Of Floods and Agricultural Wage Rates in Bangladesh: Empirical evidences from the recent past

Abstract:

Bangladesh experiences recurrent riverine floods in the Monsoon season. This paper examines how the floods have affected the agricultural wage rates in the country in the recent past. The study, carried out in context of a set of representative districts, demonstrate that agricultural wages fall in real terms in all the affected regions in the flood months. However, this decline is significant for the districts that are less frequently flooded. In contrast, the districts that experience regular periodic inundations, floods do not cause wages to deviate from their 'normal' pattern in any notable manner. In this later group of districts floods do not come as random unexpected shocks but act as a significant determining variable for agricultural wage rate formation. For the affected districts, the timings of the flood surges played important roles in mediating the flood impacts. Wage rates declined and remained low for longer periods in the districts that experienced floods in the late Monsoon months rather than early Monsoon months. Empirical evidences presented in this paper suggest that '*minor*' or localized floods of relatively short duration may play a more significant role in forming agricultural wage rates than the relatively less frequent but catastrophic '*major*' floods. The study carried out in this paper also show that for the districts that were not affected by floods, agricultural wage rates actually increase above their average non-flood levels in the flood months. This result suggests that the impacts of floods may not be adverse in an unmitigated sense. In certain situations floods can release the irrigation-constraint to cultivation and increase agricultural production. In these situations agricultural wage rates actually increases.

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"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)

1. Introduction

This paper presents a narrative of the impacts of floods[1]on the agricultural wage rates in the different regions of Bangladesh since the late 1970s through 2000.

The geomorphologic and climatic condition of Bangladesh is such that the country experiences annual riverine floods during the Monsoons[2] When the floods assume disastrous proportion they disrupt normal agricultural activities and render agricultural workers jobless. It is intuitively obvious that in such periods there is a substantial loss of wage *income* for agricultural workers. What is however not so obvious is how wage *rates* of these workers are affected in these periods. The present paper takes up this issue and examines whether or not floods in Bangladesh cause any significant deviations in agricultural wage rates from their 'normal' average levels in the non-flood years. In particular, it traces how the flood impacts vary in accordance with the nature and severity of floods and across different regions. The study focus on a set of representative districts selected from different regions (Divisions) in Bangladesh and is carried out in the following three parts: The first part presents a series of graphs to describe how wages had fluctuated in the flood years of recent past. The second part aims to statistically estimate the significance of "flood occurrence" as an explanatory variable in explaining in these fluctuations. Finally, the third parts examines what role do floods play in explaining the long-term formation of agricultural wage rates in this frequently flooded country.

The results of these analyses can be summarized as follows: The graphs presented in this paper show that, first, agricultural wages fall in real terms in all the affected regions in the flood months. However, for some districts this fall was greater than others. This is because, even in the years of catastrophic floods, not all districts were similarly affected. In the districts that experienced a more severe flooding (in terms of (a) duration of the floods and (b) depth of the standing water), real agricultural wage rates dramatically declined below their normal, non-flood average levels in the flood months. Second, wage rates recovered quickly in the districts that experienced early Monsoon floods (in May and early June). In contrast, in the districts which were severely affected in height of the Monsoon season (in late July or August) wage rates remained low for rest of the season, even though they had been high in the pre-flood Monsoon months. Finally, real agricultural wage rates actually increased during the flood months in the districts that were not affected. Interestingly, the same district could experience alternate periods of decline and rise in agricultural wage rates. This happened when the districts were subjected to multiple surges of flood, interspersed with flood-free periods.

Statistical analysis of the results obtained from studying the graphs reveals: First, in only three of the ten sample districts studied in this paper, "flood occurrence" can significantly explain the fluctuations in wage rates in the flood months. Second, "flood non-occurrence" caused wage rates in six districts significantly to increase above their 'normal' flood-free average levels during the flood months. Further statistical estimations are carried out to examine the significance of "flood occurrence" as an explanatory variable in explaining the formation of agricultural wage rates in different districts of Bangladesh. The result showed that in five out of ten districts studied in this paper, floods play a significant role in determining the patterns of real agricultural wages rates over the last two decades. Interestingly, the districts in which floods play a significant role in determining the formation of wages rates, "flood occurrence" *do not* cause a significant deviation in wage rates from their 'normal' flood-free behavior. This result suggests that flood shocks have relatively lesser impacts in the districts which experience more frequent flooding.

The remaining parts of the paper are organized in the following manner. The next section, Section 2, presents the real wage data and explains how they are analyzed to assess the flood impacts. Sections 3 and 4 focus on wage fluctuations in flood months. Section 3 presents graphs to describe how wages have fluctuated in the different districts in the times of floods. Section 4 estimates the extent of these fluctuations. Section 5 studies the role of floods in forming wage rate patterns in districts in Bangladesh in the recent past (1978-2000). Finally, the concluding section, section 6, hypothesize the explanations of the results obtained through statistical analyses in the previous sections in terms impact of floods on crop production and therefore, the demand and supply of agricultural labor.

2. Data

For the present analysis, two representative (Greater) districts- the "most flood prone" and "least flood prone"- are chosen from different Divisions[3]in Bangladesh. In this regard, the present paper follows the categorization of the different districts according to their relative flood proneness presented by the Bangladesh National Water Plan (1986: II: 10) [4]. The sample group of districts analyzed in this paper includes- Barisal and Patuakhali from Barisal Division, Comilla and Rangamati from Chittagong Division, Faridpur and Mymensingh from Dhaka Division, Jessore and Khulna districts from Khulna Division and Bogra and Dinajpur districts from Rajshahi Division[5]. Barisal, Comilla, Faridpur, Jessore and Bogra are the 'most' flood prone districts (MF henceforth), while, Patuakhali, Rangamati, Mymensingh, Khulna and Dinajpur are the 'least' flood prone districts (LF henceforth) of the respective Divisions. Appendix 1 presents a brief description of these districts in terms of their relative flood proneness, agro-ecological zone and land-types (in terms of inundation)[6].

For the ten districts studied in this paper, average daily nominal wage data for male agricultural labor (without food) [7]are obtained for different months for the years 1972 to 2000. The series has two sets of missing data: from January 1990 to November 1990 and from January 1991 to June 1992. The nominal wage rates are deflated by rural consumer price indices for different regions[8]to generate real wage series that evaluate the wages at some constant purchasing power. This paper examines the role of floods in the formation and fluctuations of these real wage series in the different sample districts. For the former analysis natural log of real wage series for each district is studied. For the later analysis monthly wage indices are generated from the real wage series. The series of wage index is then split somewhat arbitrarily into two groups: the first ranging from 1979 to 1989, while the second ranging from 1980 to 2000. Next, average of seasonal indices for non-flood years is obtained separately for each group. The non-flood averages in each group would act as reference points for analyzing the deviations in real wages during the flood months. Separate non-flood averages had been derived for two groups to account for the fact that the normal trend in real wage series might change in the study period (1979 – 2000) for this paper.

The impacts of floods are studied in context of two 'types' of floods that Bangladesh experiences: '*major*' and '*minor*' floods. The two types can be differentiated in terms of the intensity and duration of inundation (Paul and Rashid 1987, Md. Khalequzzaman 2000). The former refer to the less frequent but catastrophic floods that inundate 35% or more area of the country[9]. They may continue for two months or more. The country experienced four such '*major*' floods- in 1974, 1987, 1988 and 1998 since its independence in 1971. These floods are distinguished from '*minor*' or regionally concentrated floods that usually continue for a month or so. These localized floods had dispersedly affected the country in 1984, 1993, 1995, 1999, 2000 and 2004. Given the range of data at hand, the present paper focuses on floods that had taken place between 1979 and 2000 in Bangladesh.

3. Fluctuations in agricultural wages in the times of floods: A graphical exposition

This section presents a series of graphs to describe how the agricultural wage indices had fluctuated in the flood months. For perspicuity, the study focuses on selective districts and selective flood years. The districts studied in this section include two MF districts-

Bogra and Mymensingh and two LF districts- Barisal and Dinajpur. These districts are representative in terms of their relative “flood proneness”. Table A.1 in appendix shows that while Bogra is one of the most prone flood districts of Bangladesh (with 78% of its total area vulnerable to flood of depth 90cm and above in a normal year), Dinajpur, in contrast, is one of the least flood prone district (with no area vulnerable to flood of depth 90cm in a normal year). Mymensingh and Barisal rank in between these two extreme cases. 55% of the total areas in the former and 16% of the total area in the later are vulnerable to flood of depth 90cm and above in a normal year.

The flood years focused on in this section include following two ‘*major*’ flood years: 1987 and 1998 and four ‘*minor*’ flood years: 1984, 1989, 1995 and 1999. Table A.2 in the appendix shows the flood chronology for each of these six years. The table also indicates the districts that were affected in different flood months. Floods in 1987 started in early June and continued till mid October, while that in 1998 started in early July and continued till late September. In 1984, floods started in early May, but receded in late only to surge again in June and once again in late September. In 1989, floods continued from late June till late September. In 1995 floods continued from early July till August. The 1999 floods continued from mid July through mid September. In almost all of these years, floods came in separate and multiple surges. As a result, not all the districts affected in these flood years were submerged at the same time. Also, some districts were inundated repeatedly. Consequently, a district that remained flood free in the early monsoon months of the flood year could be submerged in late monsoon flood surges. Also, some districts experienced multiple periods of submergence, interspersed between flood-free periods.

Figures 1 to 8 below presents the monthly fluctuations in wage indices in the selected districts in the selected flood years. For clarity, separate figures are presented to analyze the impacts of ‘*major*’ and ‘*minor*’ floods. Each of the figures include a set of four graphs showing: (1) monthly real agricultural wages in the relevant district for the flood years, (2) the monthly agricultural real wages for the same flood years for the Division to which the relevant district belongs, (3) the average monthly wages for non-flood years for the district and (4) the same monthly non-flood averages for the Division in general. The present analysis focus on the movements of the wages in the following three periods: (a) during the months when the districts are flood "affected"[10], (b) in the months when the districts are "not affected", though other parts of the Division to which they belong are affected and (c) in the post flood months.

Figure 1 below illustrates the fluctuations in real wage index in Bogra district and Rajshahi Division during the '*major*' floods of 1987 and 1998.

Fig 1
Seasonal Fluctuations in Real Wage (RCPI) Index in Bogra District of Rajshahi Division in 'Major' Flood Years (1987 & 1998) and Non-Flood Years

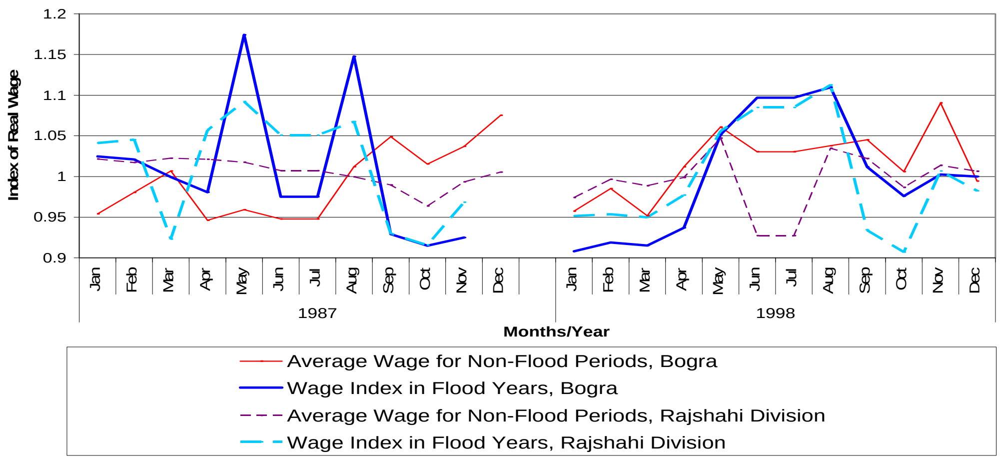
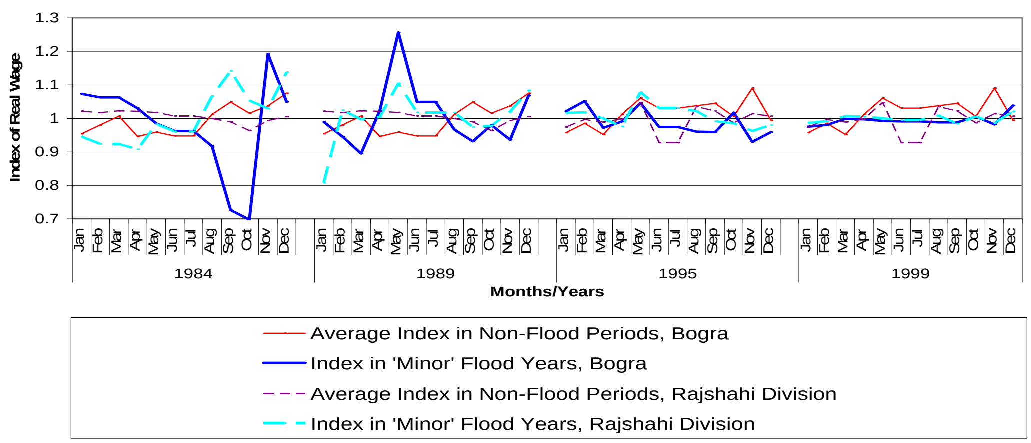


Table A.2 in the appendix shows that the district Bogra was inundated in June and once again in late August in 1987 and in late August in 1998. Figure 1 shows that wages declined in the districts in these flood months. They fell below the 'normal' non-flood averages in late August - September 1987 and August to September 1998. Figure 1 further shows that the wage rates in the district increased above their 'normal' non-flood averages in the flood months when the district remained unaffected (August 1987, June and July in 1998). The above also shows that wages in the district continued to be low in the post-flood months (October, November and December) in both of these flood years. For the Rajshahi Division as a whole, real wages remained above the Division-wise normal non-flood averages in June, July and August of 1987 and in June and July of 1998. However, they sharply declined in September 1987 and August and September 1998.

Figure 2 below describes the fluctuations in real wage index in Bogra and Rajshahi Division during the '*minor*' flood years 1984, 1989, 1999 and 2000.

Fig 2
Seaonal Fluctuations in Real Wage (RCPI) Index,
in Bogra District of Rajshahi Division,
in 'Minor' Flood Years (1984, 1989, 1995 & 1999) and Non-Flood Years

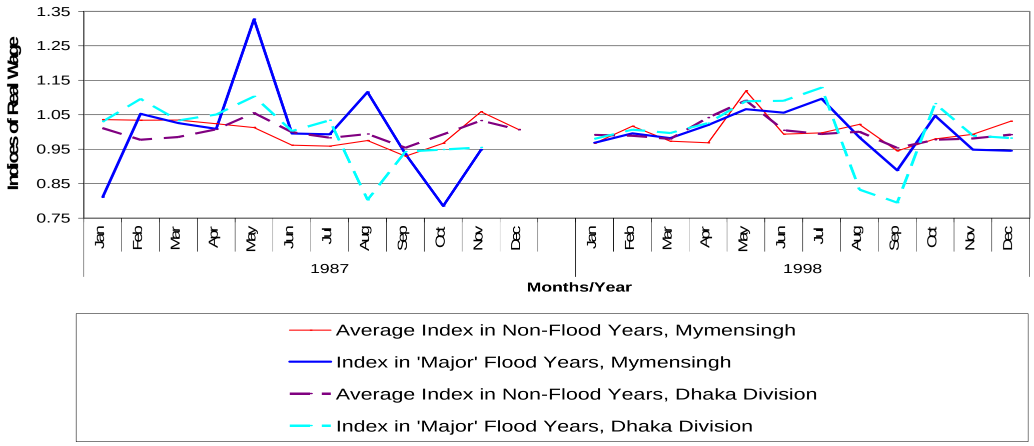


Bogra was severely affected by 1984 floods in the months of June to early September. The floods in 1989 were however moderate and submerged parts of the district in end July and August. In 1995 and 1999 the floods came in separate surges that inundated different parts of the district in June, July and August. Figure 2 shows that real agricultural wage rates declined in district during the flood months of the different '*minor*' years. The flood severity in the district did not always reflect the flood severity in the Division. The 1984 flood is a case in point. Bogra district was severely affected in 1984 and its agricultural wage rates declined dramatically below the flood-free 'normal' average level. In contrast wage rates in Rajshahi Division in general remained above the

Division-wise non-flood averages in the flood months of this year. Similar contrasts in the fluctuations of district wage index and Division-wise wage index was also observed in 1995.

Figure 3 below presents the cases of Mymensingh district and Dhaka Division during the '*major*' flood years 1987 and 1998.

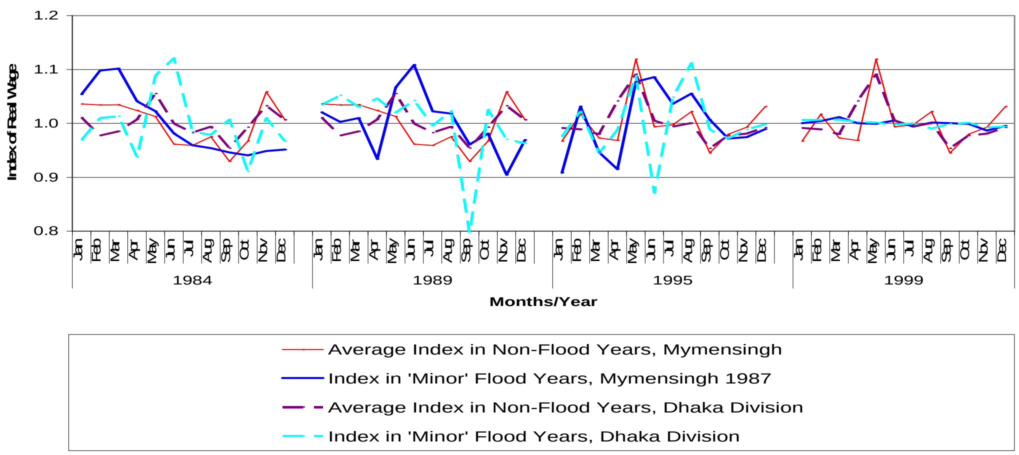
Fig 3
Seasonal Fluctuartions in Real Wage (in terms of RCPI) Index, in Mymensingh District of Dhaka Division, in 'Major' Flood Years (1987 & 1998) and Non-Flood Years



In 1987 floods, Mymensingh was affected in June and in early September, more severely in the later period. In 1998 floods the district remained submerged in July through mid August. Figure 3 shows real agricultural wages declined in Mymensingh during the flood months. This decline was remarkable in the months of most severe flooding- September of 1987 and late July and August of 1998. In these months wages fell below their 'normal' average levels observed in the flood-free years. In contrast, wages increased above their normal flood-free averages in July of 1987 and June of 1998, the months when the district was not affected. On examining the post-flood fluctuations in wage rates, it can be seen that the wage rates in the districts had continued to be low even after the flood waters had receded in 1987. The fluctuation in wage indices in Mymensingh district did not always imitate the pattern observed for Dhaka Division in general. As for example, in August 1987 wages declined in the Division while they increased in the district.

Figure 4 below illustrates the fluctuations in wage indices observed in Mymensingh district and Dhaka Division during ‘*minor*’ flood years.

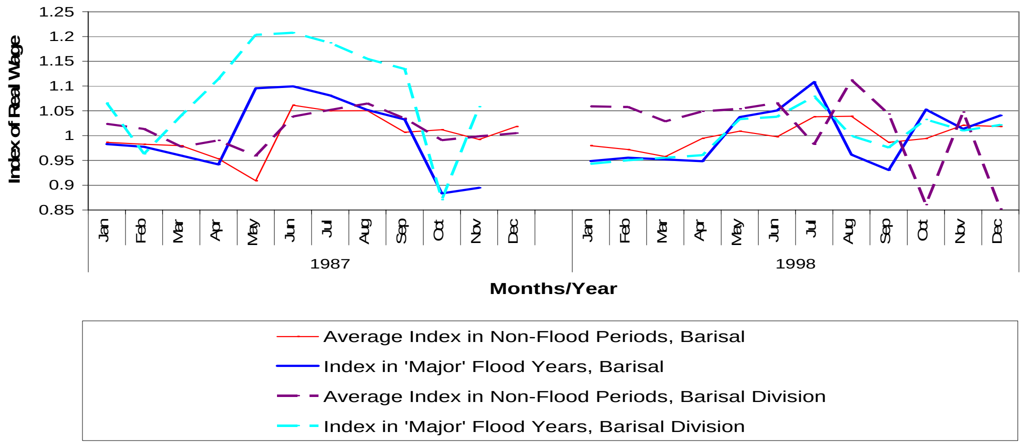
Fig 4
Seasonal Fluctuations in Real Wage (RCPI) Index, in Mymensingh District of Dhaka Division, in 'Minor' Flood Years (1984, 1989, 1995 & 1999) and Non-Flood Years



Mymensingh had remained relatively flood-free 1989 and 1995. The district was flooded twice in 1984- in June 1984 and in late September. It was also flooded, though partially, in August 1999. Figure 4 shows that wage rates declined in the district during these flood months. They however increased above the corresponding non-flood averages in the monsoon months of the years when the district remained flood-free. The patterns in the movements wage rates in the district followed that in Dhaka Division in general in 1984, 1989 and in 1999. In 1995, while wages in the Division declined below the Division-wise non-flood average, they remained high in the district.

Figure 5 below describes the fluctuations in wage indices in Barisal district and Barisal Division during the '*major*' flood years 1987 and 1998.

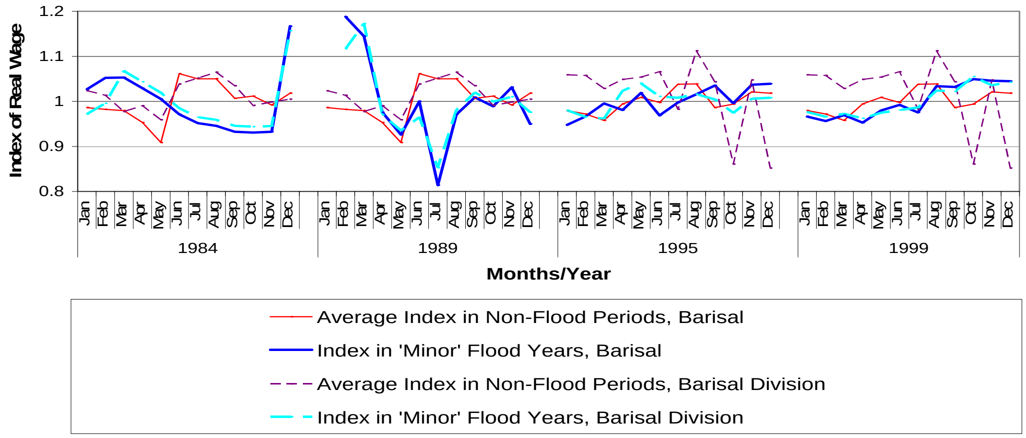
Fig 5
Seasonal Fluctuations in Real Wage (RCPI) Index, in Barisal District of Barisal Division, in 'Major' Flood Years (1987 & 1998) and Non-Flood Years



In 1987 the district remained relatively unaffected by floods in the early monsoon months. Figure 5 shows that in this period the wage indices in the district remained above their 'normal' average levels in the flood free years. However, in late monsoon of 1987, Barisal experienced severe flood surges in September. Figure 5 shows that real agricultural wage indices in the flood month in this district declined drastically below the 'normal' non-flood average level. The wage rates continued to remain low in the post-flood months of this year. Wage rates also declined in the flood months of July and August in 1998 when the district was once again severely flooded. Wage rates however recovered in Late September and October. The above mentioned patterns in the movement in the wages at the district level in the flood periods and non-flood periods in 1987 and 1998 was also observed for the Barisal Division in general.

The fluctuations in the wage indices in the times of '*minor*' floods of 1984, 1989, 1995 and 1999 in the district and the Division is shown in figure 6 below.

Fig 6
Seasonal Fluctuations in Real Wage (RCPI) Index,
in Barisal District of Barisal Division,
in 'Minor' Flood Years (1984, 1989, 1995 & 1999) and Non-Flood Years



Barisal was affected in various degrees during all the four '*minor*' flood years. In 1984, the district was repeatedly flooded in early May, in June and once again in late September. In 1989 the district was flooded in July. In 1995, it was again flooded early June. In 1999 it was flooded in May. Figure 6 shows that the real wage indices in the district had declined below their normal non-flood averages in each of the above mentioned flood periods. The figure also shows that in 1995 and 1999 the wage indices had sharply increased in the post-flood Monsoon months. The movements in the wages for the district closely matched with that observed for Barisal Division in general for all the '*minor*' flood years.

Figure 7 presents the case of Dinajpur of Rajshahi Division. Dinajpur was affected in the floods of 1987 but not in 1998. In 1987 flood surges in mid August inundated parts of the districts, but the water drained away rapidly. Figure 7 shows that in 1987, the agricultural wage rates in Dinajpur actually increased sharply above the normal non-flood average during the flood months June and July. This movement stood in sharp contrast with the movements in wages observed for the Rajshahi Division in general. However, wage rates fell in August of 1987 but recovered by September 1987. In the flood months of 1998 the wages once again increased above their normal non-flood averages in the district.

Fig 7
Seasonal Fluctuations in Real Wage (RCPI) Index in Dinajpur District of Rajshahi Division in Flood Years (1987 & 1998) and Non-Flood Years

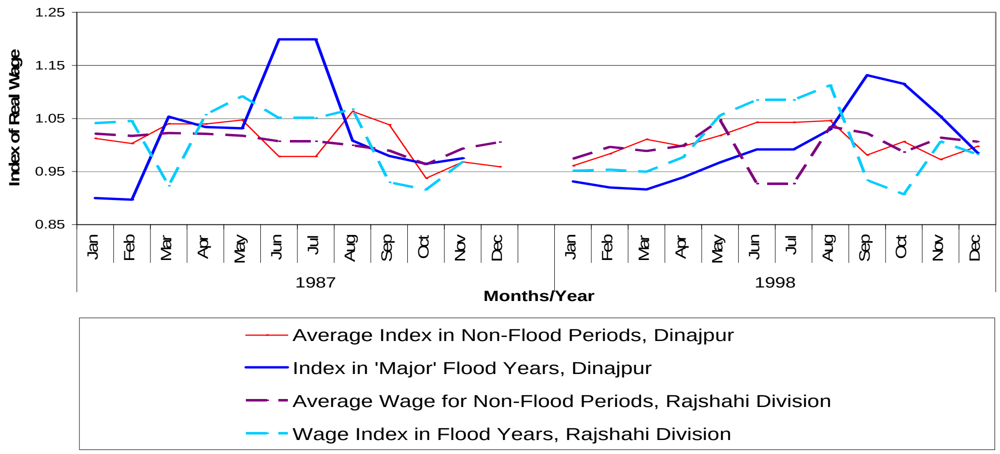
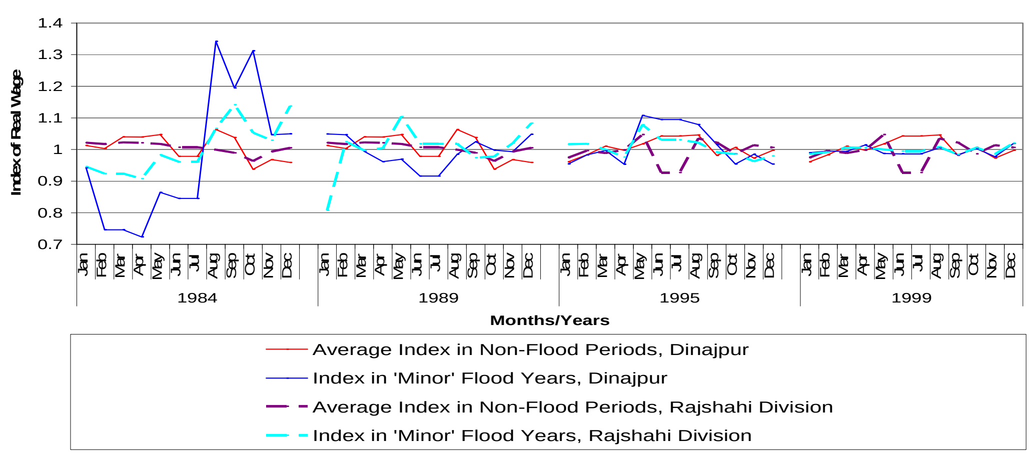


Figure 8 shows how wage indices in Dinajpur and Rajshahi Division had fluctuated in the '*minor*' flood years 1984, 1989, 1995 and 1999.

Fig 8
Seaonal Fluctuations in Real Wage (RCPI) Index, in Dinajpur District of Rajshahi Division, in 'Minor' Flood Years (1984, 1989, 1995 & 1999) and Non-Flood Years



Dinajpur experienced floods in the following periods: early May of 1984, mid June to early July in 1989, late August of 1995 and for a few days in end July of 1999. Figure 8 shows that wage rate in Dinajpur had been lower than their normal averages in the periods when the district was flooded. The figure also shows that the wage rates in the districts increased in the monsoon months when it had remained flood free. In the times when the district itself was affected wage rates fell below their normal non-flood average levels. The fluctuation patterns in the district-level wage indices closely followed that observed for Rajshahi Division only in 1999.

Inferences induced from graphical exposition:

The following inferences can be drawn from studying Graphs 1 to 8: First, real agricultural wage rates had declined below their 'normal' non-flood average levels in the flood months in the affected districts. Second, wage rates had increased in the districts that were not affected by floods at the time when other regions in the division had remained inundated. Third, the districts that had experienced a single surge of flooding in the early months of Monsoon (May and June), saw a quick recovery of the real wage rates in the post-flood agricultural seasons. This phenomenon was observed in Barisal in 1989, 1995 and in 1999 and in Dinajpur in 1984 and in 1989. For these districts, even though the real agricultural wage rates sharply declined during the flood months, they increased above their normal flood free average levels after the flood water had receded over. In contrast, the districts which were severely affected in height of the Monsoon season (in late July or August), wage rates remained low in the post flood periods, even though they had been high in the pre-flood Monsoon months. Finally, the graphs presented in this section insinuate that impact of '*minor*' floods might be as compelling as that of '*major*' floods. Accordingly, from the perspective of an individual district, the differentiation between '*major*' and '*minor*' floods may not be pertinent. The following case will illustrate this point: In Bogra district of Rajshahi Division wage rates declined more dramatically in the times of '*minor*' flood in 1984 than in the times of the '*major*' flood in 1987 or 1998. The district was more severely affected in 1984 than in 1987 or in 1998.

4. Fluctuations of agricultural wages in the times of floods: An estimation

The figures presented in the previous subsection showed that real agricultural wage indices fluctuated away from their 'normal' non-flood levels in the times of floods. Graphs had their immediate appeals as they make any deviations of the wages from their normal behavior instantly obvious. However, the graphs had focused on only four districts and described their flood-experiences for only six flood years. The present section pursues this analysis further. It aims to examine how do wage rates in the all of the ten MF and LF districts considered in this paper fluctuate during all the flood years from 1979 to 2000. In particular it aims to answer the following two questions: First, how significantly can "flood occurrence" explain the observed negative deviations in wage rates in the monsoon months of the flood years? Second, what role did "flood nonoccurrence" play in causing the positive deviations in the wage indices in the districts that remained flood-free? A simple linear model is presented for this purpose:

(1) $d_{i,t} = Y_{i,t} \ \theta_i + u_{i,t}$

where d_{it} represents the rate deviation of the wage index in the *i*th district in the *t*th month from its 'normal' non-flood level in that month, $Y_{i,t}$ is the vector of factors that cause this deviation, θ_i is the vector of coefficients on the compositional factors that cause wage deviations in the *i*th district and $u_{i,t}$ is the error term representing the deviations from the predicted value of $d_{i,t}$ due to factors not contained in the model. For the present purpose it is assumed that $Y_{i,t}$ include time trend of the wage series and flood dummies indicating "flood occurrence" and "flood non-occurrence". The estimation is carried out for the ten (greater) districts described estimates for this model are reported in Appendix 3 in Table A3.1 to A.3.10.

The results of this estimation show that "flood occurrence" can significantly explain wage deviations in only three of the ten sample districts- Jessore, Barisal and Dinajpur. The coefficients in the first two cases are negative, while in case of Dinajpur it is positive. On the other hand, "flood non-occurrence" can significantly explain the increase in the wage indices above their 'normal' flood-free average levels in case of six of the ten sample districts studied in this paper. These districts are Bogra, Faridpur, Mymensingh, Jessore, Khulna and Dinajpur. The first four are MF districts while the last two are LF districts. Flood "occurrence" or "non-occurrence" plays no role in explaining the fluctuations observed in the wage indices in Patuakhali district (the LF district in Barisal Division) in the monsoon season.

5. Long term impact of floods on agricultural wage rate formation

The previous section had analyzed the impact of flood shocks on the movements of real agricultural wage indices in the different districts of Bangladesh. This section seeks to examine what roles do flood occurrences play in explaining the formation of agricultural wage rates over a long span of time? To examine the role of 'flood occurrence' as a determinant of wage rates over the span of twenty years 1978-2000 in the sample districts the following simplified model is proposed:

(2) $w_i = X_i \beta + \varepsilon_i$

where w_i represents the natural log of the real wage rate of the ith district, X_i is the vector of factors that determine agricultural wage rates in the same district, including time trend of the wage series, seasonal dummy indicating different agricultural seasons (summer, monsoon and winter) and flood dummies indicating whether or not the district had been affected by floods, β is the vector of coefficients on the wage determining compositional factors and ε_i is the error term representing the individual deviations from the predicted value of w_i due to factors not contained in the model. The set of determining factors of wage rates considered in this paper is but incomplete. Khan (1984) had identified productivity in agriculture (which determine the demand of agricultural laborers) and the relative price of agricultural products or the terms of trade of agriculture (which determines the ability of the agricultural sector to absorb the increase in money wages) as two explanatory variables, apart from the trend factors, to explain the variations in real wage rates in Bangladesh over time. A future paper will examine the significance of these factors. The estimates for this model are reported in Appendix 4 in Tables A4.1 to A4.10.

The results of estimation of the above model shows that “flood occurrence” can significantly determine the formation of agricultural wage rates in five of the ten sample districts studied in this paper. These districts are Bogra, Faridpur, Comilla, Khulna and Rangamati. The first three are MF districts while the last two are LF districts. The coefficients in all these five cases are negative. In Jessore, Mymensingh, Patuakhali and Dinajpur the signs of the independent variable capturing “flood occurrence” are negative though coefficients are not significant. In Barisal the sign of the coefficient is positive though it is insignificant in determining wage rates.

On comparing the significance of floods in explaining wage fluctuations (discussed in section 3) and wage formations the following facts become evident: The districts for which “flood occurrence” was a significant explanatory variable in explaining wage formation, “flood occurrence” played no significant role in explaining wage fluctuations. These districts are Bogra, Faridpur, Comilla, Khulna and Rangamati. From this result the following conjecture can be made: In the districts that experience frequent flooding, floods do not cause wages to deviate from their ‘normal’ pattern in any notable manner. However, for the districts that are seldom flooded, floods come as random unexpected shocks that cause the wages to sharply fluctuate away from their ‘normal, flood-free average levels.

6. Conclusions

The objective of this paper had been to narrate the impacts of flood on fluctuation and formation of agricultural wage rates in Bangladesh. Empirical evidences presented here suggest that there are an apparently bewildering number of dimensions through which floods affect real agricultural wage rates in Bangladesh. The impacts vary corresponding to the nature and severity of floods, across the regions that are more or less flooded, according to the timings of the flood. Graphs presented in this paper to show the ‘normal’ movements in wage rates are disrupted in the times of floods. First, wages decline below their non-flood average levels in the districts that are severely affected. Second, wage rates actually increase in the flood months in the districts that are not inundated. This was observed in Bogra in 1987, 1998, and 1989, in Mymensingh in 1987 and in 1989, in Dinajpur in flood years 1984, 1987 and 1995. Interestingly, the same district could face alternate periods of rising and falling wage rates. This happened when the districts encountered repeated flood surges punctuated with flood-free periods. This phenomenon was observed in the cases of Bogra and Mymensingh districts in 1987. The graphs also show that the timings of flood surges have important bearings on flood impacts on wage rates. Wage rates remained low for longer periods in the districts that experienced floods in the late Monsoon months rather than early Monsoon months.

The causal explanations behind the above results can be surmised as follows: In terms of the crop calendar of the country, the flood months correspond with the monsoon agricultural season. In this season late *Boro* rice, *Aus* rice and Jute are harvested. In addition, *Aman* paddy is sown or transplanted. Table A.5 in the appendix presents the agricultural activities (in terms of principal food crop in Bangladesh- rice, and the principal cash crop- Jute) that are carried out in monsoon season (June to September) in Bangladesh. The table also shows the relative flood resistance of various crops. Early Monsoon floods in June destroy the standing *Aus* crops in the fields, while late Monsoon floods in August disrupt the production of *Aman* crops. In these times, the demand for agricultural laborers is reduced and accordingly wage rates fall. The situation is made worse when destruction of crops drives up the rice prices, causing the real wage rates to fall further. Field survey reports (Hossain et al 1988, del Ninno et al 1998) supports the above conjectures. These reports also suggest that monsoon floods can be beneficial to the crops, especially in regions where the fields are not completed inundated or when the standing water is quickly drained away. In these cases flood waters irrigate the fields. Even in the regions that are not flooded, the heavy rainfall that had caused flooding else where in the country increase the moisture content of the soil. In either case productivity in the fields increases, increasing the demand for agricultural labor. Accordingly, wage rates rise in the flood months in the regions which are not severely affected by floods.

The significance of the results obtained from studying the graphs are assessed through statistical analysis. The results showed that first, “flood occurrence” can significantly explain the fluctuations in wage rates in only three of the ten sample districts studied in this paper. Second, in six of the sample districts “flood non-occurrence” can significantly explain wage increase in the times when the districts were unaffected though floods submerged other parts of the country. Further statistical analyses are carried out to examine whether or not flood occurrences play any significant role in determining the long term wage patterns in a country like Bangladesh which is repeatedly and regularly inundated. The results show that “flood occurrence” has been a significant explanatory variable in determining wage rates in five of the ten sample districts studied in this paper in the time period 1979-2000. These districts are Bogra, Faridpur, Comilla, Khulna and Rangamati. The first three districts are geomorphologically more prone to floods, while the last two are less so. Interestingly, the districts for which “flood occurrence” was a significant explanatory variable in explaining wage formation, “flood occurrence” played no significant role in explaining wage fluctuations.

The above results suggest that monsoon agricultural wage rates in the districts that are recurrently flooded have been adapted to absorb the flood shocks. The districts where “flood occurrences” play significant role in explain the wage rate patterns are located either in the active floodplains of the Ganga-Brahmaputra-Meghna river system (Bogra, Faridpur, Khulna and Barisal) or in the coastal region (Comilla). Extensive areas of these districts are low-lying (See Appendix 1 for descriptions of inundation land-types of these districts) and are exposed to repeated and regular inundation. It is therefore not unreasonable to assume that for these districts *shallow* or even *moderate* floods[11] are less of a random shock and more of a periodic phenomenon for these districts. This paper surmises that the districts that experience frequent floods internalize their effects and adapt themselves to floods. The cropping pattern of these districts lends support to this hypothesis. The principal crop grown in these districts is the late wet season broadcast *Aman* rice is Monsoon (Hossain et al 1988). This crop is adapted to be cultivated in deep water and grows with the rising water level. As a result impacts of *shallow* or even *moderate* floods do not cause any significant disruption of the production of these crops and therefore no significant deviations in the wages from their 'normal' behavior in these districts[12]. Conversely, the agricultural wage rates in the districts that experience floods less frequently react more violently to flood shocks. The agricultural wages in these districts therefore fluctuate significantly away from their 'normal, non-flood average levels in the flood months.

Finally, the empirical evidences presented in this paper show that from the perspective of an individual district the distinction between '*major*' and '*minor*' floods is irrelevant in terms of their impact on agricultural wage rates. What is relevant is whether or not the district had experienced a critical flood condition in that year. The following case will illustrate this point: In Bogra district of Rajshahi Division wage rates declined more dramatically in the times of '*minor*' flood in 1984 than in the times of the '*major*' flood in 1987 or 1998. The district was more severely affected in 1984 than in 1987 or in 1998. These findings may have important policy implications. Flood mitigation measures are often designed and directed towards low frequency '*major*' floods. Less attention is paid towards managing '*minor*' flood, which though localized, are more frequent and can be as distressing as '*major*' floods for the affected regions.

Notes:

[1] Ward (1978) defined flood as "a body of water which rises to overflow land which is not normally submerged". According to Rasid and Paul (1987), floods in Bangladesh result from the following factors: (a) excessive run-off from the drainage basins and (b) the hydraulic characteristics of the river channels. The authors explain that when intensive rainfall occurs simultaneously over several tributaries in the huge drainage basins of the rivers of Bangladesh for a long duration, the combined runoff from these tributaries cause high floods in the downstream main channels. Among the hydraulic factors extremely low channel gradient of the three major rivers- Ganga, Brahmaputra and Meghna- provide inefficient channels for disposing of excess waters during high floods. The situation is exacerbated due to the loss of channel capacity through sedimentation. The surface characteristics of the flood plains- including structural depressions, innumerable abandoned channels and backswamps- contribute to the stagnation of flood waters. Following Abbas (1963), Rasid and Paul (1987) presents the following descriptive terms to specify different types of floods in Bangladesh according to flood depths: (i) *Shallow Floods* mean that the depth of flood-waters on the floodplains is less than 1 m, that is, the natural levees remain above the flood level. (ii) *Moderate Floods* indicate depth ranging 1-2 m. (iii) *Deep Floods* mean

that the depth of flood waters is above 2 m and the natural levees are submerged. The Bangladesh National Water Plan (1986: II: 10, 61-62) uses a slightly different categorization. The Board defines (i) *Shallow Floods* to be of depth below 90 cm, (ii) *Moderate Floods* to be of depth between 90 cm and 180 cm and (iii) *Deep Floods* to be of depth above 180 cm. Based on its own classifications, the Board estimates that 35% of the net cultivated area of Bangladesh is "shallowly flooded" (30 to 90 cm deep in normal year); 16% is moderately flooded" (90 to 180 cm); and 12% is "deeply flooded" (over 180 cm); the remaining 37% is not flooded. The present paper follows the categorization of floods as presented by the National Water Plan of Bangladesh.

[2] Annual frequency of floods in Bangladesh is 1.78 (Regional Cooperation of Flood Information Exchange in the Hindu Kush Himalayan Range, South Asian Floods 2002). Recorded history of disasters in Bangladesh shows that the following were the years of severe floods in Bangladesh: 1842, 1858, 1871, 1875, 1885, 1892, 1900, 1902, 1907, 1918, 1922, 1954, 1955, 1956, 1962, 1963, 1968, 1970, 1971, 1974, 1984, 1987, 1988, 1998 and, 2000 (*Banglapedia*: National Encyclopedia of Bangladesh: Asiatic Society of Bangladesh, January 2003). Documentation of floods in terms of depth, total area affected damage to crops, damage to infrastructures, number of people affected, and overall monetary damage started in 1954. Based on the historic records, writers are of the opinion that the frequency, magnitude, and duration of floods have increased substantially during the last few decades (Md. Khalequzzaman 2000). Based on historical records and some preliminary flood-frequency analysis, Coleman (1969) estimated that low floods have a recurrence interval of four years, moderate floods about seven years and catastrophic floods every 30-50 years (Quoted in Rasid and Paul (1987)).

[3] Bangladesh is divided into six *bibhag* or Administrative Divisions: Dhaka, Chittagong, Khulna, Rajshahi, Barisal and Sylhet. The Divisions are subdivided into 21 *anchal* or Regions, then further into 64 *zila* or Districts, then into about 493 thana (or *upazila*) or Sub-districts, and finally into unions. See Appendix 2 for a description and history of formation of these administrative units.

[4] See Note 1 above for the categorization of different flood types as *Shallow*, *Moderate*, and *Deep Floods* presented by Bangladesh National Water Plan according to flood depth.

[5] No representative district is chosen for Sylhet division. This is due to the following reason: this paper carries out the impact analysis of flood in terms of real agricultural wage (in terms of rural CPI) series. The complete series of real wage rates is not available for Sylhet.

[6] For the Agroecological Regions and inundation land types of the sample districts in Bangladesh under study see Yearbook of Agricultural Statistics

[7] Source: Yearbook of Agricultural Statistics (published: Bangladesh Bureau of Statistics (BBS), Dhaka), various years.

[8] The consumer price indices are given for the rural population for the six Administrative Divisions: Dhaka, Chittagong, Khulna, Rajshahi, Barisal and Sylhet. Source: Monthly Statistical Bulletin, Bangladesh (published: Bangladesh Bureau of Statistics (BBS), Dhaka), various years. The series on rural consumer price indices is available from July 1978, and has missing data for the period (a) December 1988 to October 1988 across all the Divisions and (b) January 1988 to December 2000 for Sylhet Division. The former set of missing data would pose a problem as 1988 was a '*major*' flood year. Also, impact of floods in Sylhet District cannot be studied in terms of real agricultural wage rates for flood periods after 1988. This problem of missing data can be addressed by analyzing a second series of (rice-equivalent of) wage rates generated in terms of

monthly retail price of coarse rice (Taka/Maund). A parallel study could be carried out using the rice-equivalent of wage data for (a) 'most' and 'least' flood prone districts, during (b) flood months and post-flood months and the results could be compared with that obtained from analyzing real wage series.

[9] These floods usually occur during the peak of the monsoon season, when heavy rainfall together with the increased volume and flow in the rivers causes them to spill over. The floods assume disastrous proportion when the surge of water in the three great rivers Ganga-Padma, Brahmaputra-Jamuna and Meghna peak simultaneously. As a result the rivers fail to drain their flow out to Bay of Bengal and inundate extensive areas of the country (Rogers et al 1989). Economic losses in the four major floods since the independence of the country are as follows: $600 million dollars in 1974, around $ 2.2 billion in each of the two consecutive floods of 1987 and 1988, and $3.5 billion in 1998. (The figures for 1974, 1987 and 1988 are obtained from Regional Cooperation of Flood Information Exchange in the Hindu Kush Himalayan Range, South Asian Floods 2002. The figure for 1998 was cited in Shehabuddin E (2000) Bangladesh in 1999 Asian Survey, Vol. 40 p. 181-88, Asian Development Bank). The country also experiences floods in the late Monsoon months (late September). These floods are caused by tidal surges that push huge water volumes inland through the rivers causing them to overflow.

[10] This paper assumes that a district is "affected" by floods when it is submerged under the water depth of 90 cm or more (in other words, "affected" by *Moderate* or *Deep* floods. On the other hand, it assumes that a district may be "not affected" if it experiences a flood of depth less than 90 cm or *Shallow* flood. This assumption is based on certain conjectures regarding when are floods considered to be hazardous in a land where they are regular phenomenon. This assumption had to be made as though information regarding flood depth are available for the years of 'major' floods (Ahmed 1999), no such information is readily available for the years of 'minor' floods.

[11] See Note 1 for definition of *Shallow*, *Moderate*, and *Deep Floods*.

[12] However, in the years of severe or *deep* flooding the late wet season broadcast *Aman* crops are also most vulnerable (Hossain et al 1988, Paul and Rashid 1993). But these floods are less frequent; accordingly their impact is less significantly captured in the long run determination of the patterns of wage rates.

Appendix Table A.1
Description of the sample districts in terms of relative flood proneness

Relative Flood Proneness	Districts	Divisions	Percent area of the district vulnerable to flood of depth greater than 90cm in a normal year
Most Flood Prone District in the Division (MF)	Bogra	Rajshahi	78
	Comilla	Chittagong	68
	Faridpur	Dhaka	68
	Jessore	Khulna	54
	Barisal	Barisal	16
Least Flood Prone District in the Division (LF)	Mymensingh	Dhaka	55
	Khulna	Khulna	9
	Patuakhali	Barisal	2
	Rangamati	Chittagong	0
	Dinajpur	Rajshahi	0

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

The above table arranges the 20 Greater Districts in Bangladesh in order of decreasing percentage of the area affected by floods based on the data given in Bangladesh National Water Plan (1986: II: 10, 61-62). Rogers et al assume that in exceptionally severe flood years, these percentages increase roughly in proportion.

A brief description of the sample MF and LF districts studied in terms of (a) the agroecological zone they belong to and (b) their land-type in terms of inundation

Bogra district of Rajshahi Division is located in the overlapping zone of active Brahmaputra-Jamuna floodplain and the floodplain of Karatoya-Bangali rivers. This region is classified as Medium Highland and Medium Lowland according to inundation land types of Bangladesh. Comilla district of Chittagong Division lies in the Chittagong Coastal plain where the land is classified as Medium Highland and Highland in terms of inundation land-type. Faridpur district of Dhaka Division is located in Low Ganges River Floodplain. It has the land-type that is classified as Highland to Medium Lowland in terms of inundation. Jessore district of Khulna Division lies in the High Ganges River floodplains. The land type in the district is Medium High and Highland in terms of inundation. Barisal district of Barisal Division is located in the Old Meghna Estuarine Floodplain and has the land-type that is classified as Medium Highland to Lowland in terms of inundation. Mymensingh district of Dhaka Division lies in the Old Brahmaputra floodplain, and has land-type classified as Medium Highland and Highland in terms of inundation. Khulna district of Khulna Division is located in High Ganges River Floodplains. Some of the area of this district also spread over the Gopalganj-Khulna Bills Agroecological region. The district has land-type classified as Medium Highland and Highland in terms of inundation. Patuakhali district of Barisal Division is located in the Ganges tidal floodplain. The land-type of this district is classified as Mainly Medium Highland in terms of inundation. Dinajpur of Rajshahi Division is part of the Level Barind Tract and has land-type classified as Medium Highland and Highland. Rangamati (or Chittagong Hill Tracts) district of Chittagong Division is part of the Northern and Eastern Hills and has the Mainly Highland land-type in terms of inundation.

Appendix Table A.2

Chronology of selective '*major*' and '*minor*' floods and the area affected in Bangladesh (flood years: 1984, 1987, 1989, 1995, 1998 and 1999)

Flood Years		Flood Months	Districts Severely Affected
***Major* Floods**	1987	early June	— Flash floods affected the following districts: Rangpur, Comilla, Noakhali, Bogra, Mymensingh, Faridpur, Khulna & Sylhet
		July	— By the end of July following districts were severely affected: Chittagong, Cox's Bazaar, Netrokona, Gaibanda, Naogaon, Kurigram, Jamalpur
		mid August	— Condition deteriorated in additional districts: Dinajpur, Pabna, Tangail, Rajbari, Manikganj, Faridpur
		end August	— Districts continued to be inundated: Faridpur, Munshiganj, Madaripur, Shariatpur
		September	— Another flood wave affecting Rajshahi, Chapai Nawabganj, Pabna, Mymensingh, Bogra, Faridpur Regions that were not affected earlier were also affected: Barisal, Rangamati, Patuakhali
		mid October	— The emergency phase was over
	1998	early July	— Flash flood affected Chittagong, Cox's Bazaar, Bandarban
		mid July	— Flood waters rising in Mymensingh, Jamalpur, Sherpur, Habiganj, Rangpur, Sirajganj, Manikganj, Pabna, Rajbari, Rajshahi, Kurigram, Faridpur, Nilphamari, Tangail, Natore, Barisal.
		end July	— Incessant rainfall and new flood waves worsened the conditions in the districts already flooded. Additional districts affected: Dhaka, Sherpur, Feni, Ramgarh, Gaibanda, Lalmonirhat, Khagrachari
		mid August	— New flood surge. Districts affected: Sylhet, Munshiganj, Kurigram, Khulna
		end of August	— 45 out of 64 districts inundated. Newly flooded districts include: Bogra, Jessore
		early September	— 52 out 64 districts inundated
		late September	— Water started receding
***Minor* Floods**	1984	early May	— Widespread heavy rainfall causes severe flooding in Comilla, Rangamati, Jessore, Barisal, Patuakhali
		June	— Barisal. Additional districts were affected: Khulna, Patuakhali, Maulavi Bazaar, Sylhet, Sunamganj, Habiganj, Bogra, Faridpur & Mymensingh
		late September	— Tidal surges caused flooding in Comilla, Faridpur, Rangamati, Jessore, Barisal, Khulna & Mymensingh
	1989	late June	— Jessore, Dinajpur & Comilla
		end July	— Flash floods affected Sylhet, Patuakhali, Barisal, Faridpur, parts of Bogra
		August	— Bandarban, Cox's Bazaar, Chittagong, Bogra, Faridpur
	1995	early July	— Khulna, Brahmanbaria, Narshingdi, Munshiganj, Narayanganj, Dhaka, Jessore, Barisal, Rangamati, Patuakhali, Bogra
		August	— Sylhet, Dinajpur
	1999	mid July	— Rangpur, Kurigram, Gaibanda, Bogra, Kushtia, Dinajpur, Patuakhali
		end July	— Chittagong, Barisal, Bogra, Comilla, Rangamati
		August	— Cox Bazaar, Bandarban, Chittagong, Dhaka, Mymensingh
		mid September	— Sherpur, Jamalpur, Manikganj, Madaripur, Narshingdi, Nilphamari

Source: United Nations Department of Humanitarian Affair. Posted at www. reliefweb.net

Appendix A. 3

Estimates of "flood occurrence" and "flood non-occurrence" as determinant of wage rate fluctuations

<u>Estimation Equation:</u>

(1) $d_{i,t} = Y_{i,t} \ \theta_i + u_{i,t} = \delta_i + \theta_{1i} * T + \theta_{2i} * FO_i + \theta_{3i} * FN_i + u_{i,t}$

where $d_{i,t}$ = Rate deviation of the wage index in the *i*th district in the *t*th month from its 'normal' non-flood level in that month

T = Periods (1 for Jan 1979, 2 for Feb 1979 etc.) representing trend factor

FO_i = 1 for "flood occurrence"

= 0 otherwise

FN_i = 1 for "flood non-occurrence"

= 0 otherwise

δ = Constant of regression (representing the intercept of trend line)

θ_1 = Coefficient for independent variable T (representing the slope of trend line)

θ_2 = Coefficient for dummy indicating "flood occurrence"

θ_3 = Coefficient for dummy indicating "flood non-occurrence"

$u_{i,t}$ = Unexplained part of estimation

Least square estimates of equation for the sample MF and LF districts studied in this paper are presented in the following tables.

Table A3.1
Bogra District of Rajshahi Division

Dependent Variable: d_i
$d_{i,t} = \delta_i + \theta_{1i} * T + \theta_{2i} * FO_i + \theta_{3i} * FN_i + u_{i,t}$
Included observations: 215 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
δ	0.003307	0.012557	0.263316	0.7926
θ_1	-4.06E-05	0.000107	-0.377820	0.7059
θ_2	-0.030769	0.016529	-1.861540	0.0641
θ_3	0.140602	0.041828	3.361445	0.0009
R-squared	0.074513	Adjusted R-squared		0.061355

Table A3.2
Faridpur District of Dhaka Division

Dependent Variable: d_i
$d_{i,t} = \delta_i + \theta_{1i} * T + \theta_{2i} * FO_i + \theta_{3i} * FN_i + u_{i,t}$
Included observations: 218 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
δ	0.004899	0.014937	0.327962	0.7433
θ_1	-8.13E-05	0.000120	-0.680475	0.4969
θ_2	-0.017725	0.020734	-0.854907	0.3936
θ_3	0.118631	0.032883	3.607695	0.0004
R-squared	0.066733	Adjusted R-squared		0.053650

Table A3.3
Comilla District of Chittagong Division

Dependent Variable: d_i $d_{i,t} = \delta_i + \theta_{1i}* T + \theta_{2i}* FO_i + \theta_{3i}* FN_i + u_{i,t}$ Included observations: 214 after adjusting endpoints				
	Coefficient	Std. Error	t-Statistic	Prob.
δ	-0.000547	0.010249	-0.053330	0.9575
θ_1	1.24E-05	8.83E-05	0.140937	0.8881
θ_2	-0.008561	0.013889	-0.616441	0.5383
θ_3	0.012802	0.020440	0.626302	0.5318
R-squared	0.004602	Adjusted R-squared		-0.009618

Table A3.4
Mymensingh District of Dhaka Division

Dependent Variable: d_i $d_{i,t} = \delta_i + \theta_{1i}* T + \theta_{2i}* FO_i + \theta_{3i}* FN_i + u_{i,t}$ Included observations: 218 after adjusting endpoints				
	Coefficient	Std. Error	t-Statistic	Prob.
δ	0.003492	0.010344	0.337558	0.7360
θ_1	-7.43E-05	8.33E-05	-0.892443	0.3732
θ_2	0.003857	0.014682	0.262728	0.7930
θ_3	0.100864	0.020628	4.889741	0.0000
R-squared	0.102271	Adjusted R-squared		0.089686

Table A3.5
Jessore District of Khulna Division

Dependent Variable: d_i $d_{i,t} = \delta_i + \theta_{1i}* T + \theta_{2i}* FO_i + \theta_{3i}* FN_i + u_{i,t}$ Included observations: 195 after adjusting endpoints				
	Coefficient	Std. Error	t-Statistic	Prob.
δ	-0.001187	0.013668	-0.086820	0.9309
θ_1	3.84E-05	0.000124	0.309916	0.7570
θ_2	-0.068113	0.023844	-2.856562	0.0048
θ_3	0.079931	0.032960	2.425077	0.0162
R-squared	0.189784	Adjusted R-squared		0.172727

Table A3.6
Barisal District of Barisal Division

Dependent Variable: d_i $d_{i,t} = \delta_i + \theta_{1i}* T + \theta_{2i}* FO_i + \theta_{3i}* FN_i + u_{i,t}$ Included observations: 214 after adjusting endpoints				
	Coefficient	Std. Error	t-Statistic	Prob.
δ	0.000243	0.010680	0.022779	0.9818
θ_1	5.34E-05	9.12E-05	0.584884	0.5593
θ_2	-0.038621	0.015087	-2.559841	0.0112
θ_3	-0.002222	0.020632	-0.107676	0.9144
R-squared	0.030965	Adjusted R-squared		0.017122

Table A3.7
Khulna District of Khulna Division

Dependent Variable: d_i
$d_{i,t} = \delta_i + \theta_{1i} * T + \theta_{2i} * FO_i + \theta_{3i} * FN_i + u_{i,t}$
Included observations: 203 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
δ	0.002128	0.013460	0.158120	0.8745
θ_1	-5.29E-05	0.000119	-0.444923	0.6569
θ_2	-0.041066	0.023390	-1.755724	0.0807
θ_3	0.073383	0.023307	3.148519	0.0019
R-squared	0.069375	Adjusted R-squared		0.055345

Table A3.8
Patuakhali District of Barisal Division

Dependent Variable: d_i
$d_{i,t} = \delta_i + \theta_{1i} * T + \theta_{2i} * FO_i + \theta_{3i} * FN_i + u_{i,t}$
Included observations: 213 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
δ	0.001410	0.016917	0.083350	0.9337
θ_1	-3.97E-05	0.000145	-0.273594	0.7847
θ_2	-0.019891	0.023219	-0.856685	0.3926
θ_3	0.044920	0.045815	0.980472	0.3280
R-squared	0.009889	Adjusted R-squared		-0.004323

Table A3.9
Rangamati District of Chittagong Division

Dependent Variable: d_i
Sample(adjusted): 1 199
Included observations: 199 after adjusting endpoints
$d_{i,t} = \delta_i + \theta_{1i} * T + \theta_{2i} * FO_i + \theta_{3i} * FN_i + u_{i,t}$

	Coefficient	Std. Error	t-Statistic	Prob.
δ	0.002684	0.014809	0.181257	0.8564
θ_1	1.36E-05	0.000136	0.099972	0.9205
θ_2	-0.008781	0.020867	-0.420797	0.6744
θ_3	0.046462	0.040682	1.142071	0.2548
R-squared	0.008377	Adjusted R-squared		-0.006879

Table A3.10
Dinajpur District of Rajshahi Division

Dependent Variable: d_i
$d_{i,t} = \delta_i + \theta_{1i} * T + \theta_{2i} * FO_i + \theta_{3i} * FN_i + u_{i,t}$
Included observations: 215

	Coefficient	Std. Error	t-Statistic	Prob.
δ	1.641782	0.004691	349.9843	0.0000
θ_1	0.000399	3.94E-05	10.12681	0.0000
θ_2	0.021431	0.007635	2.806903	0.0055
θ_3	0.057630	0.008338	6.911943	0.0000
R-squared	0.499749	Adjusted R-squared		0.492636

Appendix A. 4

Estimates of "flood occurrence" as a determinant of agricultural wage rate formations

Estimation Equation:

(1) $w_i = X_i \beta + \varepsilon_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$

where w_i = Natural log of real wage rate (daily) in district i

T_i = Periods (1 for Jan 1979, 2 for Feb 1979 etc.) representing trend factor

S_1 =1 for winter season (November, December, January and February)

= 0 otherwise

S_2 = 1 for summer season (March, April and May)

= 0 otherwise

S_3 = 1 for monsoon season (June, July, August and September)

= 0 otherwise

FO_i = 1 for "flood occurrence"

= 0 otherwise

α = Constant of regression (representing the intercept of trend line)

β_1 = Coefficient for independent variable T (representing the slope of trend line)

β_2, β_3, β_4 = Coefficients for seasonal dummies S_1, S_2, S_3

β_5 = Coefficient for dummy indicating "flood occurrence"

ε_i = Unexplained part of estimation

Least square estimates of equation for the sample MF and LF districts studied in this paper are presented in the following tables.

Table A4.1
Bogra District of Rajshahi Division

Dependent Variable: w_i
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$
Included observations: 215 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
α	1.624319	0.107454	15.11643	0.0000
β_1	0.001406	0.000176	8.004184	0.0000
β_2	-0.053370	0.106377	-0.501701	0.6164
β_3	-0.062675	0.106968	-0.585920	0.5586
β_4	-0.025710	0.107237	-0.239750	0.8108
β_5	-0.092760	0.031278	-2.965628	0.0034
R-squared	0.239018	Adjusted R-squared		0.220813

Table A4.2
Faridpur District of Dhaka Division

Dependent Variable: w_i
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$
Included observations: 218 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
α	1.677250	0.039732	42.21378	0.0000
β_1	0.001037	0.000156	6.664390	0.0000
β_2	-0.006534	0.040785	-0.160200	0.8729
β_3	0.047003	0.041171	1.141635	0.2549
β_4	0.026565	0.038790	0.684831	0.4942
β_5	-0.059243	0.030164	-1.964016	0.0508
R-squared	0.183916	Adjusted R-squared		0.164669

Table A4.3
Comilla District of Chittagong Division

Dependent Variable: w_i
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$
Included observations: 214 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
α	1.986082	0.034284	57.92961	0.0000
β_1	-0.000508	0.000152	-3.340886	0.0010
β_2	0.011556	0.034103	0.338865	0.7351
β_3	0.024109	0.036243	0.665215	0.5066
β_4	-0.009625	0.033725	-0.285383	0.7756
β_5	-0.050045	0.025325	-1.976091	0.0495
R-squared	0.112125	Adjusted R-squared		0.090782

Table A4.4
Mymensingh District of Dhaka Division

Dependent Variable: w_i
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$
Included observations: 218 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
α	1.760342	0.061463	28.64083	0.0000
β_1	0.000986	0.000136	7.267252	0.0000
β_2	-0.021986	0.058632	-0.374973	0.7081
β_3	-0.000428	0.060545	-0.007070	0.9944
β_4	-0.045853	0.058441	-0.784605	0.4336
β_5	-0.013352	0.026084	-0.511888	0.6093
R-squared	0.219623	Adjusted R-squared		0.201218

Table A4.5
Jessore District of Khulna Division

Dependent Variable: w_i				
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$				
Included observations: 195 after adjusting endpoints				
	Coefficient	Std. Error	t-Statistic	Prob.
α	1.722314	0.045277	38.03921	0.0000
β_1	0.001360	0.000208	6.528618	0.0000
β_2	-0.036974	0.049059	-0.753659	0.4520
β_3	-0.010011	0.035915	-0.278745	0.7807
β_4	-0.029190	0.039712	-0.738442	0.4632
β_5	-0.13352	0.02654	-0.735042	0.6099
R-squared	0.189784	Adjusted R-squared		0.172727

Table A4.6
Barisal District of Barisal Division

Dependent Variable: w_i				
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$				
Included observations: 214 after adjusting endpoints				
	Coefficient	Std. Error	t-Statistic	Prob.
α	1.826137	0.026946	67.77094	0.0000
β_1	0.001334	0.000143	9.311875	0.0000
β_2	-0.016296	0.023149	-0.703967	0.4822
β_3	-0.035668	0.028168	-1.266260	0.2068
β_4	-0.017116	0.023298	-0.734656	0.4634
β_5	0.030057	0.033744	0.890741	0.3741
R-squared	0.331507	Adjusted R-squared		0.315438

Table A4.7
Khulna District of Khulna Division

Dependent Variable: w_i				
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$				
Included observations: 203 after adjusting endpoints				
	Coefficient	Std. Error	t-Statistic	Prob.
α	1.808060	0.029148	62.03061	0.0000
β_1	0.001314	0.000164	8.031147	0.0000
β_2	0.051874	0.030654	1.692226	0.0922
β_3	0.008344	0.031363	0.266034	0.7905
β_4	0.013539	0.028527	0.474587	0.6356
β_5	-0.112334	0.034278	-3.277149	0.0012
R-squared	0.282710	Adjusted R-squared		0.264504

Table A4.8
Patuakhali District of Barisal Division

Dependent Variable: w_i
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$
Included observations: 213 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.763098	0.051043	34.54162	0.0000
C(2)	0.001326	0.000178	7.437871	0.0000
C(3)	-0.004927	0.050304	-0.097954	0.9221
C(4)	0.012386	0.047416	0.261229	0.7942
C(5)	0.010669	0.048990	0.217784	0.8278
C(6)	-0.037222	0.032415	-1.148286	0.2522
R-squared	0.213915	Adjusted R-squared		0.194928

Table A4.9
Rangamati District of Chittagong Division

Dependent Variable: w_i
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$
Included observations: 199 after adjusting endpoints

	Coefficient	Std. Error	t-Statistic	Prob.
α	2.115091	0.125727	16.82282	0.0000
β_1	0.000425	0.000159	2.683496	0.0079
β_2	0.019365	0.126207	0.153440	0.8782
β_3	0.017190	0.126104	0.136316	0.8917
β_4	-0.008667	0.124484	-0.069621	0.9446
β_5	-0.064089	0.027024	-2.371517	0.0187
R-squared	0.078364	Adjusted R-squared		0.054487

Table A4.10
Dinajpur District of Rajshahi Division

Dependent Variable: w_i
$w_i = \alpha + \beta_1 * T + \beta_2 * S_1 + \beta_3 * S_2 + \beta_4 * S_3 + \beta_5 * FO_i + \varepsilon_i$
Included observations: 215

	Coefficient	Std. Error	t-Statistic	Prob.
α	0.011851	0.000533	22.24919	0.0000
β_1	0.286522	0.325254	0.880919	0.3794
β_2	0.425286	0.357070	1.191042	0.2350
β_3	0.140037	0.337968	0.414351	0.6790
β_4	-0.173509	0.264479	-0.656041	0.5125
β_5	-0.263178	0.286344	-0.919100	0.3591
R-squared	-26.284094	Adjusted R-squared		-26.93682

Appendix Table A.5
Agricultural activities in Monsoon season (June – September) in Bangladesh and relative flood tolerance of different crops

Crop and its Growing Season		Time of Sowing/ Transplanting	Time of Harvest	Relationship with flood
Aus (Pre-monsoon or Summer Paddy)	Local Broadcast		mid July to early August	Can tolerate only shallow(1) flooding: Harvested prior to monsoon peak flood
	HYV Transplant		July to August	
	HYV Broadcast		Late July to August	
Aman (Monsoon Paddy)	Local Transplant	End June to early September		Can tolerate moderate(1) flooding: Vulnerable to flood during the sowing season, all along the growing period, as well at the time of harvest.
	HYV Transplant	Late June to mid August		
	Broadcast *Aman*	March to April	Late October to November	Resistant to flood, floating variety Vulnerable to flood all along the growing period.
Boro (Winter Paddy)	HYV		Mid April to June	Dry season crop that is cultivated in low lands with some standing water: Harvested prior to peak flood seasons. Require irrigation
Jute	White (Capsularis)		July to August	Can tolerate only shallow(2) flooding: Harvested during peak monsoon floods
	Tossa (Olitorius)		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
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