Are embankments a good flood-control strategy? A case study of the Kosi river *

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1 Introduction

The eastern Gangetic plains and the adjoining floodplain of the Brahmaputra river have suffered from catastrophic floods, not only in recent decades, but far back into recorded history. It is well known that these rivers deposit large amounts of silt and eventually change their course as a result, often causing huge flood damage. Of them, the Kosi, which originates in Tibet and Nepal and joins the Ganges in Bihar, is known to be one of the most dynamic. Between 1736 and 1950, the Kosi shifted its course westwards across north Bihar by some 140 km (Hill 1997). It shifted abruptly by several kilometres once every few years, causing devastation each time. The building of a barrage in Nepal in the 1950's and subsequent embankments along its course in Bihar appear to have halted the movement of the riverbed. But the embankments have breached frequently, with *major* breaches occurring once every six years, on average (Mishra, 2008a). For example, in October 1984, a breach in the eastern embankment in Saharsa district inundated 500 villages, leaving half a million people homeless and killing at least 200 (Hill, 1997).

Embankments were built because it was thought that they would provide flood protection and enable an additional crop to be grown (Appu 1973). However, the building of embankments on the Kosi and other Himalayan rivers with high silt loads was controversial from the start. For example, at the Patna Flood Conference in 1937, the Chief Engineer of Bihar, G. F. Hall, said that he

> gradually came to the conclusion that not only was flood prevention undesirable but that bundhs [embankments] are primary causes of excessive flooding, and I think that a majority of people now agree that provided they are evenly distributed and are of moderate depth, north Bihar needs floods and not their prevention, notwithstanding the numerous articles in the press to the effect that the government must take steps to prevent floods. (Quoted in Mishra (2008c)).

Several authors have called for a strategy of dispersed or "soft" infrastructure to cope with inevitable floods rather than relying on the "hard" infrastructure of embankments (Mishra 2008b; Sinha 2008; Dixit 2009). So far there has not been a cost-benefit analysis of an alternative strategy. In the absence of more comprehensive data, this paper attempts to shed some light on these issues using a survey of 504 households in the Kosi basin following the last major flood in 2008-09.

On August 18, 2008, the Kosi breached its embankment in Nepal close to the Bihar border. The westward loop taken by the river was cut off, flooding a vast roughly triangular area with its apex at the breach and its base at the Kosi where it flows east 150 kilometres to the south. According to official sources 493 people were killed and some 3500 reported missing after the disaster. 3.3 million people in Bihar were affected and at the peak of the flood, 440,000 were living in camps (Anonymous 2010).

In February and March 2009, Rohini Somanathan and I conducted a survey of 10 villages in Bihar that were flood affected. These ten villages, labelled 1-10 in Figure 1 below, were chosen to lie in a roughly north-south line following the course of the floodwaters that ran east of the river bed. Villages 1-8 were flooded by the Kosi after it breached the embankment. They will be referred to as the "unexpectedly flooded villages".

Village 9, near the regular course of the Kosi, and Village 10 near the Ganga, are flooded during the monsoon every year by their respective rivers, so they are adapted to flooding. In fact, both these villages have most of their fields inside an embankment.[1] Some results from the village and hamlet-level data from this survey were reported in an earlier paper (Somanathan and Somanathan 2009).[2]

In April and May 2010, we re-surveyed the 10 villages and surveyed 8 more villages.[3] These villages, numbered 11-18, lie to the west of the eight

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[1] It may seem peculiar that villages would be inside an embankment. The embankments were built several kilometres from the river bed since an attempt at narrower confinement would have been obviously doomed to failure. This meant that villages would have to be moved. It was inevitable that this would not, in fact, happen, given the usual failure of the government to arrange for proper rehabilitation. All this was foreseen and there was a political struggle between villages that thought to benefit from flood control and the "embanked" villages. The latter lost. See Mishra (2008c) for a comprehensive history.

[2] Indian villages often have more than one hamlet. A hamlet is a cluster of houses and may be as much as a kilometre away from another hamlet in the same village.

[3] 28 households were interviewed from each village. A sketch map of each village was made first, and the number of households ascertained. This was divided by 28 to get a number n. The surveyors then traversed the whole village

unexpectedly flooded villages and were chosen for comparison. Our intention was to choose villages that were far enough away that they were not affected by the breach in the Kosi embankment. One of these villages, number 12, has most of its fields inside the embankment of the Kosi (downstream and to the south-west of the breach), so that its fields are flooded by the Kosi every year. The fields of Village 18 are also flooded during the monsoon every year by a small river, the Sursa. Villages 9, 10, 12 and 18, since they are adapted to flooding by rivers during the monsoon, will be referred to as "regularly flooded villages".

The remaining six villages, Villages 11 and 13-17, will be referred to as "control villages" since they are not regularly flooded by river overflow, nor were they unexpectedly flooded due to the embankment breach. It should be kept in mind, however, that such villages may also have localized flooding during the monsoon due to rain collecting in low-lying lands. This is common in the eastern Gangetic plain.

In what follows, the three groups of villages will be compared over the period July 2008 to March 2010. My purpose is to ask whether a strategy of allowing floods but building dispersed infrastructure to cope with them would be better than the current strategy of flood protection based on embankments. I will focus on comparing the regularly flooded villages with the control villages. Note that the regularly flooded group includes two kinds of villages: Villages 9, 10 and 12 that are inside (or have most of their fields inside) embankments on major rivers, the Kosi and the Ganga, and Village 18 that is subject to river overflow from a minor river. By including both kinds I am including what I think are likely to be the effects on different villages of removing embankments. Villages currently protected by embankments but close to a major river are likely to face flooding that may be similar to that faced by Villages 9, 10, and 12. Of course, they are likely to be better off in one respect: floodwaters not confined in embankments are likely to not rise as high. Villages further away from the river

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interviewing every nth household. In each hamlet, a hamlet questionnaire was filled in with at least two respondents to confirm information. The respondent was the household head, if available, and another responsible adult, if not. In the second survey of Villages 1-10, the original respondent was interviewed, if he/she was available. Interviews lasted about one and a half hours.

may, when embankments are removed, find themselves in a situation more like that of Village 18.

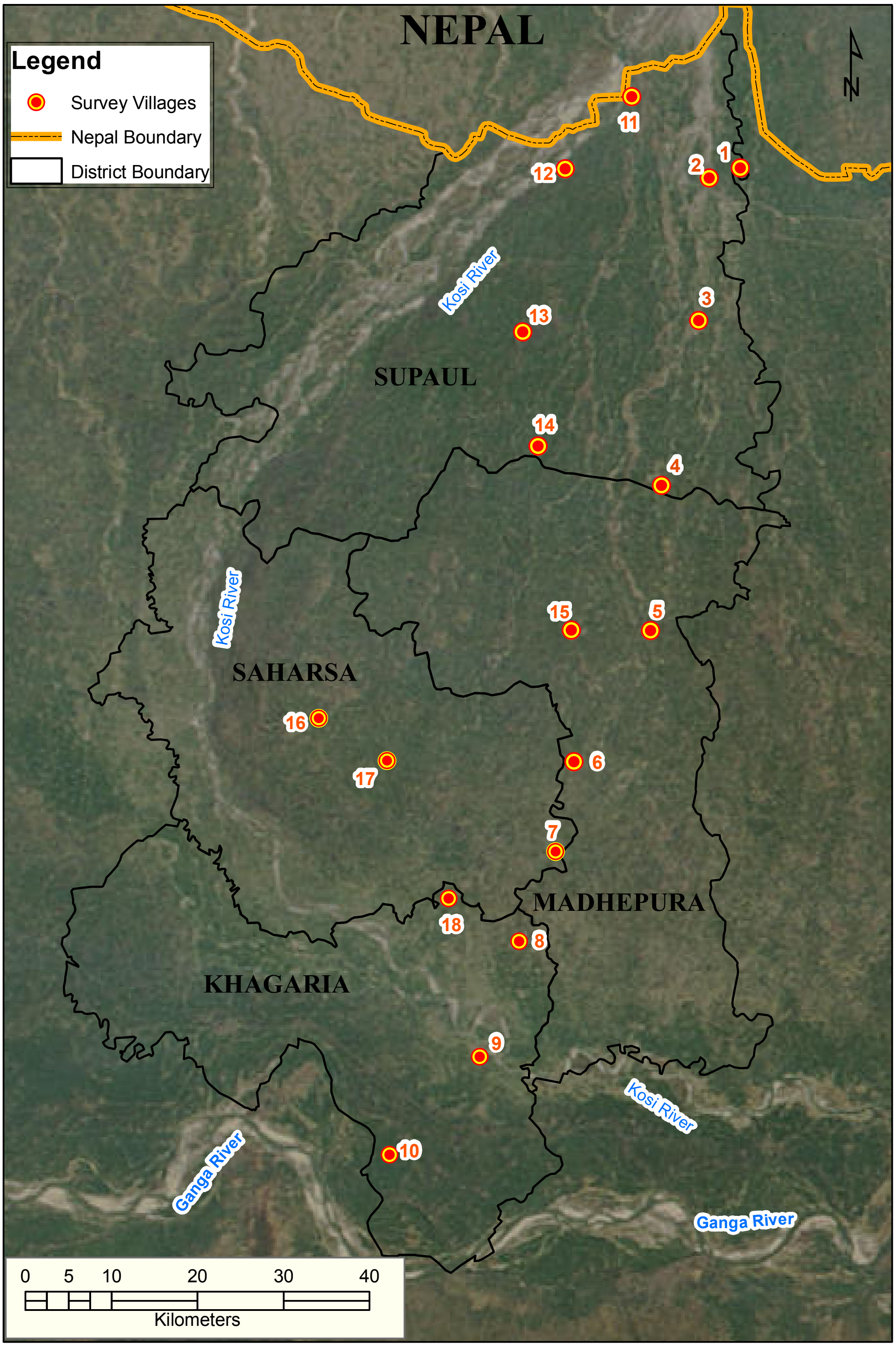
Thus, the regularly flooded group is meant to be a rough proxy for what villages on major riverbanks would be like if their embankment protection were removed *and no compensating infrastructure to help them cope were built*. The control group is meant to proxy their situation under the status quo, (but only in a normal year, when there is no major breach and flood protection really works.)

If it is found that the regularly flooded group are no worse off than the control group, then this would suggest that the embankment strategy of flood control is a mistake, since our comparison does not take into consideration the dispersed or "soft" infrastructure that could be built with the resources currently being expended on embankments, or the damage resulting from the occasional catastrophic embankment breach. The unexpectedly flooded group will provide some information on the lasting impact of a major embankment breach some months after it occurred.

In fact, this is what I do find. With some qualifications, the regularly flooded villages are no worse off than the control villages. A re-allocation of resources from embankments towards dispersed infrastructure and some social security for those whose livelihoods are especially vulnerable to seasonal flooding appears to be called for. G. F. Hall's misgivings about embankments seem to have been well-founded. It is true that this paper presents data for only two monsoons, and there is considerable inter-annual variability in floods. However, I think that at least the burden of proof is now shifted to those who advocate a continuance of the embankment strategy.

In Section 2, I provide some background information on infrastructure and occupational structure in the villages. In Section 3, I compare the gross returns to land among the three types of villages, unexpectedly flooded, regularly flooded, and control villages. In Section 4, I compare the returns to labor and examine food sufficiency. In Section 5, I briefly examine and compare some other characteristics and outcomes among the three groups including schooling, health, and some measures of wealth. Section 6 concludes.

Figure 1: Location of Study Villages



2 Infrastructure and occupations in the Study Villages

The three types of villages are quite similar in the rarity with which household amenities are present. Only about 6% of households in the sample have electricity for lighting and the differences between the three groups are not statistically significant. None of the sampled households have access to piped water (most of them use handpumps), and only about 10% have toilets. Again, the differences in the frequency of these amenities across village types is minor.

Tables 1A and 1B below show that the four regularly flooded villages are not noticeably different from the others with regard to other infrastructure. The exception to this statement is that Village 10 does not have a school at all, which is clearly unusual. Only one other village does not have a school.

Table 1A: Infrastructure in the study villages (continued in Table 1B)

		Number of hamlets with a							
Village number	Number of households	Govt primary school	Private primary school	Middle school	Madrasa (Muslim school)	Primary Health Centre	Primary Health Sub-Centre	Midwife or Nurse	Total hamlets
1	905	1	1	1	1	0	1	1	5
2	140	1	0	0	0	0	0	0	2
3	412	1	0	0	0	0	0	0	4
4	475	1	0	1	1	0	0	0	5
5	1300	1	1	1	1	1	1	1	5
6	129	0	0	1	0	0	0	0	4
7	311	1	0	1	0	0	0	0	2
8	163	1	0	0	0	0	0	1	5
9	460	1	0	0	0	0	0	1	3
10	385	0	0	0	0	0	0	1	1
11	160	1	0	0	0	0	0	1	2
12	459	1	1	1	0	0	0	1	2
13	251	1	0	1	1	0	0	1	4
14	300	1	0	0	0	0	0	1	1
15	191	1	0	1	0	0	1	1	1
16	580	1	0	1	0	0	0	0	2
17	209	1	1	0	1	0	0	0	1
18	526	1	0	1	0	0	0	1	1

Note: None of the study villages had a high school. Regularly flooded villages are shaded.

Table 1B: Infrastructure in the Study Villages, continued.

Village number	Childcare centre	Money Lender	Govt fair price shop	Paved road	Unpaved road	Bank	Post office	Total hamlets
1	1	0	0	5	5	0	0	5
2	1	0	0	0	2	0	0	2
3	1	0	0	4	0	0	0	4
4	2	0	0	5	5	0	0	5
5	5	0	1	5	5	1	1	5
6	0	0	0	4	4	0	0	4
7	1	1	1	2	2	0	0	2
8	1	1	0	0	4	0	0	5
9	1	1	1	3	0	0	1	3
10	1	0	0	1	0	0	0	1
11	2	0	0	2	2	0	0	2
12	2	0	0	2	2	0	0	2
13	1	1	0	4	4	0	1	4
14	1	0	0	1	1	0	0	1
15	1	1	1	0	1	0	0	1
16	2	0	0	2	2	0	1	2
17	1	0	1	1	1	0	0	1
18	1	0	0	1	1	0	0	1

Note: Regularly flooded villages are shaded.

Farmers, that is, the owners or operators of farms, constituted about 34% of the workforce in the sample, while wage workers in agriculture constituted about 10%. Casual (daily-wage) workers outside agriculture were another 36% of the labor force, and about 8% of the labor force was unemployed (Table 2). Of the 20,000 person-months in the labor force from July 2008 to March 2010, more than 18000 were man-months. The workforce was overwhelmingly male, at least as reported by respondents. This might understate female labor force participation since that could have been considered a secondary occupation in the case of many women.

Table 2: Percentage of person-months out of those in the labor force in various main occupations in a given month from July 2008 to March 2010.

Main occupation	Unexpectedly flooded villages	Regularly flooded villages	Control villages	All villages
Wage worker in agriculture	11	12	8	10
Self-employed in agriculture (farmer)	31	41	36	34
Daily-wage worker outside agriculture	38	35	33	36
Salaried worker outside agriculture	4	3	8	5
Self-employed outside agriculture	10	5	5	7
Unemployed	7	4	11	8
Total percentage	100	100	100	100
Total person-months in labor force	9,282	4,179	6,552	20,013

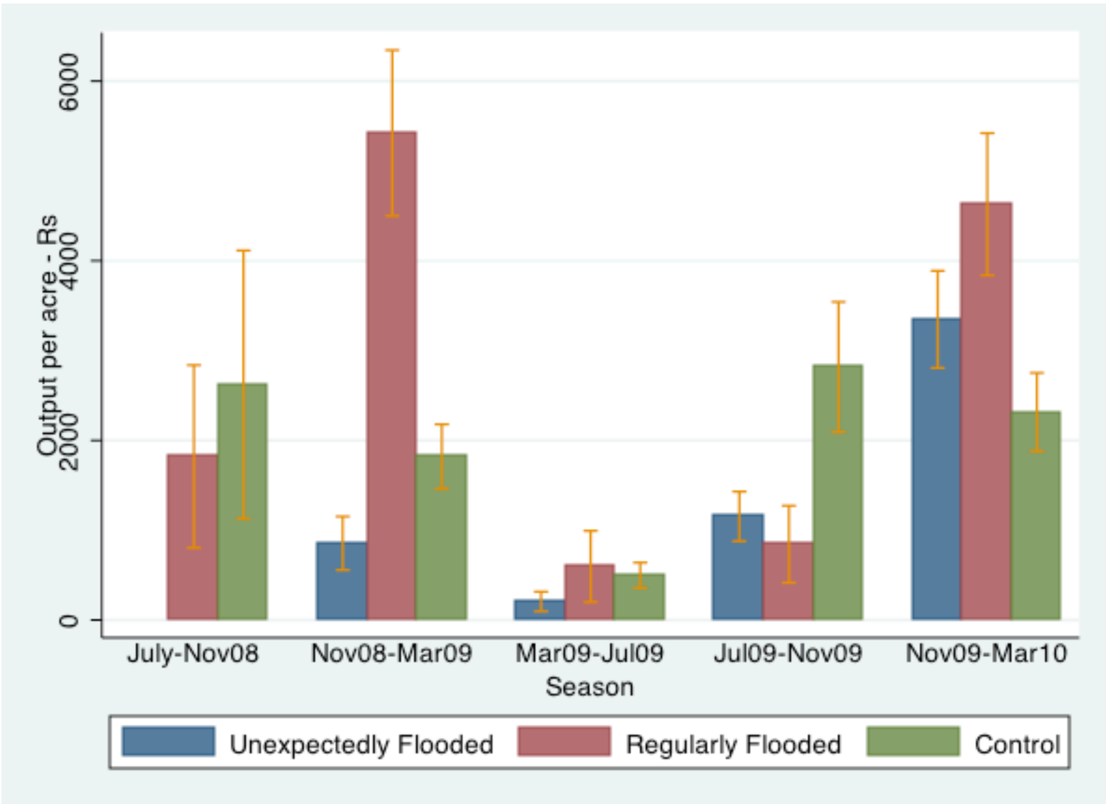
Note: Columns may not add to exactly 100 due to rounding. Note that the unemployment rate if measured on a daily basis would probably be higher.

3 The returns to land compared

Since agriculture constituted a large share of the labor force, we first examine the effects of flooding on crop output. A second reason for comparing agricultural productivity in the three types of villages is that land, unlike labor, is immobile. Thus, while the effects of flooding on the returns to labor might be spatially diffused via migration, the returns to land cannot be. We did not collect data on input costs, so the returns to land mentioned below are gross returns, not net returns. There is no reason to believe that this would bias the comparisons being made.

Figure 2 below shows the total value of crop output per acre owned or operated by households. Note that the denominator is not cultivated acres, but all acres, cultivated and uncultivated. Thus it takes into account the loss of output when lands are left uncultivated due to floods.

Figure 2: Rupee value of output per acre of cultivable area.



Note: Bars are means taken over all households in each group. 95% confidence intervals are superimposed. The data above for the Regularly Flooded villages in July-November 2008 are from only Villages 12 and 18 because we did not collect data for that season in Villages 1-10.

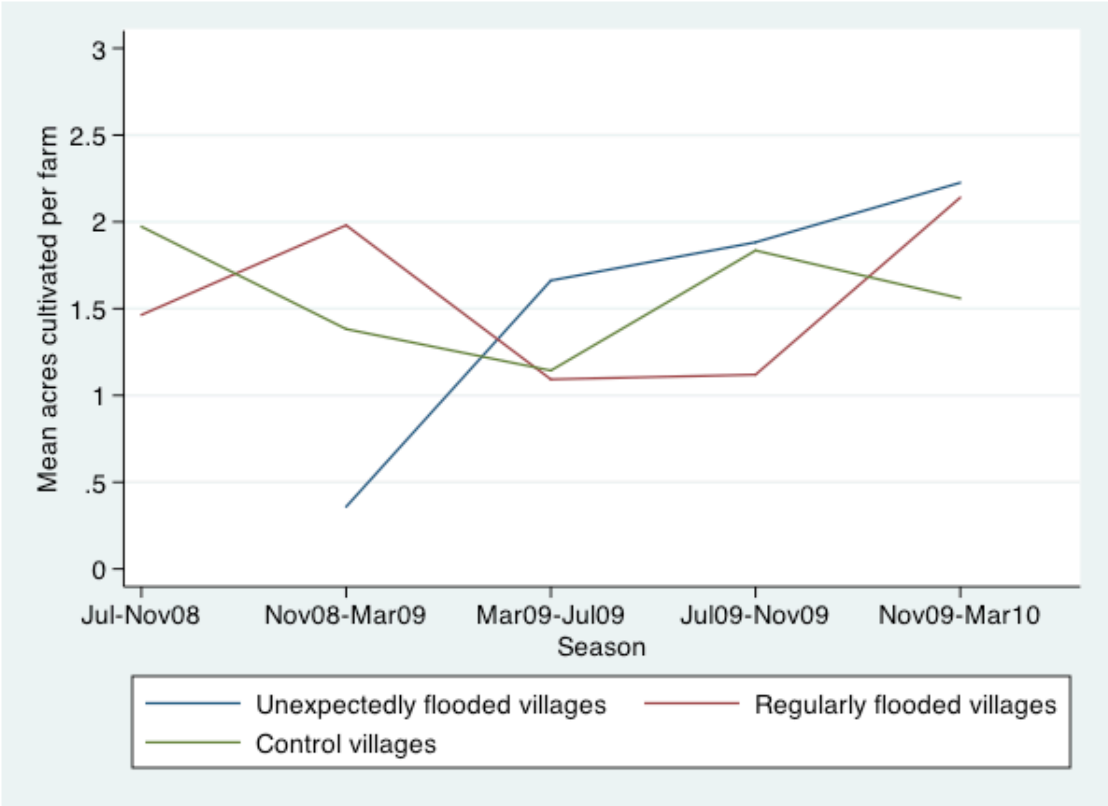
The monsoon arrives in Bihar in mid-June and lasts till September. This is the Kharif cropping season and paddy is the most common crop. However, if flooding is severe, there may be no Kharif crop. Following the Kharif season, maize and wheat are the most common crops, generally planted in November. The November-March season is known as the Rabi season. Following the Rabi season, fields are sometimes left fallow during the spring and summer, but may be planted with a third crop, for example jute, pulses, paddy, or maize. We did not collect data on crop output in the Kharif (July to November) season of 2008 in the flooded villages since the crop (mostly rice) was entirely destroyed by the unexpected flood. However, it is possible that in Villages 9 and 10, where flooding was expected, crop output may have been positive. Unfortunately, we do not have these data.

What is immediately striking from this figure is the high Rabi (winter) output (mostly maize and wheat) in the two regularly flooded villages. Villagers say that this is due to silt deposition from flooding. This winter yield is large enough that it compensates for the very limited Kharif crop so that over the course of an agricultural year, output per acre is about the same as in the control villages. To be precise, over the three successive seasons starting with the 2008-09 Rabi season, the value of output per acre in the regularly flooded villages exceeds that in the control villages by Rs 1103/acre, with the difference not being statistically significant ($p = 0.17$). If we instead aggregate over three successive seasons starting with the 2009 summer season, we find that output per acre in the regularly flooded villages falls below that in the control villages by Rs 116/acre with the difference again not statistically significant ($p = 0.90$).

The patterns in the value of output per acre of farmland are broadly consistent with the data on the mean acreage cultivated per farm given in Figure 3 and 4 below. The fall in acreage planted, and hence in output, in the regularly flooded villages during the monsoon season of 2009 is clearly because of flooding. On the other hand the recovery in acreage cultivated in the unexpectedly flooded villages must be due to the decline in waterlogging over time.[4]

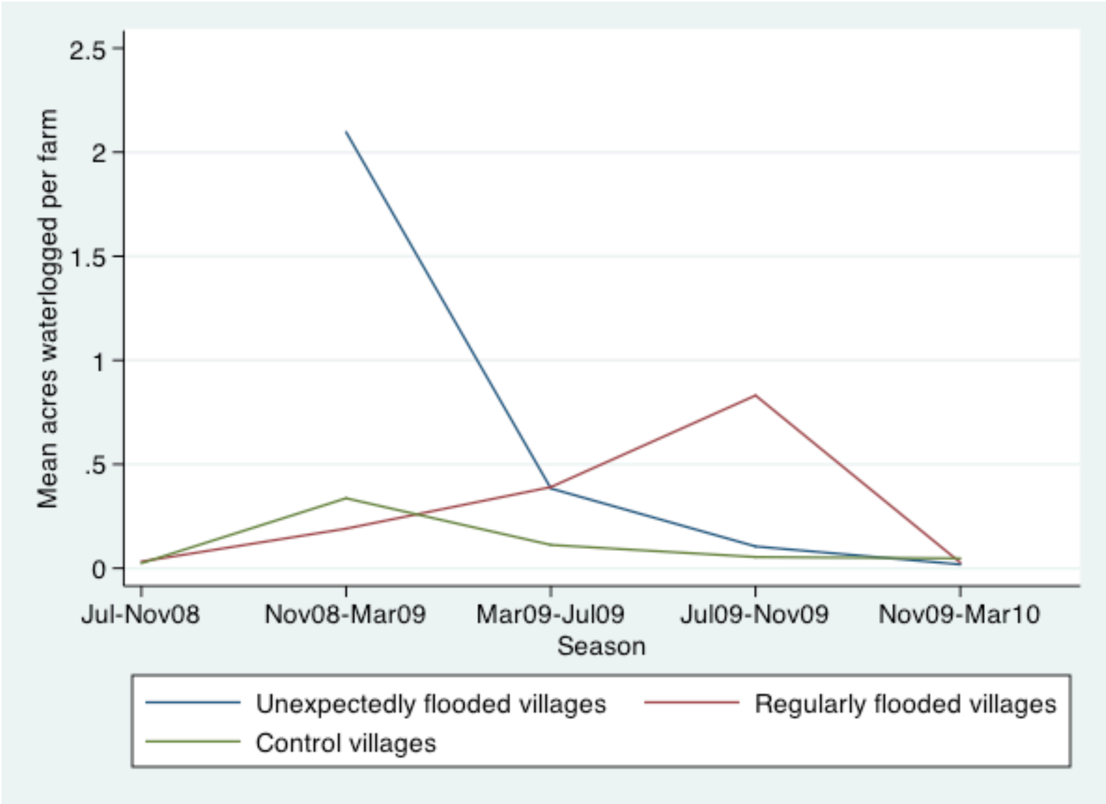
[4] The other major reason for land being uncultivable was sand deposition. This was worst in villages nearest the embankment breach and is a much longer-lasting problem.

Figure 3: Mean acreage planted per farm



This is confirmed in Figure 4 below which shows mean acres waterlogged per farm.

Figure 4: Mean acres waterlogged per farm



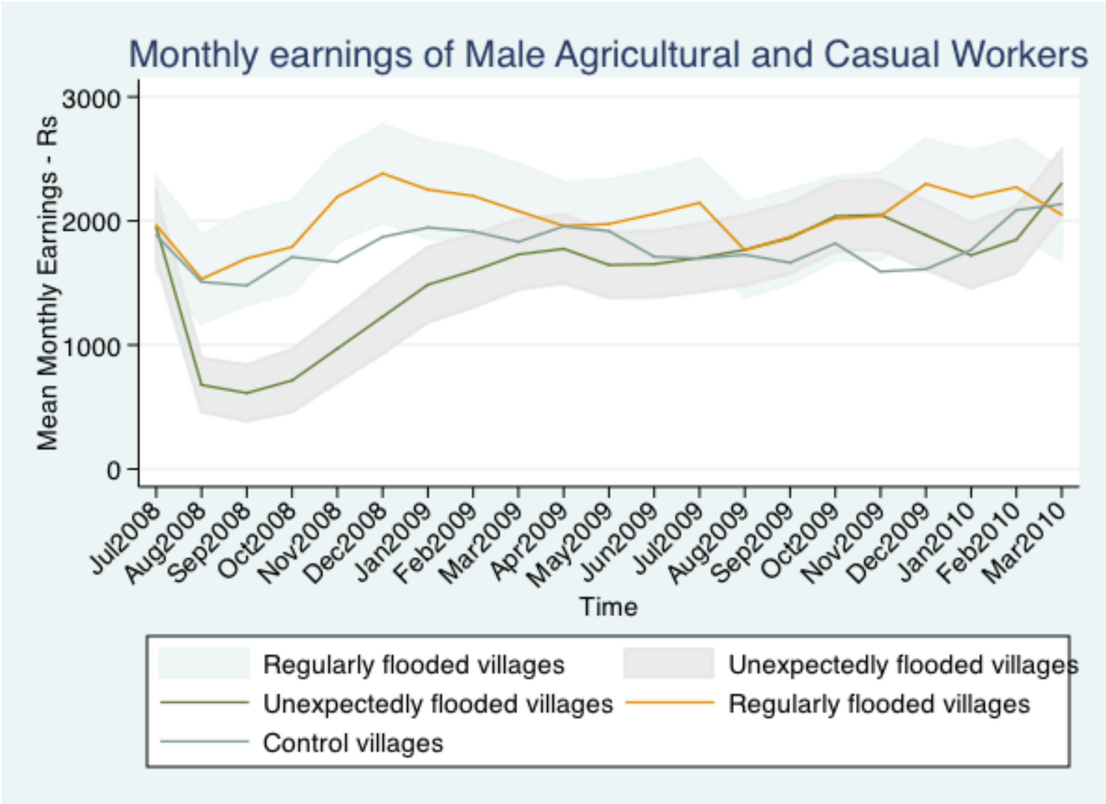
4 Labor earnings and food sufficiency compared

I focus on male workers employed in agriculture and other daily wage workers since these constitute a majority (72%) of wage earners and are poorer and less secure than those with permanent employment.

The impact of the loss of earnings from the flood in the villages that suffered from the embankment breach is clearly visible in Figure 5. Although less sharp, the two regularly flooded villages also suffered a loss of earnings during the monsoons of 2008 and 2009. The eight control villages show a dip in earnings during the 2008 monsoon, though not during the 2009 monsoon. It is clear from Figure 5 that the differences in earnings between the three types of villages are not statistically significant except during the months immediately following the embankment breach when Villages 1-8 suffered disastrous damages. By the second quarter of 2009, average earnings in these villages had recovered to their pre-flood level and are no longer distinguishable from those in the other two categories of villages.

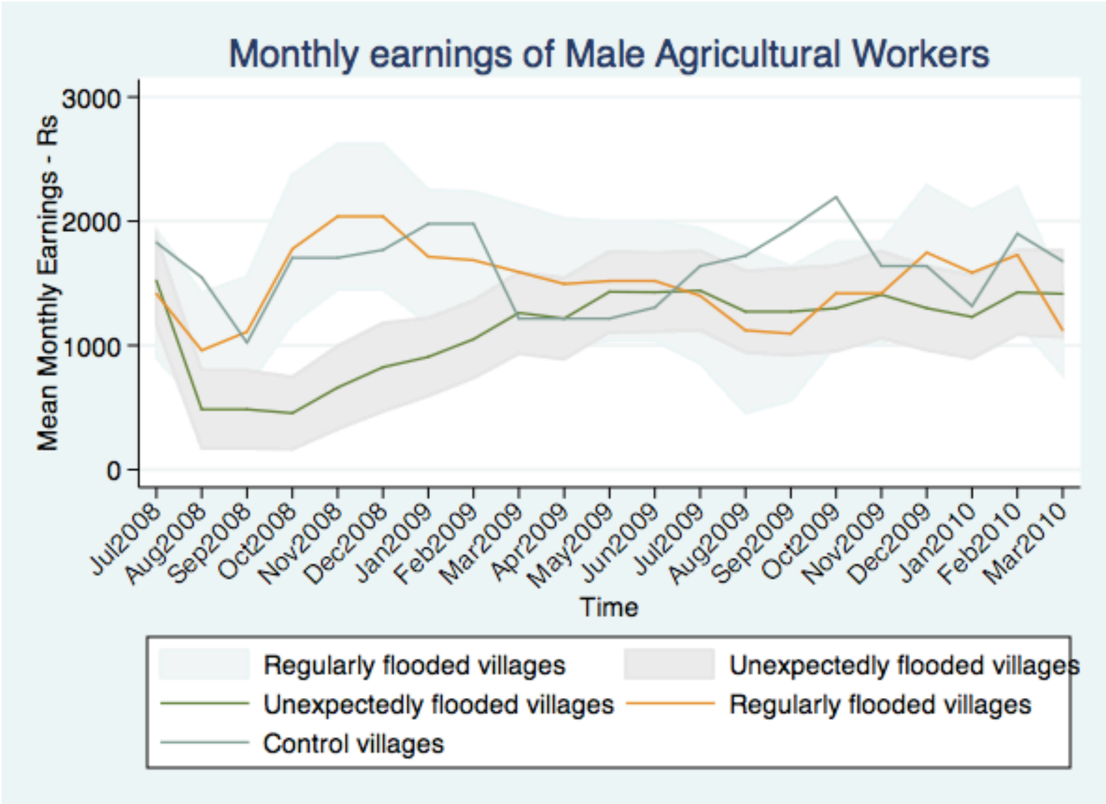
Since about 80% of the wage workers are not in agriculture, it is perhaps not so surprising that the impact of flooding in the regularly flooded villages on mean monthly earnings is not very marked. Figure 6 shows mean monthly earnings of only workers in agriculture. Not surprisingly, the decline in earnings in the regularly flooded villages during the monsoon season is greater in this figure.

Figure 5



Note: 95% confidence intervals for the Unexpectedly and Regularly Flooded Villages are shown as shaded areas.

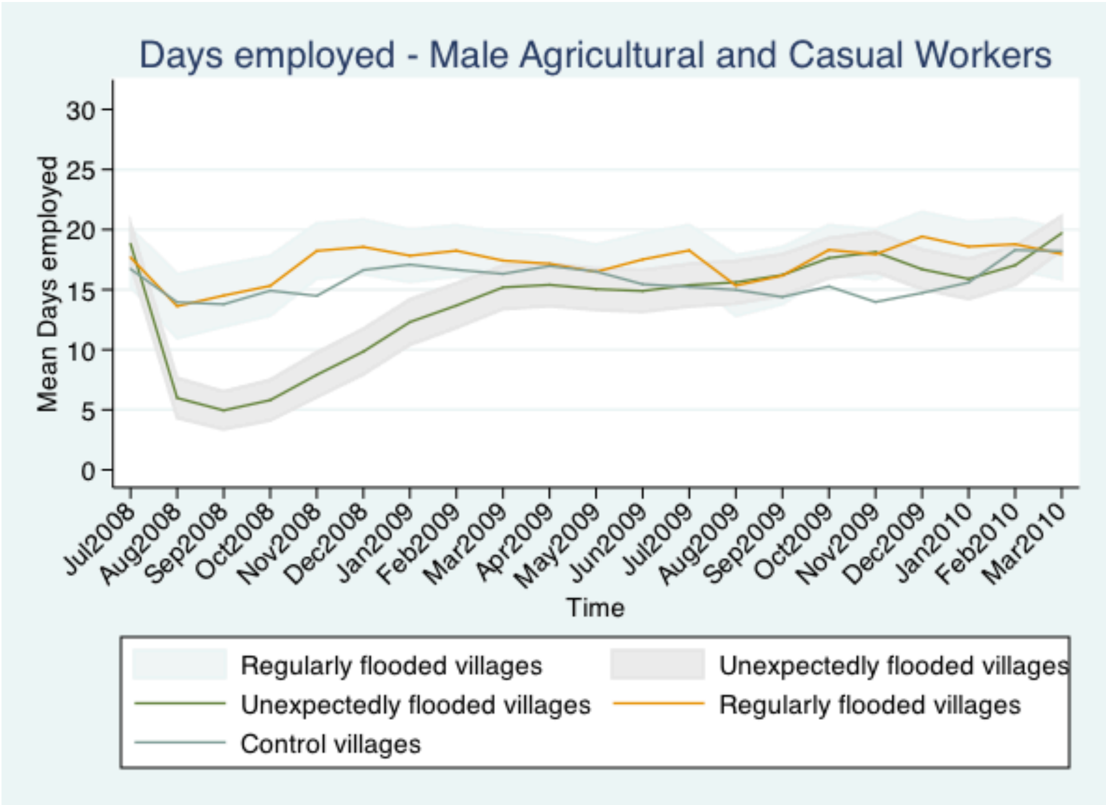
Figure 6



What is perhaps most surprising about these figures is that *there is no significant difference in mean monthly earnings between the two regularly flooded villages inside embankments and the control villages*.

Figure 7 below shows days employed.

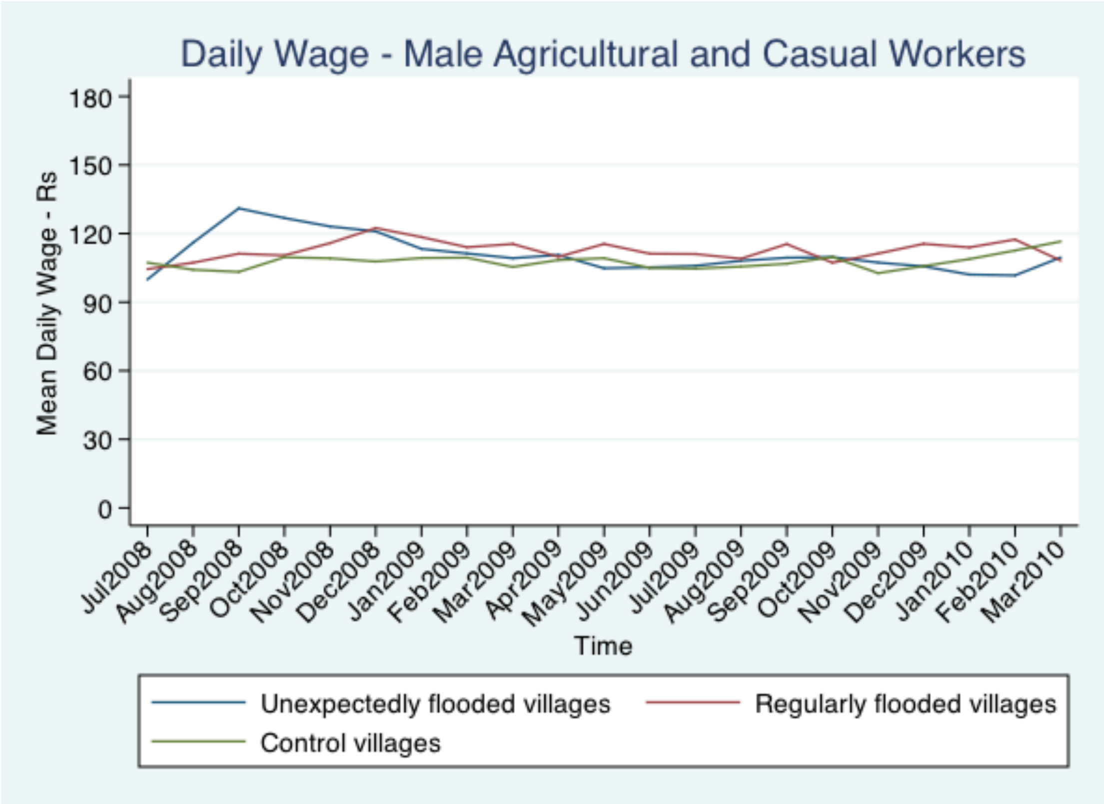
Figure 7



Note: 95% confidence intervals for the Unexpectedly and Regularly Flooded Villages are shown as shaded areas.

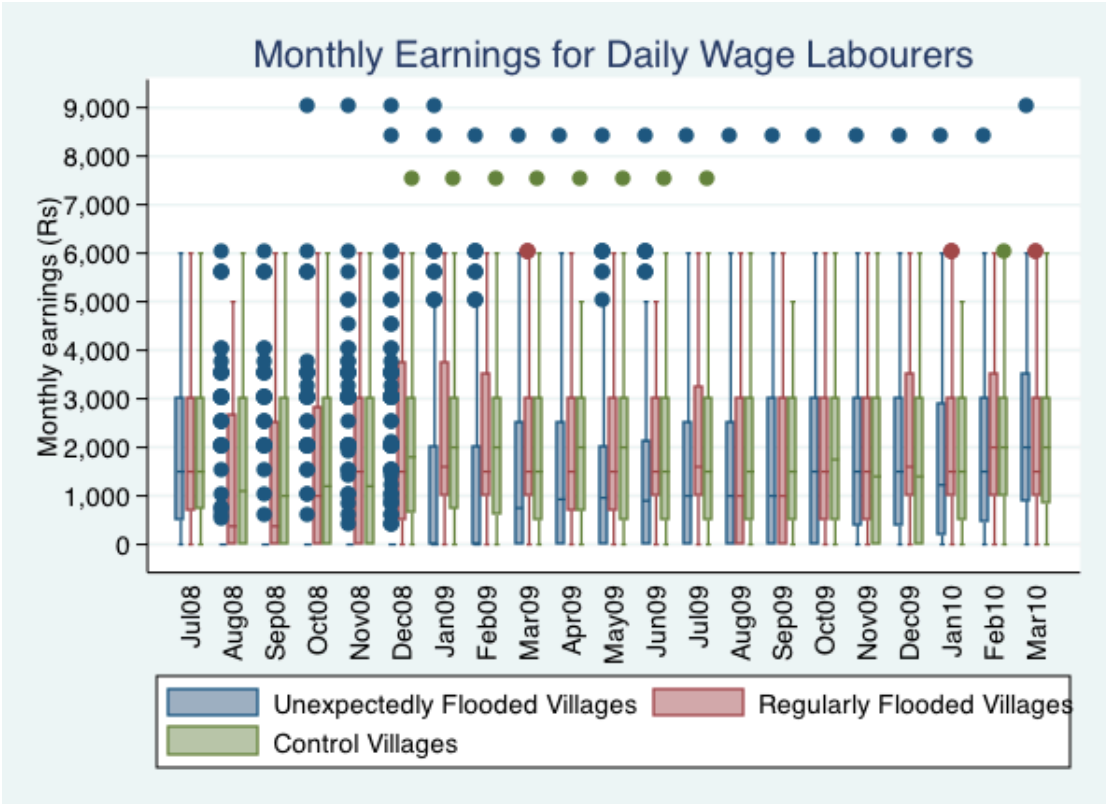
The pattern is exactly the same as for monthly earnings. What this shows is that the collapse of earnings in Villages 1-8 due to the embankment breach was driven by a loss of employment and not by a fall in the daily wage. Figure 8, which plots monthly earnings divided by days employed, confirms this impression. In fact, the slight *rise* in the daily wage during periods of flood suggests that individuals over-stated the loss in employment during such periods. Since these data are all based on recall over a period of at least a few months, this is not surprising. In any event, it is clear that wages did not fall in response to even massive negative shocks to labor demand, although the features of the labor market that are responsible for this are not clear.

Figure 8



This being the case, it is possible that the loss of earnings from a reduction in the demand for labor during floods could be unequally distributed among workers. Some may be unemployed more frequently than others. In this case, mean monthly earnings will not sufficiently capture the losses to these workers. We need to examine the entire distribution of earnings. Figure 9 below plots measures of the distribution of monthly earnings among adult male casual and agricultural workers in the sample households, by village type for each month.

Figure 9



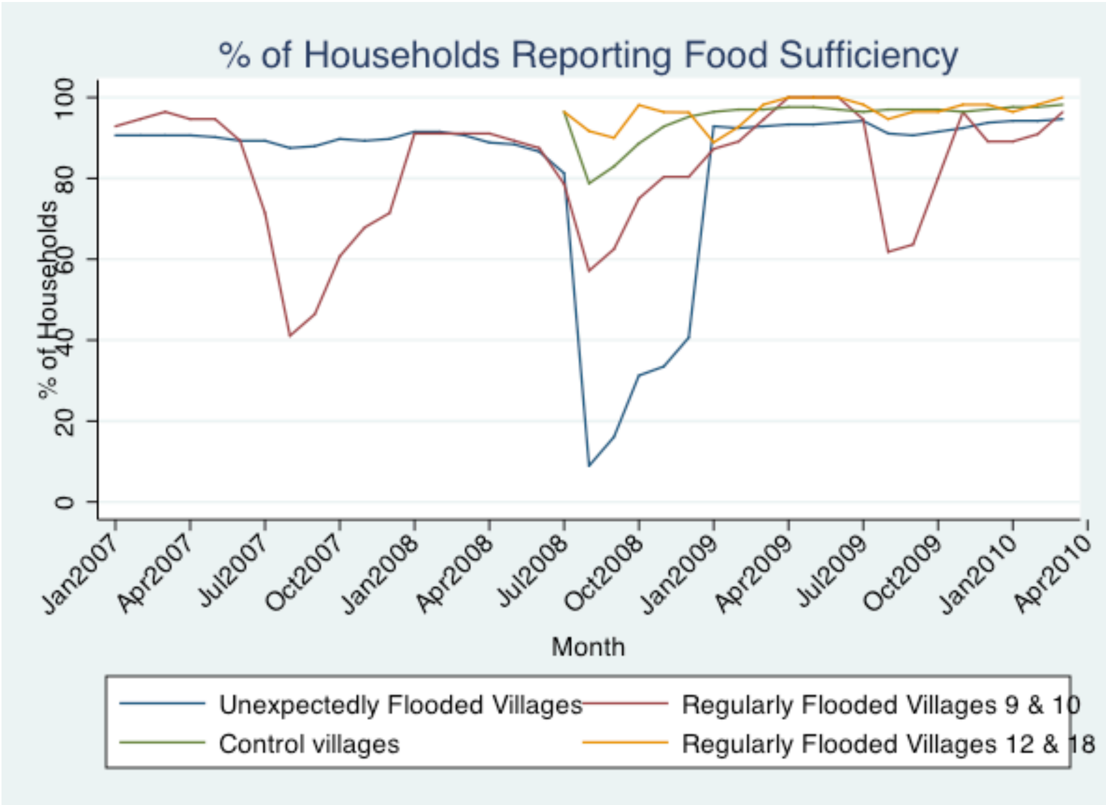
Note: The ends of each box are the 25th and 75th percentiles of the sample distribution, the horizontal line in each box is the median, while the ends of the whiskers are the upper and lower adjacent values. The adjacent values are the most extreme values within 1.5 times the inter-quartile range of the nearer quartile. Circles denote outliers, that is, observations beyond the adjacent values.

Our suspicion above is confirmed. During the monsoon seasons of 2008 and 2009, in the regularly flooded villages a quarter or more of workers in the sample had zero earnings. Clearly, the relatively small dips in mean monthly earnings in these villages during the monsoon does not capture the full extent of wage losses from flooding. Presumably, as suggested by the data on crop output (Figure 2) and agricultural earnings (Figure 6), agricultural workers were the ones at the bottom of the earnings distribution during times of flooding.

This look at the distributions also shows that the fall of earnings in the bottom quartile in the unexpectedly flooded villages persisted into October 2009, six months longer than the apparent recovery of mean earnings.

Another way to examine the impacts of flooding on the poor is to look at food sufficiency. The sampled households were asked in which months they got three full meals a day. Figure 10 below displays the resulting picture.

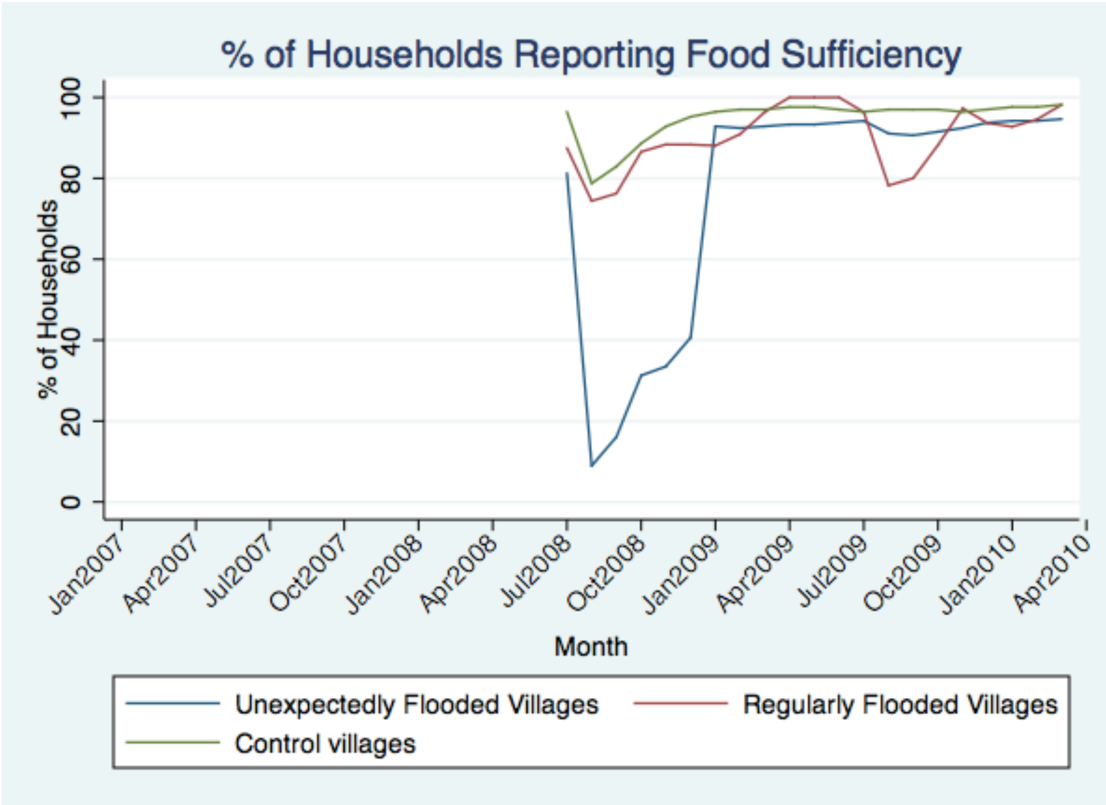
Figure 10:



There are steep dips in the fraction of sample households getting adequate food during the monsoon months when flooding occurs. This is consistent with the collapse in wage earnings at the bottom of the distribution during periods of flooding. The worst impact was, of course, due to the embankment breach in August 2008. However, the regularly flooded villages 9 & 10, both of which have fields inside embankments, also saw steep declines in the fraction of households getting three full meals a day. The other two villages that are regularly subject to flooding by rivers, only one of which has fields inside an embankment, are not as badly affected. Indeed, they were not even as badly affected as the control villages in 2008 and 2009, the two years for which we have data on all villages.

If we club the regularly flooded villages together and graph the data for 2008 and 2009 alone, we see that the regularly flooded villages had lower food sufficiency than the control villages in 2009 but not in 2008 (Figure 11). The worse performance of the regularly flooded villages on this score is clearly driven only by Villages 9 & 10 (both inside embankments).

Figure 11



The results so far show that the returns to land in the regularly flooded villages are no lower, on average, than in the control villages. Nor are the returns to labor. However, flooding results in both agricultural output and labor earnings at the bottom of the distribution being much more volatile over the course of a year in the regularly flooded villages than in the control villages because the latter are less subject to flooding. This results in the poor being worse off in some years in the regularly flooded villages as evidenced by the data on food sufficiency. It must be remarked, however, that this is driven entirely by villages inside embankments, and is not the case for Village 18 although it is flooded by the Sursa river every year.

5 Other outcomes compared

We compare the villages in terms of levels of schooling achieved in Table 2 below. The three types of villages do not appear very different in this regard.

Levels of educational attainment are very low. The mean for adult women is about 2 years of schooling and that for men about 5 years of schooling.

Table 2: Schooling outcomes

	Regression 1: Age group 0-18	Regression 2: Age group 18+
VARIABLES	Years of Schooling	Years of Schooling
Age in years	0.441***	
	(0.0288)	
Sex (1 if Male)	0.896***	2.985***
	(0.183)	(0.171)
Unexpectedly flooded village = 1	0.0289	0.411
	(0.254)	(0.376)
Regularly flooded village = 1	-0.171	-0.534
	(0.403)	(0.541)
Constant	-1.745***	1.994***
	(0.287)	(0.232)
Clusters	412	504
Observations	1,117	1,714
R-squared	0.269	0.099

Note: Ordinary Least Squares. Standard errors clustered by household in parentheses

*** p<0.01, ** p<0.05, * p<0.1

I turn to health outcomes, on which we have self-reported data based on recall over the period January 2009 to March 2010. It might be expected that villages more prone to flooding have a higher incidence of diarrheal disease and other infectious diseases. Cases of diarrheal disease and other infectious disease were, in fact, no more frequent in the regularly flooded villages than in the control villages over the whole period among the 3213 individuals in the sample.[5] However, these illnesses were more frequent in the unexpectedly flooded villages than in the controls or in the regularly flooded villages, and the differences are statistically significant at the 5% level for diarrheal disease, and at the 1% level for all infectious diseases put together. These results hold when controlling for age and sex. When one includes all other diseases, there are no statistically significant differences between the different classes of villages. These results suggest that there was an increase in infectious disease in the unexpectedly flooded villages following the disaster and the attendant waterlogging. However, the regularly flooded villages were no worse off than the controls.

Next, I ask whether the three types of villages show any differences in measures of wealth such as ownership of consumer durables, farm equipment, livestock, and financial assets.

Only about 5% of the 504 sample households owned TV sets, not surprising in view of the limited access to electricity. About 20% owned a radio or TV (or both). About 66% of households had at least one telephone.[6] There were no statistically significant differences in the ownership of any of these goods between village types, nor in the total value of such goods owned.

The total value of agricultural equipment (pumpsets used for irrigation, threshers, tractors) and vehicles (bicycles, motorcycles, cars and jeeps, bullock carts) showed no statistically significant difference across village types. Except for bicycles, ownership of these goods was rare, with fewer than 10% of households possessing them. 55% of households owned bicycles and they were more common in the control villages than in the other two groups, with the differences being statistically significant at the 1% level.

The average holding of large livestock (cows, bull and bullocks, and buffaloes) in March 2010 was 1.3 head per household, with this number being about 1.5 for the regularly flooded and control villages, and about 0.8 for the unexpectedly flooded villages. In July 2008, before the flood, the unexpectedly

[5] These disease frequencies were, in fact, slightly lower in the regularly flooded villages than in the control villages.
[6] These were most likely nearly all mobile phones.

flooded villages had about 0.8 head per household more large livestock than the other two groups. Livestock loss was clearly considerable in the unexpected flood. In both periods, the difference between the regularly flooded and control villages was not statistically significant.

About 39% of the sample households had bank accounts. This percentage was 32% in the control group, 35% in the regularly flooded group, and 47% in the unexpectedly flooded group. Only the difference between the unexpectedly flooded group and the other two is statistically significant. The differences in reported savings, either in bank accounts or cash, between the groups was not statistically significant at the 10% level. This could be because the less wealthy households in the unexpectedly flooded villages had drawn down their assets after the flood. It could also be due to systematic under-reporting of the amounts.

6 Conclusions

The most striking finding from the comparisons between regularly flooded and control villages made here is that the gross value of crop output in the regularly flooded villages is higher, or at least no lower, than that in the control villages. This is especially striking since three out of four of the regularly flooded villages in this sample are located inside embankments, and therefore, are highly exposed to seasonal and concentrated river flooding. The second major finding is that mean wages of agricultural and casual workers are no lower in these villages than in the controls. Third, these villages do no worse on measures of schooling, health, wealth and household amenities.

There is one big difference between these villages and the controls, and that is that agricultural output varies much more sharply over the year. This results in dips in the proportion of households getting sufficient food during the monsoon. Although this pattern was also seen in the control villages in 2008 when some of them suffered flooding from heavy rain, it did not appear in the control villages in 2009. Poor workers evidently lack the means to smooth consumption between seasons, and the loss of the monsoon crop to flooding causes them to go hungry during the monsoon.

The results on crop output, mean wages, assets and other measures of welfare such as schooling and health indicate that the regularly flooded villages , three of them with most of their fields inside embankments on major rivers, are no worse off than the controls that are not near rivers. Being exposed to river flooding does not appear to be a bad deal after all. These results suggest that a strategy of gradually moving away from reliance on embankments and instead building infrastructure to live with floods would (1) Not result in a net loss of agricultural or other output or health, etc., (2) Save large sums of money currently going into embankment maintenance, and (3) Prevent the apparently inevitable disasters that occur every few years when there is a major embankment breach. The infrastructure to replace embankments, apart from obvious measures like raising buildings on stilts and digging new channels for river flow, should include the social infrastructure of employment generation or other social security during the monsoon for areas that will face increased flooding.

It is possible that data from a larger sample of villages over a longer period of time would overturn these conclusions. Until and unless such data emerge, the burden of proof is now on those who would advocate continuing with the current strategy of flood control by embankment.

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