded districts and the districts that are less so. case of those districts that are submerged in the times of extreme floods. As we compare the estimated value of the coefficient on the interaction dummies  $INUNDATED_{d,t} * MORE_d$  and  $E_t * INUNDATED_{d,t} * MORE_d$ , we find that the former is lesser in value and in significance than the latter. This result lends support to our hypothesis in proposition 3 that though agricultural wages decline in more flooded districts in normal flood years, this decline is more dramatic in the years of extreme floods. However, a comparison of the estimated value of the coefficient on the interaction dummies  $E_t * INUNDATED_{d,t}$  and  $E_t * INUNDATED_{d,t} * MORE_d$  reveals that the former is larger in value. We also find that the former variable is a significant determinant of real agricultural wages in the periods of extreme floods, while the latter is not. This result indicates that though extreme floods in a more flooded district cause a decline in agricultural wages in the district, this decline is less dramatic compared to less flooded districts. This can be accounted for in the following manner: in a more flooded district, proportionately greater area is exposed to flooding, and therefore potentially greater amount of crops are vulnerable to floods. At the same time, as the more flooded districts are regularly and periodically inundated, the floods do not come as unexpected shocks to the peasants. While the first feature of the district would plausibly lead to a greater decline in labor demand in the flood periods, the latter feature would imply that the land owners and the agricultural workers anticipate this decline. However, extreme floods are unpredictable phenomena and come as non-systemic shocks even to the more flooded districts. In this extreme situation agricultural wages fluctuate significantly away from their normal pattern in the more flooded districts. As Paul and Rasid (1993 p.150) pointed out, '[A]lthough people in Bangladesh have evolved numerous adaptive strategies to benefit from normal flooding, an abnormal one surpasses their ability to adjust'. However, the peasants and the agricultural workers in a more frequently flooded district would have comparatively greater ability to adjust in an extreme flood situation than their counterparts in the less frequently flooded districts.

## **6. Related results:**

### **6.1 Role of past history in formation of agricultural wages**

Column 3 in appendix table 6 shows that real agricultural wages are positively and significantly affected by their past values. A high real wage in the past will lead to higher current

real wages. This result indicates the downward rigidity of agricultural wages in Bangladesh even in the presence of widespread involuntary unemployment (Horowitz 1974, Rogers 1975, Ahmed 1981, Osmani 1989, Hossain 1990). Bardhan (1984) explained that the employers place high premium on quick and ready availability of labor during peak seasonal agricultural operations. The employers' need for ensuring timely and reliable supply of labor in the peak season generates labor-tying arrangements whereby workers are paid high wages. Osmani (1989) on the other hand explains that implicit cooperation among workers ensures that wages do not decline over time.

## 6.2 Role of favorable demand conditions in mitigating flood impacts on wages

What role do agricultural productivity and real price of crops play in explaining fluctuations in agricultural wages in a district in the times of floods in Bangladesh? Column 5 in appendix table 6 presents the estimates of the main explanatory variables of model (4) in this paper. The column shows that when we include productivity of rice and jute and the prices of these two crops as explanatory variables to explain wage formation, the coefficient estimate on flood period dummy ( $FLOOD_t$ ) increases in value and becomes more significant as a determining variable. On the other hand, the district flooded dummy ( $INUNDATED_{d,t}$ ) reduces in value, and becomes less significant as a determining variable for agricultural wage formation. These results show that in presence of favorable demand conditions in the agricultural labor market (like improved productivity and/or terms of trade conditions in agriculture), the negative impact of flood are reduced while the positive impacts of floods are magnified.

Column 5 in appendix table 6 also shows that the estimated coefficients of current productivity of rice ( $RICE_{d,t}$ ) and jute ( $JUTE_{d,t}$ ) are positive and significant. The coefficient estimates of past productivity of rice ( $RICE_{d,t-k}$ ) and past productivity of jute ( $JUTE_{d,t-k}$ ) are also positive. The estimated impact of agricultural productivity on real wages is consistent with that obtained by Khan (1984): a rise in productivity will increase real wages by stimulating demand. We also find that the estimated coefficient of current real price of rice ( $PRICE^{RICE}_{d,t}$ ) is negative and significant. This result suggests that the cost of living effect of rice prices outweigh the terms of trade effect at least in the short run. This result is similar to that obtained by Boyce and Ravallion (1991). The authors explained that as the price of the staple food grain (relative to other goods) rise, the rice purchasing power of agricultural wages will fall, and therefore the real agricultural wages will also fall. The increase in rice price may impose high burden on the rural poor at least in the short run. However, the present model estimates that the coefficients of past

prices of rice ( $PRICE^{RICE}_{d,t-k}$ ) are all positive, suggesting real agricultural wages in the current period will increase to adjust itself to any past increases in real rice price. The estimated coefficient of current real price of jute ( $PRICE^{JUTE}_{d,t}$ ) is positive though not significant. Evidently, an increase in the price of jute will encourage greater production of jute. As a result demand for labor is expected to increase and so do agricultural wages. The model performed well in terms of stationarity test for residuals and other diagnostics.<sup>9</sup>

The estimation results of model (3) that we discussed above are important as they indicate that the factors that might increase demand for agricultural labor in the non-flood period are instrumental in determining the severity of disaster impact on wages in the flood months. In the regions where there were already a high demand for labor in the flood season, the fall in wage rates will be relatively low and vice versa.

Next, we examine what role do agricultural productivity and real prices of crops play in mediating the impacts of floods on agricultural wages in the more flood prone districts. The estimates of the main determining variables in model (6) are presented in column 7 of appendix table 6. A comparison of columns 5 and 6 in the table shows that on inclusion of agricultural productivity and real prices of crops as determinants of agricultural wages, the negative impact of floods in the inundated more-flooded district (given by the coefficient of the interaction dummy  $INUNDATED_{d,t} * MORE_d$ ) is moderated as we include productivity and real prices of crops as determinants of agricultural wages. Column 6 in appendix table 6 also shows that the estimated value of the district flood proneness dummy ( $MORE_d$ ) has reduced in value and in significance. This result suggests that over the long run, the positive impacts of frequent flooding on monthly agricultural wages are realized via the positive impacts of floods on agricultural productivity and, therefore, on the demand for agricultural workers.

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<sup>9</sup> I have also modeled (log) real agricultural wages *in absence of flood* as a dynamic process in terms of past wages, current and past (log) productivity of rice and jute, current and past (log) real prices of rice and jute, linear trend and quadratic trend. I found that the estimates of past wages, current and past productivity and crop prices retain their signs as in model (3) when we do not include flood as an explanatory variable in explaining agricultural wage formation in Bangladesh. I also found that including productivity and real prices as determinants of agricultural wages in absence of floods, the linear time trend is estimated to be positive and significant, while the quadratic trend is insignificant. It seems that output growth and improved terms of trade for agriculture has been able to overcome the trend factors that depress the real agricultural wages (as was seen in model (1)).

## 7. Conclusions

This paper sought to examine the effects of floods on the agricultural wages across time and over districts in Bangladesh.<sup>10</sup> I have argued that the impacts of floods on real agricultural wages are realized through the effects of floods on the demand and supply conditions in the agricultural labor market. Delving into the antecedents in the literature, I have found that agricultural productivity and price of crops are important determinants of agricultural wages. By analyzing the data on real wages, I have found that past wages and past values of agricultural productivity and crop prices are also important determinants of agricultural wages. I have therefore modeled agricultural wages in Bangladesh as a dynamic process and analyzed the impacts of flood on the series.<sup>11</sup> I examined the cases when the districts are inundated in the flood months and the cases when they are not. While the former indicates the direct effects of flood on real agricultural wages, the latter examines the spillover effects of floods on the neighboring districts. I have also examined whether or not the relative flood proneness of a district plays any significant role in explaining agricultural wage formation. In addition, I asked whether or not the relative severity of flood situation can explain wage fluctuations across the districts. Finally, I analyzed how agricultural productivity and real price of crops mediate the impacts of flood on agricultural wages across regions in Bangladesh.

The results obtained in this paper can be summarized as follow: agricultural wages generally increase in flood months in Bangladesh but decline in the flood affected districts in these months. These patterns in fluctuations of wages are also observed in the times of extreme floods. Wages in agriculture, in general, tend to be higher in more flooded districts than less flooded districts. In extreme flood months, wages are found to decline by a lesser extent when the former group of districts are inundated, compared to the case when the less-frequently districts are inundated. The results in this paper also indicate that factors that might increase demand for labor (including agricultural productivity and real prices) in absence of floods are instrumental in mitigating the negative impacts and exacerbating the positive impacts of floods on real agricultural wages. Increased agricultural productivity will cause an increase in real wages of agricultural workers, and though an increase in the real price of rice will cause a decline in the

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<sup>10</sup> The present paper does not examine the dynamic adjustment process of real agricultural wages in response to flood shocks. A future paper will address that issue.

<sup>11</sup> I have not examined the significance of urban wages as a determinant of rural agricultural wages for two reasons: First, monthly data on urban wages of unskilled workers are not available. Second, as Osmani (1991) pointed out that outside option and migration for casual agricultural laborers are limited.

real wages in the current period, over time the terms of trade for agriculture will dominate and real wages will increase.

The decline in wages in the inundated districts has severe negative implications for the well-being of the poor agricultural workers in the district. The decline in wage income leads to consumption decline and incidence of illness increases in the times of floods (del Ninno and Dorosh 2003). The wages in agricultural can continue to remain low in the post-flood months in the aftermath of extreme disasters (del Ninno and Roy 2001). In these situations, the negative effects of floods on welfare of workers can continue through increase in household debt and lingering nutritional consequences (del Ninno et al 2001). However, the effects of floods are not bad in an unmitigated sense as wages increase in flood months in the unaffected districts. This result seems counterintuitive. Why are the employers willing to pay higher wages to workers in a labor surplus economy, especially in the times of disaster when they can hire the unemployed workers from the neighboring flood affected districts? Osmani (1991) explains that the rural market for casual (or daily) agricultural workers is closed and highly segregated. ‘The workers of a certain village (or in some cases a cluster of tiny villages) do not normally seek daily farm-employment outside their village (or cluster). Such traditional boundaries are often transcended in the case of non-farm employment as well as long-term regular jobs on the farms; but ‘casual’ wage employment in agriculture, which is the market we are studying here, does seem to respect fairly narrow geographical boundaries’ (Osmani 1991:7). The author also explains that in this close market for agricultural workers, the process of wage formation takes the form of implicit cooperation among workers. Even threatened with the prospect of imminent unemployment, the workers do not offer to work for lower wages as they fear ‘undercutting even by one person will bring the whole market down in future so that everybody will suffer in the end’ (ibid. 20). The repeated nature of the casual labor market and the so called ‘trigger strategy’ adopted by the workers ensure that this cooperation is self-enforced.<sup>12</sup>

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<sup>12</sup> Bardhan (1984) presented an alternative explanation to account for the downward rigidity in agricultural wages even in the face of unemployment in context of the agricultural labor supply behavior in West Bengal (India), the region that share a common cultural and physical sub-system with Bangladesh. He found that the employers place high premium on quick and ready availability for labor during peak operations. ‘The employer clearly puts a high value on his expected recruitment cost, even though the prevailing unemployment of workers should have made recruitments easier than otherwise’ (Bardhan 1984: 61). He further found that there are serious incentives in rural South Asia working towards territorial affinities. Labour markets oftentimes do not extend beyond the confines of the villages (ibid p. 71). These factors indicate that increase in demand for labor will lead to increase in wages even for the labor-surplus economies of South Asia.

The significance of rice productivity as a determinant of wages also imply that negative impacts of the disasters can be mitigated through increased production of rice. In this context, Rasid and Paul (1987) had argued the importance of dry season cultivation on one hand and the cultivation of flood-resistant variety of rice in monsoon season on the other. del Ninno et al (2003) had emphasized that disaster effects can be reduced through long-term agricultural and investment policies of the Bangladesh government towards expansion of post-flood winter crops rather than flood-susceptible monsoon crops. However, the positive benefits of increased productivity can be translated to increased welfare of agricultural workers on in presence of adequate ‘social transfer mechanism to compensate the losers’ (Montgomery 1985). Agricultural wage rates in Bangladesh are as much dependent on agricultural productivity as they are on land distribution among households. In presence of such structural and institutional constraints of wage determinants, the issues of disaster responses cannot be separated from the processes of development and they have to be embedded in the long-term, ongoing process of poverty reduction and income generation.

## 7. Appendix

### 7.1 Agricultural wage formation in Bangladesh- A brief review of literature

There are conflicting claims regarding how agricultural wage rates in Bangladesh have responded to variations in rice price and agricultural productivity over the time. Khan (1984) presented a static model of wage determination and used the annual data for the period 1949-1982 for Bangladesh to conclude that in the long run, real agricultural wages are positively associated with improved terms of trade for agriculture and higher agricultural productivity, but negatively associated with the trend factors that capture such time-dependent variables as population growth and slower growth of output and employment due to institutional and technological constraint. He further pointed out that improved terms of trade and higher productivity conditions were 'able to overcome the effects of these trend factors for short period' (p. 195). He however noted that 'such a combination of favorable factors have been rare and not observed since the mid-1960s'. Boyce and Ravallion (1991) challenged some of these conclusions. They offered a dynamic model of wage determination using annual data for the period 1949/50-1980/81. They concluded that (a) the agricultural productivity measured in terms of average value of agricultural output per unit of cropped area has no significant effect on long-run real wage rates. Also, (b) though the changes in the price of rice relative to other goods (the terms of trade in agriculture in Khan's model) have significant and negative impacts on real wages in the short run, they have negligible effects on the long-run real wage. However, they concurred with Khan that the implicit long run real wage rate showed an alarming downward trend from mid 1960s up to the early 1980s. The significance of the trend factors in determining wage rates in agriculture was questioned by Palmer-Jones (1993), but Ravallion (1994) rebutted it. Rashid (2002) carried out an alternative empirical analysis based on cointegration technique. He used the annual data for Bangladesh for the period 1976/77-1998/99. He found that (a) rice price is not a significant determinant of agricultural wage rates in Bangladesh. On the other hand, (b) the urban wage rates of unskilled workers in major cities are the single most important variable to explain the long run dynamics of agricultural wage rates. He also concluded that (c) a positive long run relationship between agricultural productivity (indexed by per acre production) and nominal wages is very unlikely. Bardhan (1979 and 1984) and Mukherjee and Ray (1992) had found similar downward rigidity in agricultural wages in for agricultural workers in India.

Variations in agricultural wages have also been explained in terms of the nature of contractual agreements that determine the incentive payments and terms of employment of labor

(Bardhan 1979 and 1984, Datta 1998). Osmani (1991) found that the relative bargaining power of labor is determined by the nature of their implicit cooperation. Ahmed (1981) explained that the bargaining power of the workers will be less in the regions with higher concentration of landless households. Datta (1998) points out that inter-village variation in wages are also greatly influenced by the nature of wage payments. The cost of hiring labor is lowest in the districts where only cash payments are made to the hired workers. They are relatively more when payments are made partly in cash and partly in kind, or entirely in kinds. The exact nature of wage payment depends on traditions and conventions of the region, as well as the relatively bargaining power of labor. Datta further explained that the variations among the villages can also be explained in terms of the social and political relationships between employee and employer and variations in religious composition of their population. Other factors that explain agricultural wage formation in Bangladesh include level of childhood education of the workers (Skoufias 1993), availability of alternative means of livelihood (Hossain 1988 and Rashid 2002)

## **7.2 Description of data**

The series of real agricultural wage rate is put together in the following manner: average daily nominal wage data for male agricultural labor (without food) are obtained for each month for the years 1979 to 2000 for different districts in Bangladesh. The nominal wage rates are deflated by rural consumer price indices to generate real wage series. Rural consumer price index gives the cost of living index for the average rural family, not for the income group that represents a typical agricultural wage laborer. The former is therefore used as a proxy for the latter, as data on cost of living index for agricultural workers are not available. The consumer price indices are given for the rural population for the four Administrative Divisions: Dhaka, Chittagong, Khulna and Rajshahi. The series on rural consumer price indices is available from July 1978, and has missing data for the period December 1988 to October 1989 across all the Divisions. (Source: Monthly Statistical Bulletin, Bangladesh, various years).

The series on rice productivity is generated in the following manner: the data on per acre yield rate of different types of rice (*aus*, *aman*, and *boro*) are obtained for different months for the years 1979 to 2000 for different districts in Bangladesh. This data is then used to generate the series on rice productivity per district by taking a weighted average of the yield rate of these different types of rice for each month for each district. The relevant weights are assigned in terms of the crop calendar of the country. For example, March is the harvest month for the winter *boro*

rice and sowing period of the summer *aus* rice. According to the crop calendar of Bangladesh (Source: Yearbook of Agricultural Statistics), *boro* rice (HYV Transplant) production activities are carried out for approximately  $\frac{3}{4}$  of the month (three weeks) while *aus* rice production activities are carried out for approximately  $\frac{1}{4}$  of the month. Accordingly, rice productivity for March is obtained by the following equation:  $Q^R_{d,MARCH} = 0.75 * Q^{BORO}_{d,MARCH} + 0.25 * Q^{AUS}_{d,MARCH}$ , where  $Q^R_{d,MARCH}$  is the rice productivity in district  $d$  in March,  $Q^{BORO}_{d,MARCH}$  is the per acre yield of *boro* rice in district  $d$  in March,  $Q^{AUS}_{d,MARCH}$  is the per acre yield of *Aus* rice in district  $d$  in March. The series on jute productivity is in terms of per acre yield of jute for different months for different districts in Bangladesh. Table 1 describes how the series on rice and jute productivity are generated. Table 2 presents the crop calendar of Bangladesh in terms of rice and jute and relative flood tolerance of the two crops.

**Table 1**  
**Series on rice and jute productivity in Bangladesh by month**

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

**Table 2**  
**Crop calendar (rice and jute) of Bangladesh and relative flood tolerance of the crops**

Crop and its Growing Season		Sowing/Transplant Months	Harvest Months	Relationship with flood
<i>Aus</i> (Pre-monsoon or Summer Paddy)	Local Broadcast	Mid March to mid April	Mid July to early August	Can tolerate only shallow <sup>(1)</sup> flooding. Harvested prior to monsoon peak flood
	HYV Transplant	Mid March to mid April	July to August	
	HYV Broadcast	Mid March to mid April	Late July to August	
<i>Aman</i> (Monsoon)	Local Transplant	End June to early September		Can tolerate moderate <sup>(1)</sup> flooding. Vulnerable to

Paddy)	HYV Transplant	Late June to mid August		flood during the sowing season, all along the growing period, as well at the time of harvest.
	Broadcast <i>Aman</i>	March to April	Late October to November	Resistant to flood, floating variety. Vulnerable to flood all along the growing period.
<i>Boro</i> (Winter Paddy)	Local	Mid November to Mid January	April to May	Dry season crop that is cultivated in low lands with some standing water: Harvested prior to peak flood seasons. Require irrigation
	HYV	December to mid February	Mid April to June	
<i>Jute</i>	White ( <i>Capsularis</i> )	Early March to mid April	July to August	Can tolerate only shallow <sup>(2)</sup> flooding. Harvested during peak monsoon floods
	Tossa ( <i>Olotorius</i> )	Mid April to early May	August to September	

Note: (1) Moderate flooding refers to the level of inundation where the depth of standing water in the fields is 1m – 2m (2) Shallow flooding refers to the level of inundation where the depth of standing water in the fields is less than 1m.

Source: Crop Calendar: Yearbook of Agricultural Statistics of Bangladesh, various years. Flood resistance of crops: Rashid and Paul, 1987

The series on nominal price of rice is obtained from the Monthly Statistical Bulletin of Bangladesh, various years. The series on nominal prices of jute is obtained from Yearbook of Agricultural Statistics (BBS various years). The nominal rice price series is generated as a simple average of monthly nominal prices of coarse quality and medium quality rice. The series is generated for different months for different districts. The series on average rice price is then deflated by the relevant rural CPI to generate the real price of rice. The nominal jute price series is generated as a simple average of *white* type and *tossa* type of jute. Once again, the series on average jute price is then deflated by the relevant rural CPI to generate the real price of jute.

The data on relative flood proneness of the districts in Bangladesh is obtained from Rogers et al (1989) and BBS (2001). Rogers et al (1989) had classified the districts in Bangladesh as ‘more flooded’ and ‘less flooded’ on the basis of the percentage area of a district vulnerable to inundation in a normal year. In exceptionally severe flood years, these percentages increase roughly in proportion. A more flooded district experiences more frequent flooding and at the same time, relatively more area of the district is submerged. This classification is based on the information provided by the Bangladesh National Water Plan (1986:II:10, 61-62). The Plan has classified different regions in Bangladesh in terms of exposure to different types of flood in a normal year. The different types of floods in the country as follows: (1) ‘shallow flood’ as flood

of depth 30-90 cm, (2) 'moderate flood' as flood of depth greater than 90 cm-180 cm and (3) 'deep flood' as flood depth over 180 cm. The Plan estimates that in a normal year 35% of the net cultivated area of the country is shallowly flooded, 16% is moderately flooded and 12% is deeply flooded. The remaining 37% is not flooded. Rogers et al (1989) had used this data to generate a map that shows the areas in Bangladesh that are subject to flooding to depths less than and greater than 90cm in a normal year, in relation to the major rivers. Table 3 presents the classification:

**Table 3**  
**Description of the sample districts in terms of relative flood proneness**

Relative Flood Proneness	Districts	Percent Area Flooded	
		0 to 90 cm	> 90 cm
More flooded districts (MF)	Bogra	22	78
	Pabna	25	75
	Comilla	32	68
	Faridpur	32	68
	Tangail	38	62
	Sylhet	42	58
	Dhaka	43	57
	Mymensingh	45	55
	Jessore	46	54
Less flooded districts (LF)	Rajshahi	60	40
	Noakhali	78	22
	Barisal	84	16
	Kushtia	87	13
	Khulna	91	9
	Rangpur	94	6
	Chittagong	97	3
	Patuakhali	98	2
	Rangamati	100	0
	Bandarban	100	0
	Dinajpur	100	0

Source: Rogers et al (1989) - Computer Assisted Development Inc

The data on flood years, flood months, district affected and relative severity of flood are obtained various sources including United Nations Department of Humanitarian Affairs (DHA) (various years), Asiatic Society of Bangladesh (various years), Hossain et al (1988), del Ninno et al (1999 a,b), Ahmed et al (2001), BUP (1999) and Hossain (2000). Table 4 presents a chronology of flood occurrence in Bangladesh in the period 1979-2000.

**Table 4**  
**Chronology of flood occurrence area affected, nature and causes of flooding and estimates of flood loss in Bangladesh in the period 1979-2000**

Flood year	Flood months	Region affected	Nature and cause of flooding and estimated flood losses
1984	May-June(1)	Habiganj, Maulavi Bazaar, Sunamganj and Sylhet	Damage to crops estimated at 175,000 tons of rice and 80,000 tons of jute. 2 million people affected, of whom 100,000 are rendered homeless (Total population in Bangladesh as in 1981 census: 87,118,000).
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	An estimated 1.3 million acres of crops damaged. Approximately 3.4 million people were affected (Total population in Bangladesh as in 1981 census: 87,118,000.) 200,000 people rendered homeless.
1987*	July-August(2)	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.	The flood is estimated to be a once in 30-70 year event. Excessive rainfall both inside and outside of the country was the main cause flooding. The floods continued for 63 days
1988*	July(1) August-early September (3) Late September -early October (1)	About 82,000 sq km (about 60% of the area, total area of Bangladesh being 100,250 sq. km.) was inundated. <u>Districts affected in July:</u> Bogra, Habiganj, Netrokona, Maulavi Bazaar, Rangpur, Satkhira and Sunamganj. <u>Districts affected in August-September:</u> Bogra, Chandpur, Comilla, Dhaka, Faridpur, Gaibanda, Habiganj, Jamalpur, Manikganj, Munshiganj, Mymensingh, Pabna, parts of Narshingdi, Sirajganj, Sunamganj, Tangail and western part of Brahmanbaria. <u>Districts affected in October:</u> Barisal, Netrokona, Lakshmipur and Sirajganj.	The return period of this flood is estimated to be 50-100 years. Rainfall together with synchronization of very high flows of all the three major rivers of the country in only three days aggravated the flood. The flood lasted 15 to 20 days. Most serious flooding in the first 10-12 days in September It was estimated that cumulative loss of 1987 & 1988 floods worth US \$ 2 billion, reducing GDP about 4%. Most severely affected: Deep water broadcast <i>Aman</i> belt.
1989	Late July-early August (1) Late August(2)	Bandarban, Chittagong, Cox Bazaar and Sylhet Maulavi Bazaar, Sirajganj and Sylhet	200,000 people were affected. Seed beds and standing crops in over 9,000 ha were partially affected. 600,000 people were trapped by water.
1991	July-September (1)	Northwestern part of the country.	Excessive rainfall with onrush of upstream waters breached the embankments, causing floods. 1.5 million peoples were affected (Total population in Bangladesh as in 1991 census: 111,456,000. No significant loss of crops was reported.
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 (approx. 20% of the total population in affected districts) were affected. 958,766 acres of crops were damaged. 2,664 educational institutes were damaged.
1995	June-July(1)	Bogra, Gaibanda, Jamalpur, Kurigram, , Madaripur, Maulavi Bazaar, Netrokona, Pabna, Rangpur, Shariatpur Sirajganj, Sunamganj and Sylhet	Incessant rainfall and onrush of waters from the Indian upstream caused flooding. 463000 people in Sunamganj and 47000 people in Sylhet and Gaibanda were affected. 20% of the houses in the affected districts were destroyed.
1996	July(1)	Bogra, Dhaka, Faridpur, Gaibanda, Jamalpur, Kurigram, Lalmonirhat, Manikganj, Madaripur, Narayanganj, Rajbari, Shariatpur, Sherpur, Sirajganj, Tangail	Heavier than usual monsoon on the various small river basins caused floods. 2200357 people were affected. 8148 acres of crop was fully damaged. 158,0693 acres of crop were partially damaged. 49875 houses were fully damaged.
1997	July(1)	Bandarban, Barisal, Chittagong, Cox's Bazaar, Dhaka, Dinajpur, Gopalganj, Khagrachari, Munshiganj, Mymensingh, Netrokona, Rangamati and Thakurgaon	100,000 people lost their homes, and nearly 800,000 people were marooned in different parts of the country. At least 300,000 acres of crop had been inundated.

1998*	July – September (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 <i>Not Affected: Jessore, Bogra, Dinajpur</i>	100,250 sq. km, about 68% of the total area of the country <sup>(4)</sup> , was inundated. A combination of heavy rainfall within and outside the country, synchronization of peak flows of the major rivers and a very strong backwater effect coalesced into a mix that resulted in the worst flood in recorded history. The flood lasted for more than two months. 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	

Note: \*Years of extreme (or ‘major’ or abnormal floods), when 35 per cent or more of the total area of Bangladesh be inundated under a standing water of depth of 90 cm or more, for two months or more (Rogers et al, 1989; Zaman, 1993).

Sources:

- (1) United Nations Department off Humanitarian Affairs (DHA), <http://www.releifweb.int>
- (2) Sifatul Quader Chowdhury and Md Sazzad Hossain: Flood in Bangladesh  
Source: Banglapedia.com [http://search.com.bd/banglapedia/Content/HT/S\\_0564.HTM](http://search.com.bd/banglapedia/Content/HT/S_0564.HTM)
- (3) Hossain Mahabub, Rahman Atiur, and Hossain Zillur Rahman (December 1988): “Economic Impact of the 1988 floods Impression from Field Visits”, BIDS, Dhaka
- (4) del Ninno, Carlo, and Roy, Dilip. K. (October 1999): “The 1998 Flood and Household Food Security: Evidence From Rural Bangladesh”, FMRSP Working Paper No. 9, Food Management and Research Support Project (FMRSP), Ministry of Food, Government of the People’s Republic of Bangladesh and International Food Policy Research Institute (IFPRI)
- (5) Ahmad, Q.K, Chowdhury, AKA, Imam, S.H and Sarker, M (2001): Perspectives on Flood 1998, The University Press Limited, Dhaka
- (6) “The assessment of environmental impacts of flood 1998 on Dhaka city” (September 1999), Final Report, Economic Impact Study- Industry, trade, commerce and crops, Department of Environment, Prepared by Bangladesh Unnayan Parishad (BUP) for Ministry of Environment and Forest, Government of Bangladesh
- (7) Akhtar Hossain, ANH (November 2000): “Late Monsoon floods in the Southwest region of Bangladesh 2000” Prepared on the basis of joint study by Surface Water Modeling Centre (SWMC), Bangladesh Water Development Board, Ministry of Water Resources

### 7.3 Estimation results of the models: The main explanatory variables

**Table 5**  
Trend and seasonality in agricultural wages in Bangladesh:  
Estimates of main explanatory variables in model (1)

Explanatory Variables	Estimated value of coefficient ( <i>t</i> -statistic in the parenthesis)
Constant of regression	0.925347 (210.0984)
Linear trend (t)	-8.12E-05 (-16.21558)
Quadratic trend (t <sup>2</sup> )	1.01E-08 (7.626690)
Seasonal dummy indicating Summer (SUMMER)	-0.004715 (-1.753514)
Seasonal dummy indicating Winter (WINTER)	0.006754 (2.513796)
<b>R-squared</b>	0.263982
<b>Adjusted R-squared</b>	0.263180

**Table 6**  
Significance of past wages, past and current agricultural productivity, past and current real prices of crops, and floods in determining agricultural wages in Bangladesh:  
Estimates of main explanatory variables in models (2) to (6) \*

Explanatory Variable	Symbol	Estimated value of coefficient in model (2) ( <i>t</i> -statistic in parenthesis)	Estimated value of coefficient in model (3) ( <i>t</i> -statistic in parenthesis)	Estimated value of coefficient in model (4) ( <i>t</i> -statistic in parenthesis)	Estimated value of coefficient in model (5) ( <i>t</i> -statistic in parenthesis)	Estimated value of coefficient in model (6) ( <i>t</i> -statistic in parenthesis)	Estimated value of coefficient in model (7) ( <i>t</i> -statistic in parenthesis)
Past values of log real wages	$w_{d,t-1}$	0.590845 (35.69871)	0.589502 (35.62812)	0.561301 (33.78659)	0.588988 (35.58867)	0.560884 (33.74927)	0.561715 (33.78968)
	$w_{d,t-2}$	0.086491 (4.506746)	0.093228 (4.817639)	0.091684 (4.785966)	0.094155 (4.863052)	0.092444 (4.822839)	0.091019 (4.749048)
	$w_{d,t-3}$	0.066274 (3.454580)	0.064894 (3.384013)	0.058982 (3.1043660)	0.065131 3.396037	0.059132 (3.111857)	0.058557 (3.078829)
	$w_{d,t-4}$	0.039119 (2.362565)	0.036697 (2.214491)	0.037730 (2.277863)	0.036380 2.194705	0.037412 (2.257849)	0.035888 (2.166880)
Rice productivity (in terms of log of yield per acre)	$RICE_{d,t}$	-	-	0.059136 (3.622840)	-	0.059365 (3.636187)	0.056970 (3.495525)
	$RICE_{d,t-1}$	-	-	0.008570 (0.355826)	-	0.009010 (0.374014)	0.008396 (0.348708)
	$RICE_{d,t-2}$	-	-	0.041950 (1.685349)	-	0.041860 (1.681481)	0.035334 (1.429395)
	$RICE_{d,t-3}$	-	-	0.072255 (2.998720)	-	0.072279 (2.999447)	0.072112 (2.990563)
	$RICE_{d,t-4}$	-	-	0.014028 (0.864000)	-	0.013646 (0.840261)	0.014063 (0.865196)

Jute productivity (in terms of log of yield per acre)	$JUTE_{d,t}$	-	-	0.102651 (4.081142)	-	0.102567 (4.077311)	0.1012419 (4.022439)
	$JUTE_{d,t-1}$	-	-	0.080420 (2.311767)	-	0.080447 (2.312406)	0.078900 (2.266740)
	$JUTE_{d,t-2}$	-	-	0.014945 (0.429754)	-	0.014781 (0.425011)	0.014907 (0.428372)
	$JUTE_{d,t-3}$	-	-	0.037265 (1.071499)	-	0.037262 (1.071351)	0.037035 (1.064091)
	$JUTE_{d,t-4}$	-	-	0.029533 (1.177917)	-	0.029418 (1.173258)	0.030065 (1.198326)
Log real price of rice ( in terms of rural CPI)	$PRICE^{RICE}_{d,t}$	-	-	-0.146534 (-4.522348)	-	-0.146671 (-4.524534)	-0.140157 (-4.335691)
	$PRICE^{RICE}_{d,t-1}$	-	-	0.057830 (1.371666)	-	0.057912 (1.373492)	0.057827 (1.370758)
	$PRICE^{RICE}_{d,t-2}$	-	-	0.062612 (1.482162)	-	0.063568 (1.502677)	0.065418 (1.546240)
	$PRICE^{RICE}_{d,t-3}$	-	-	0.084307 (2.009761)	-	0.084200 (2.006576)	0.084208 (2.005321)
	$PRICE^{RICE}_{d,t-4}$	-	-	0.096649 (3.005181)	-	0.096857 (3.011420)	0.096237 (2.989579)
Log real price of jute ( in terms of rural CPI)	$PRICE^{JUTE}_{d,t}$	-	-	0.004450 (0.233971)	-	0.006997 (0.359437)	0.006002 (0.308127)
	$PRICE^{JUTE}_{d,t-1}$	-	-	0.014725 (0.560210)	-	-0.014811 (-0.563438)	-0.011718 (-0.446633)
	$PRICE^{JUTE}_{d,t-2}$	-	-	0.004580 (0.173627)	-	-0.006885 (-0.257353)	-0.006836 (-0.255855)
	$PRICE^{JUTE}_{d,t-3}$	-	-	0.035250 (1.339175)	-	-0.035204 (-1.337261)	-0.035102 (-1.332457)
	$PRICE^{JUTE}_{d,t-4}$	-	-	0.033852 (1.818276)	-	0.033686 (1.808711)	0.033116 (1.776923)
Flood occurrence in month $t$	$FLOOD_t$	0.000554 (0.300281)	0.001324 (0.668708)	0.04555 (2.125582)	0.001384 (0.698807)	0.004588 (2.140501)	-
Flood inundation of district $d$ in flood month $t$	$INUNDATED_{d,t}$	-	-0.010389 (-2.594570)	-0.0011417 (-1.874572)	-0.004560 (-0.749847)	-0.006341 (-1.057382)	-0.003554 (-1.589810)
More flood prone district	$MORE_d$	-	-	-	0.008954 (0.703261)	0.007294 (0.545932)	0.006747 (0.504890)
Flood inundation of more flood prone district $d$ in flood month $t$	$INUNDATED_{d,t} * MORE_d$	-	-	-	-0.009635 (-1.274055)	-0.008410 (-1.129360)	-0.008917 (-1.172772)
Extreme flood occurrence in month $t$	$E_t$	-	-	-	-	-	0.000724 (0.044243)

Flood inundation of <u>any</u> district $d$ in extreme flood month $t$	$E_t^* INUNDATED_{d,t}$	-	-	-	-	-	-0.064 (-2.15661)
Interaction effect of extreme flood in the more flood prone districts that are not inundated	$E_t^* MORE_{dt}$	-	-	-	-	-	0.021301 (0.617243)
Interaction effect indicating inundation of <u>more</u> flood-prone district $d$ in extreme flood month $t$	$E_t^* INUNDATED_{d,t} * MORE_d$	-	-	-	-	-	-0.0724 (-1.668484)
<b>R-squared</b>		0.728768	0.729268	0.740207	0.729427	0.740321	0.740077
<b>Adjusted R-squared</b>		0.726981	0.727410	0.736975	0.727421	0.736946	0.736481

Note:\*The estimates of the coefficients of the district dummies are not reported here.

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