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

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Background

- Between 1736 and 1950, the Kosi shifted its course westwards across north Bihar by some 140 km (Hill, 1997).
- 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 river bed.
- These had occurred in discrete jumps every few years causing floods that led the Kosi to be called the "river of sorrow".
- But the embankments have breached frequently, with *major* breaches occurring once every six years, on average (Mishra, 2008). 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).

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.

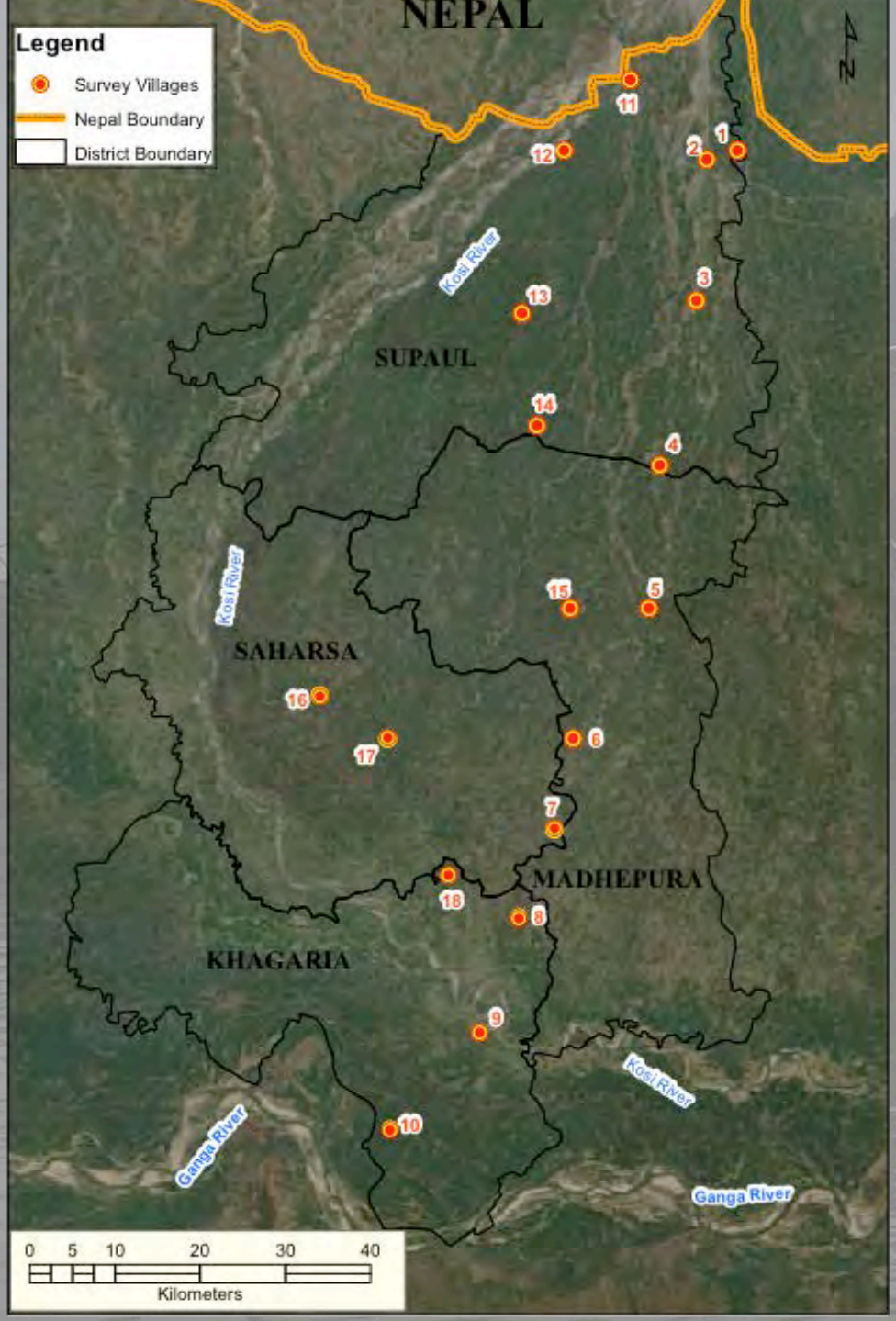
This paper provides some inputs for such an analysis.

The August 2008 flood

- On 18 August 2008, the Kosi breached its embankment in Nepal sending water flooding into northern Bihar.
- 493 people were reported killed and 3500 missing after the disaster.
- 400,000 people were displaced with nearly a thousand villages containing 3.3 million people affected.

Surveys

- Rohini Somanathan and I conducted a survey of 10 villages in March-April 2009 to examine the impact and the recovery process.
- Second round in April-May 2010 plus 8 more villages.
- 28 households surveyed in each village using systematic random sampling.
- Total of 504 households in 18 villages.

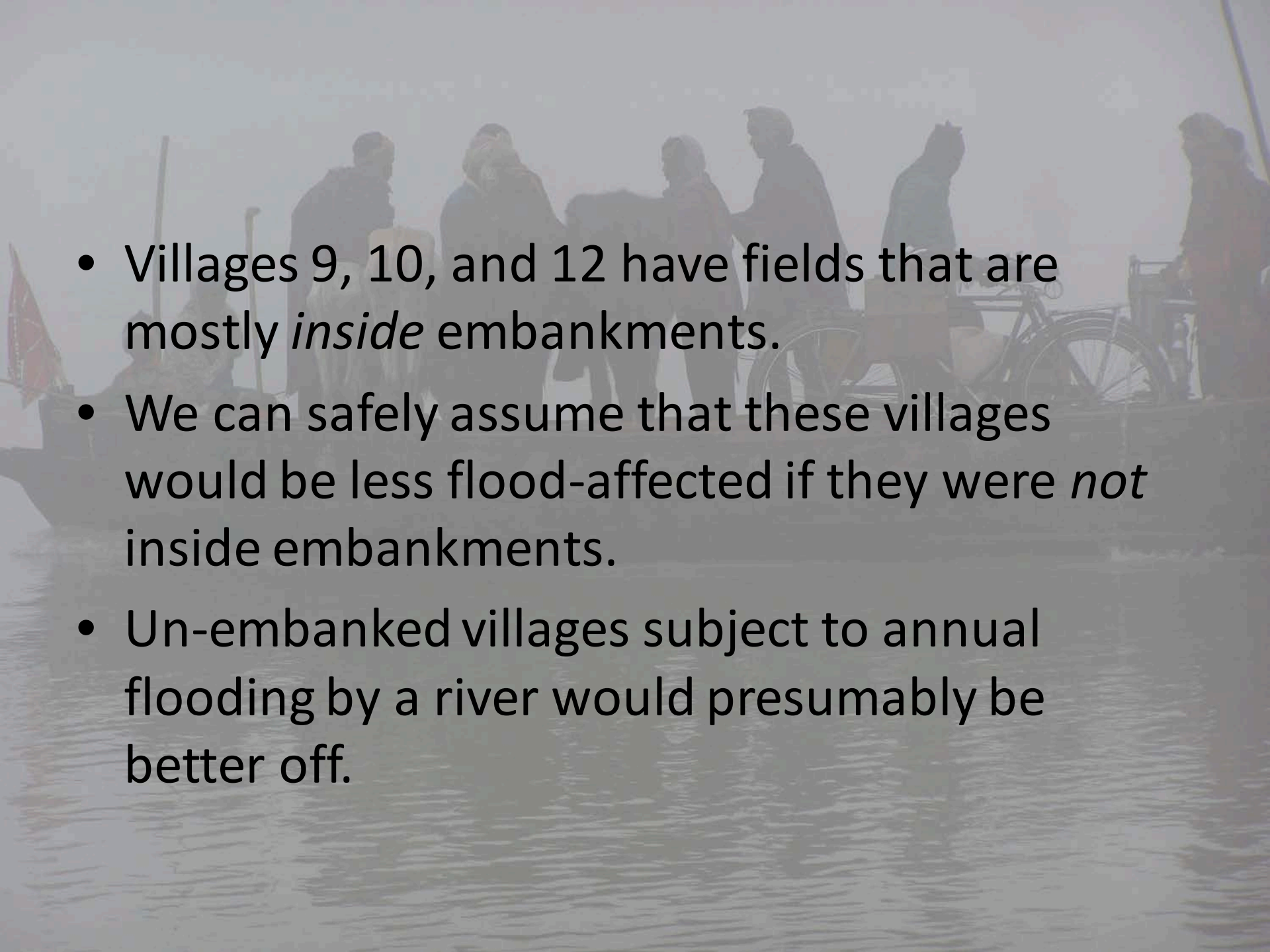

NEPAL
Legend
Survey Villages
Nepal Boundary
District Boundary
SUPAUL
SAHARSA
MADHEPURA
KHAGARIA
Kosi River
Kosi River
Kosi River
Ganga River
Ganga River
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
0 5 10 20 30 40
Kilometers

Typology of villages

- Can we use these data to examine the role of embankments?
- Village type 1: Villages 1-8, **unexpectedly** flooded by the Kosi.
- Village type 2: Villages 9, 10, 12, 18 **regularly** flooded (9 & 12 by the Kosi, 10 by the Ganga, 18 by the Sursa).
- Village type 3: No river flooding.

Strategy

- Compare Type 2 (regularly flooded) villages with Type 3 (not affected by river flooding) villages.
- Type 2 are a proxy for villages unprotected by embankments and prone to river flooding.
- Type 3 are a proxy for villages protected by embankments (since they are not affected by river flooding).



- Villages 9, 10, and 12 have fields that are mostly *inside* embankments.
- We can safely assume that these villages would be less flood-affected if they were *not* inside embankments.
- Un-embanked villages subject to annual flooding by a river would presumably be better off.

- Thus, if Type 2 villages are no worse off than Type 3 villages, we may conclude that embankments don’t help.
- Moreover, Type 1 villages show us that embankments lead to huge damages once in a while.
- This is what we actually find. It undermines one of the major points in favour of embankments.

Background data - Infrastructure

- Only about 6% of households in the sample have electricity for lighting.
- None of the sampled households have access to piped water (most of them use handpumps).
- Only about 10% have toilets.
- The frequency of these amenities is very similar in all three types of villages.

Amenities

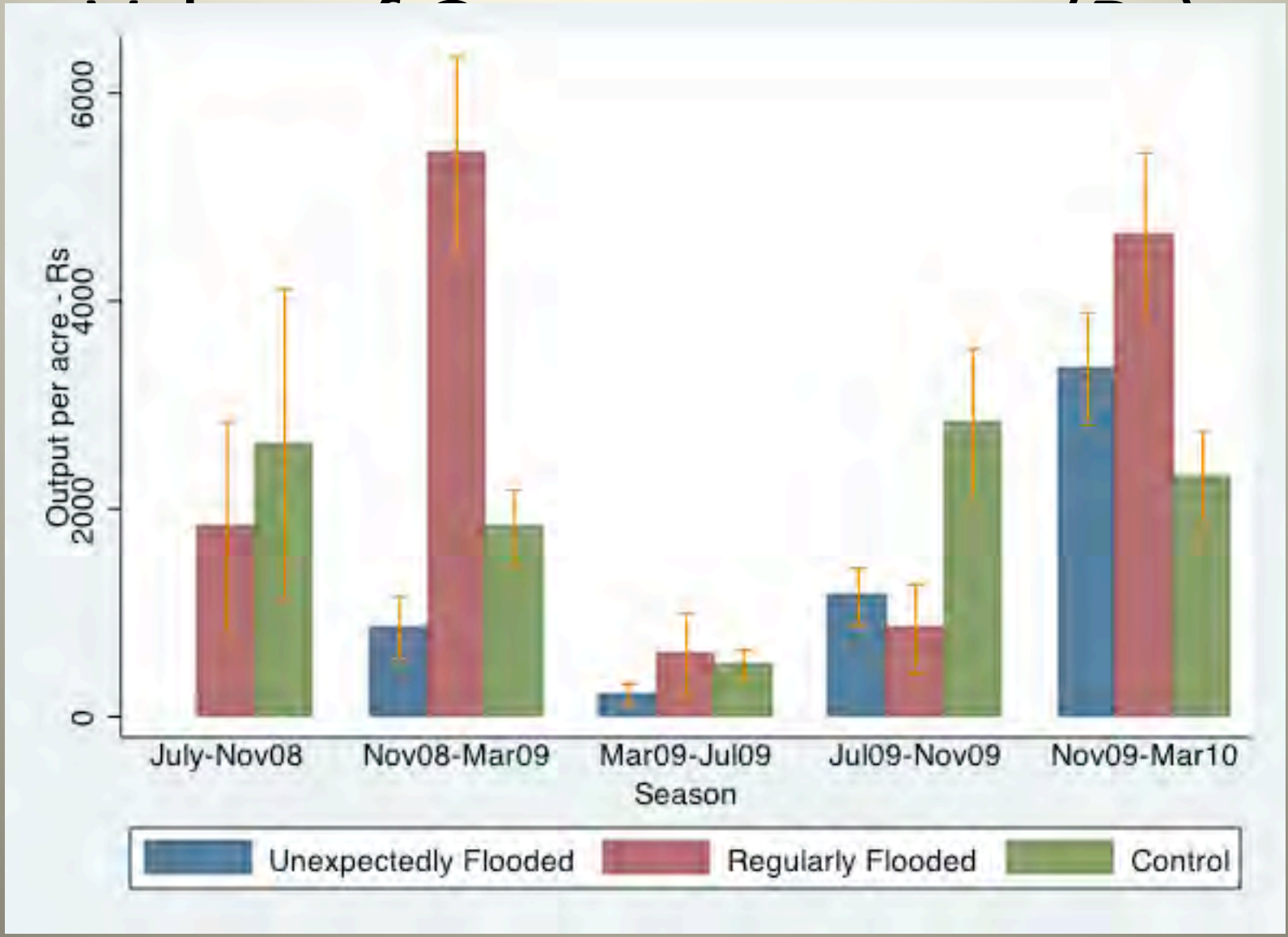
- Nearly all the villages have a government primary school.
- Only 2 have a primary health centre or sub-centre.
- All the Type 2 villages have mid-wives. These are less frequent in Type 1 & Type 3 villages.

Occupations

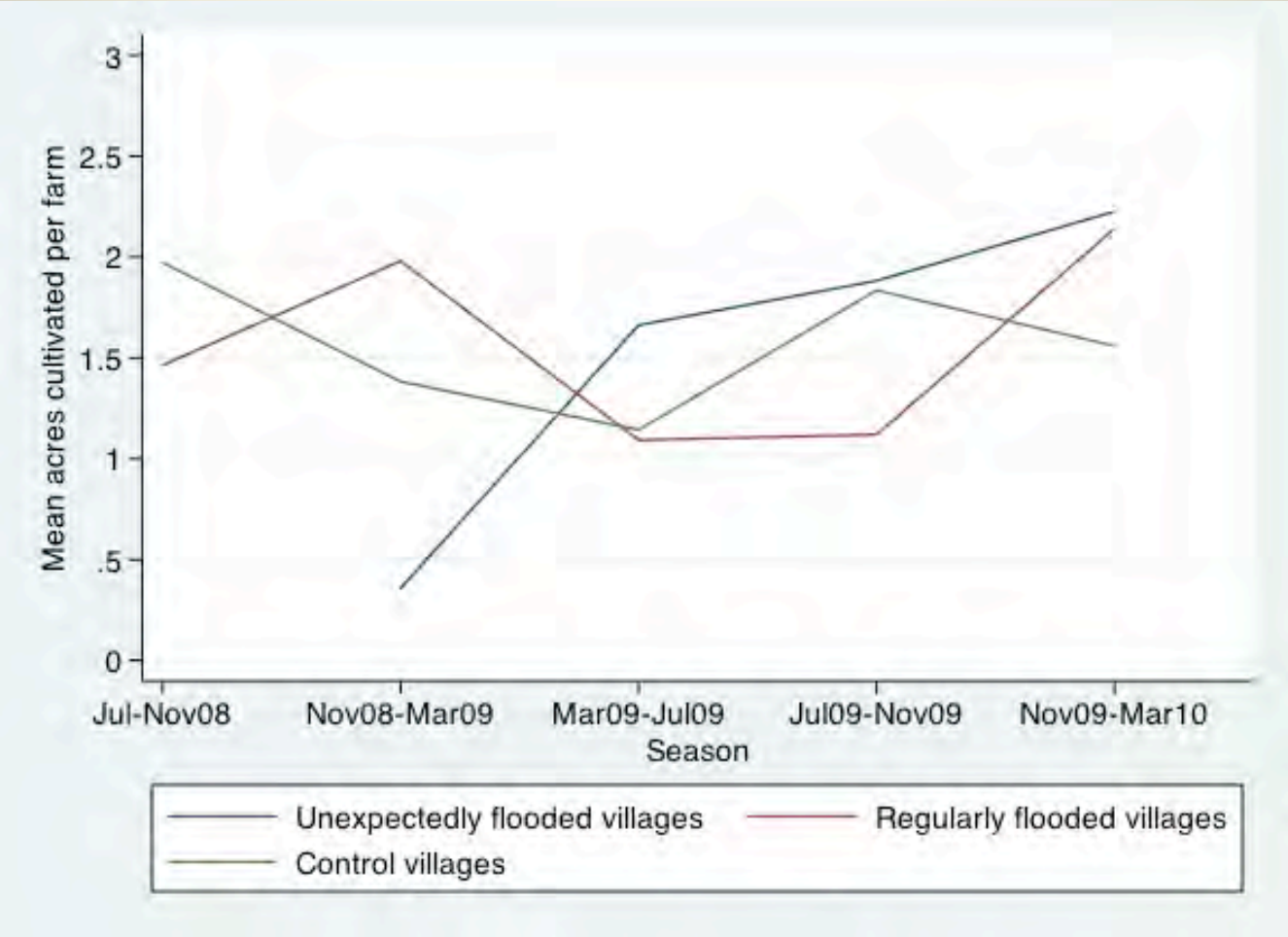
- Farmers (owners or operators) were 35% of the workforce in the sample
- Wage workers and the unemployed were roughly 55% (farm workers 10% + non-farm workers 36% + unemployed 8%).
- Self-employed (non-farm) 10%.
- This means about half the workforce had agriculture as its principal occupation.
- Accordingly, we first examine the effects of flooding on crop output.

Results – Crop output

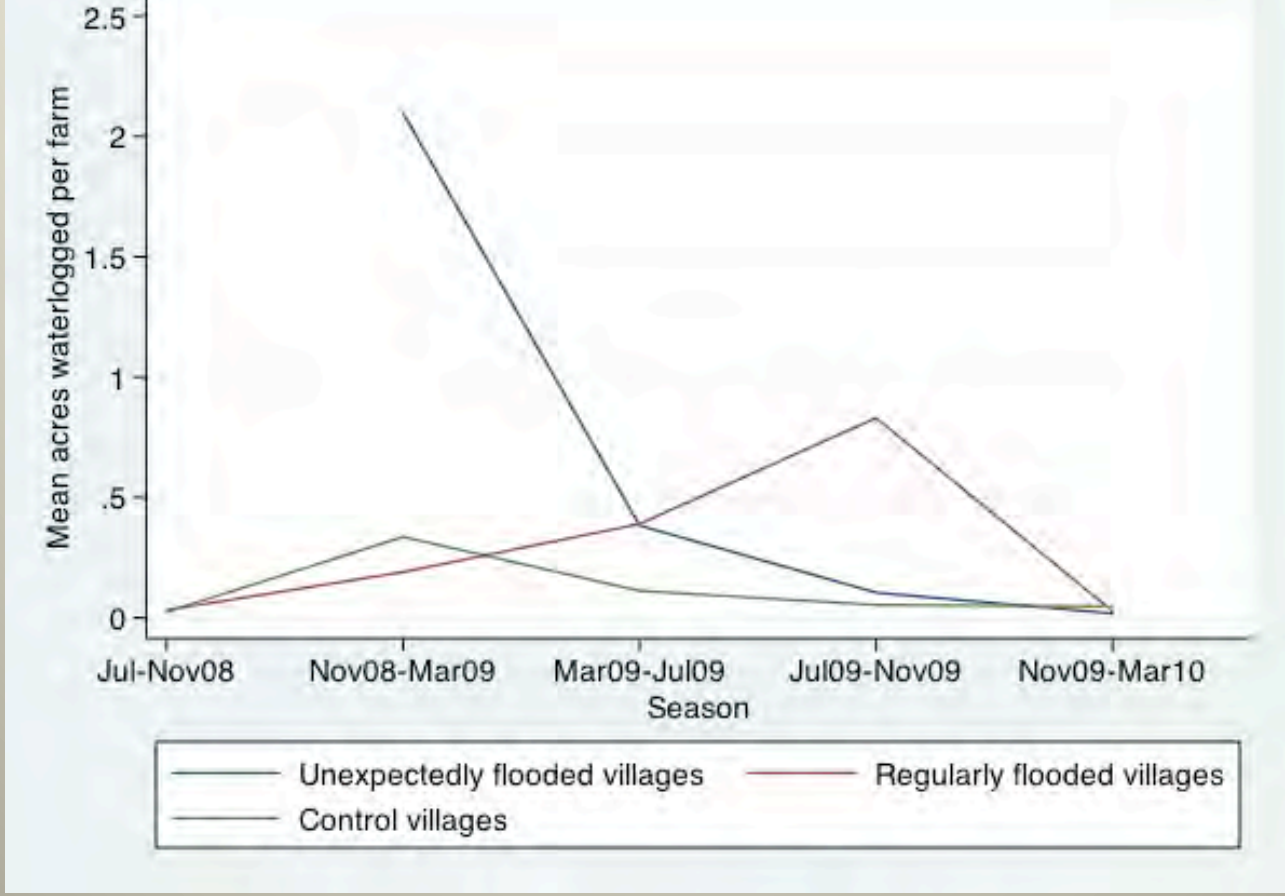
- I first examine the effect of flooding on crop output. Land, unlike labor is immobile, so the effects of flooding on the returns cannot be diffused through migration.
- Output in the regularly flooded (Type 2) villages is lower during the kharif or monsoon season than in the control (Type 3) villages, but this is more than made up for by the rabi crop.


Output per acre - Rs
0
2000
4000
6000
July-Nov08
Nov08-Mar09
Mar09-Jul09
Jul09-Nov09
Nov09-Mar10
Season
Unexpectedly Flooded
Regularly Flooded
Control

- In fact the value of crop output per acre owned is ***greater*** in regularly flooded villages than in the control villages when measured over the course of a year. The difference is statistically significant at 5% if one begins with the winter season of 2008-09 but not if one begins with the summer season of 2009.
- Evidently soil deposition from flooding raises fertility a lot.



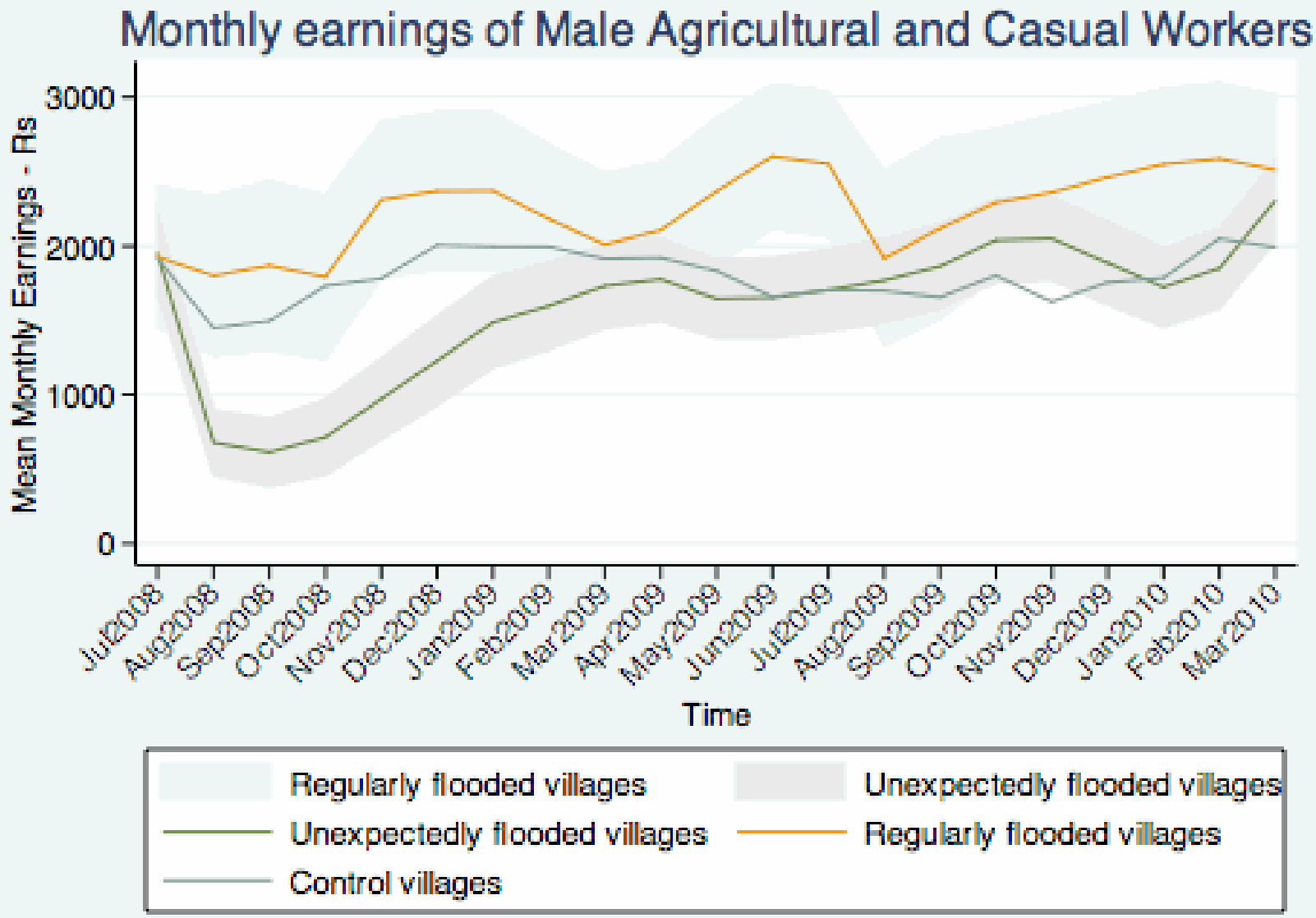
Farm acres cultivated are lower during the monsoon (July-November) in flooded villages.



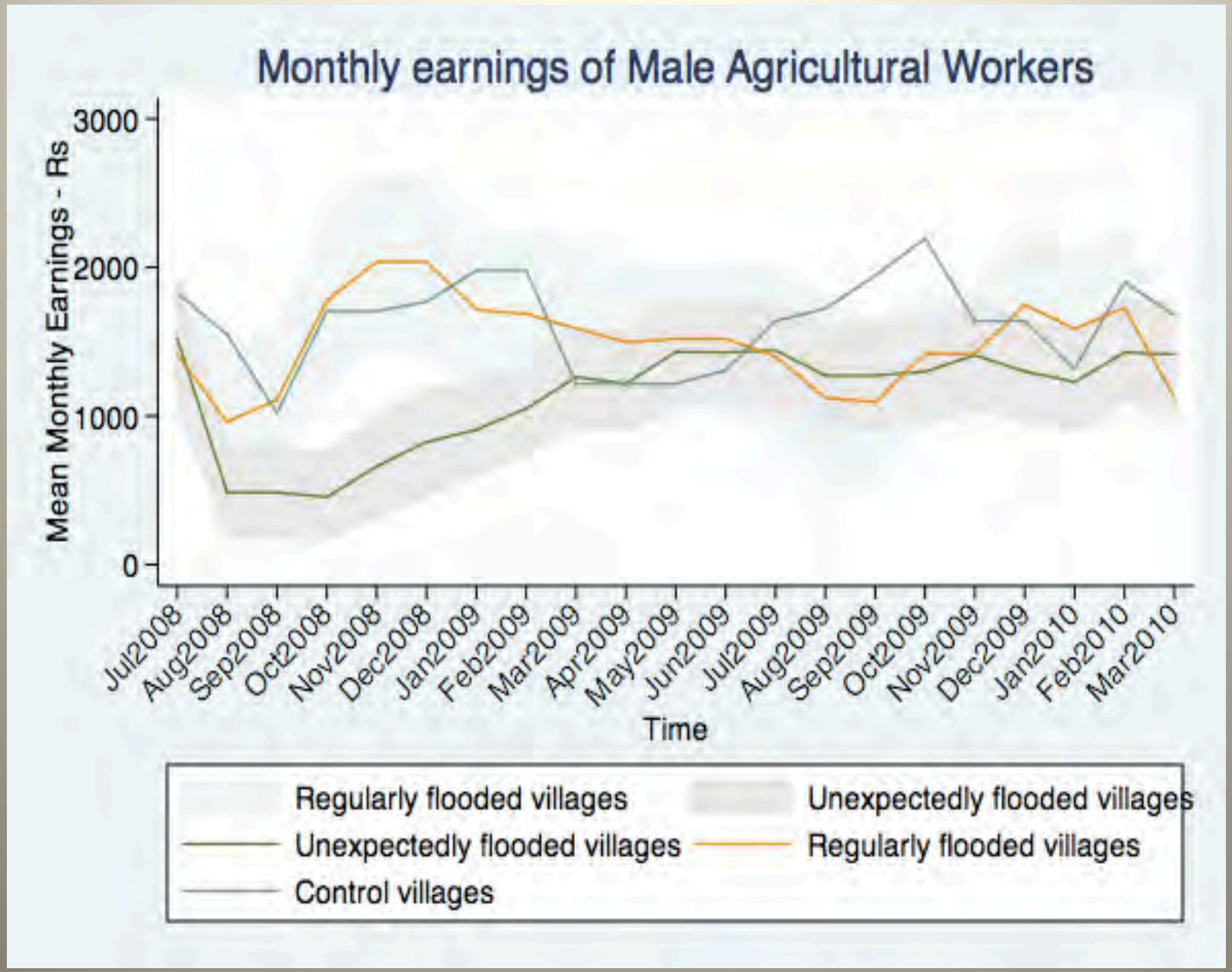
Farm acres waterlogged are higher in the regularly flooded villages in the monsoon of July-November 2009, but not in 2008.

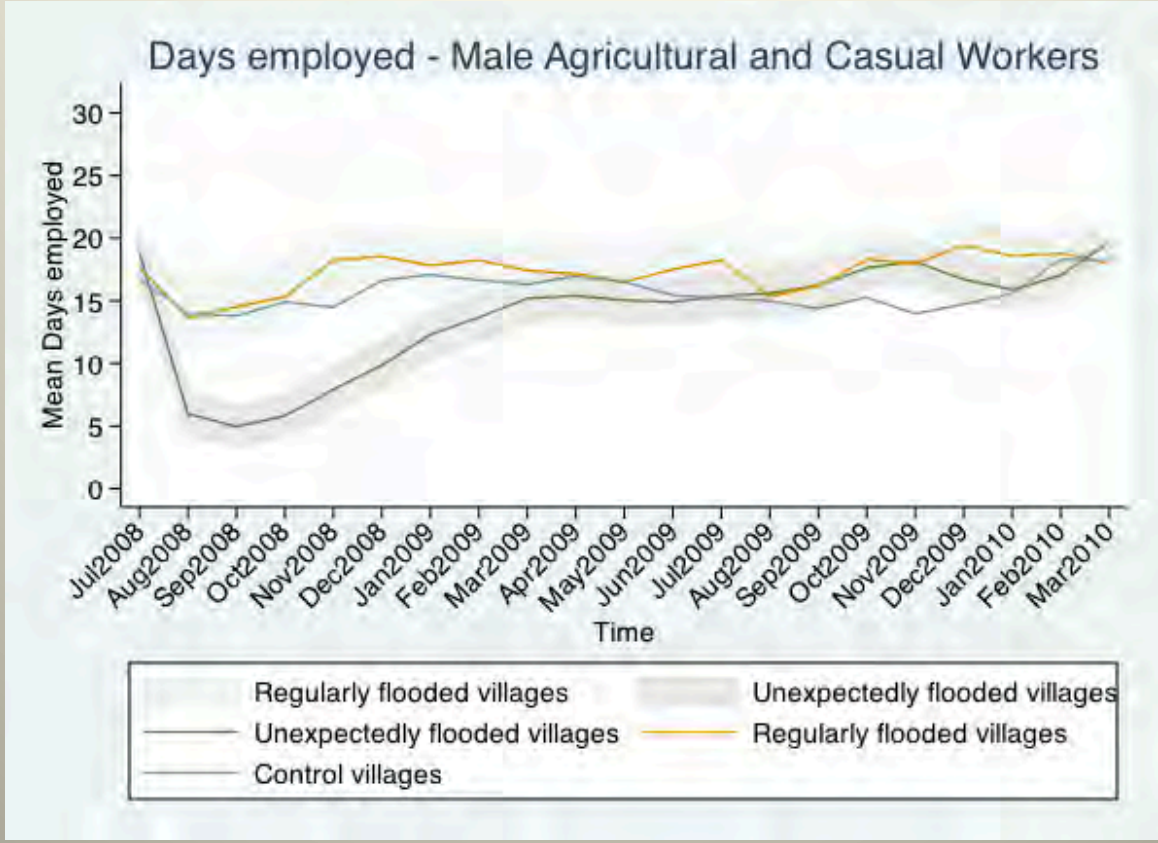
This is because the 2008 data don't include villages 9 and 10 that are inside embankments. Village 12 is largely inside an embankment but suffered very little flooding in 2008 due to the embankment breach that took place just a little upstream. Village 18 does not usually lose a crop despite its fields flooding from the overflow of the Sursa because of good drainage.

Returns to labour

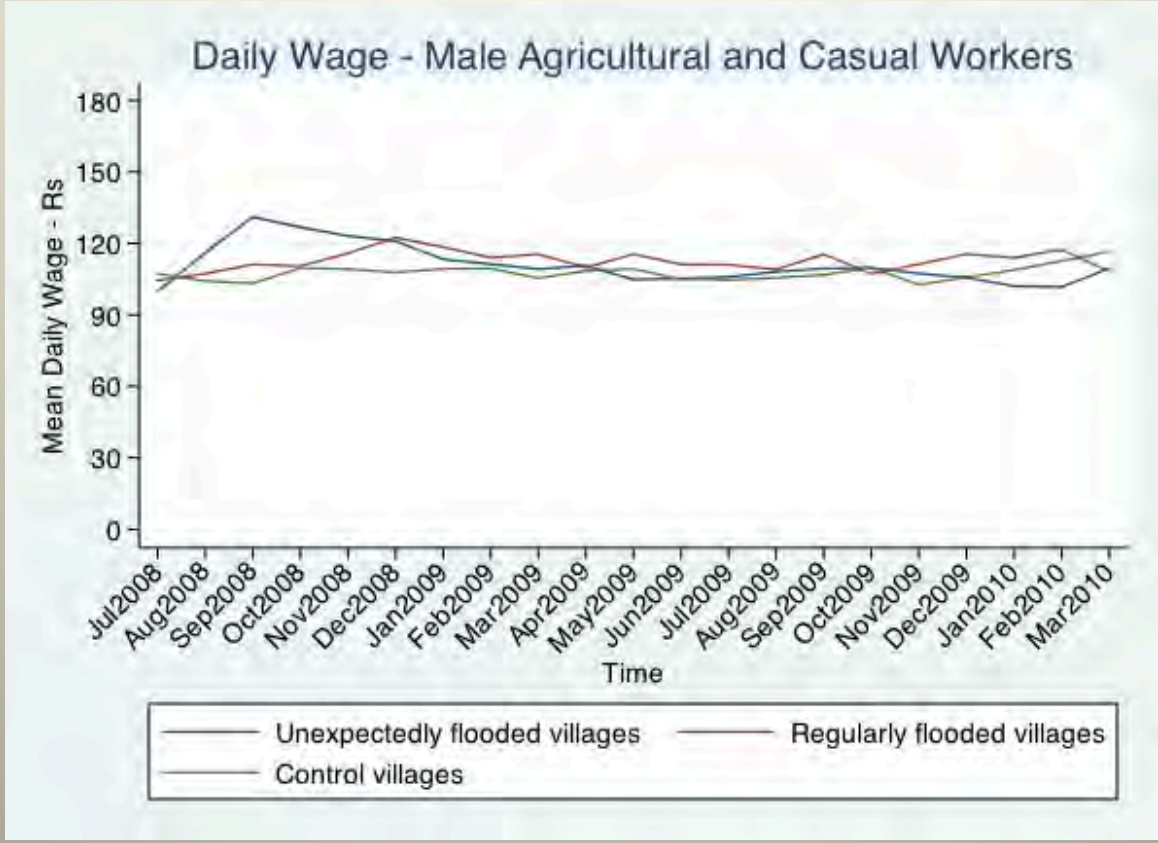


- Notice that average earnings in control villages are everywhere below those in the regularly flooded villages!
- Differences not statistically significant.
- This is consistent with the pattern we saw in agricultural output.

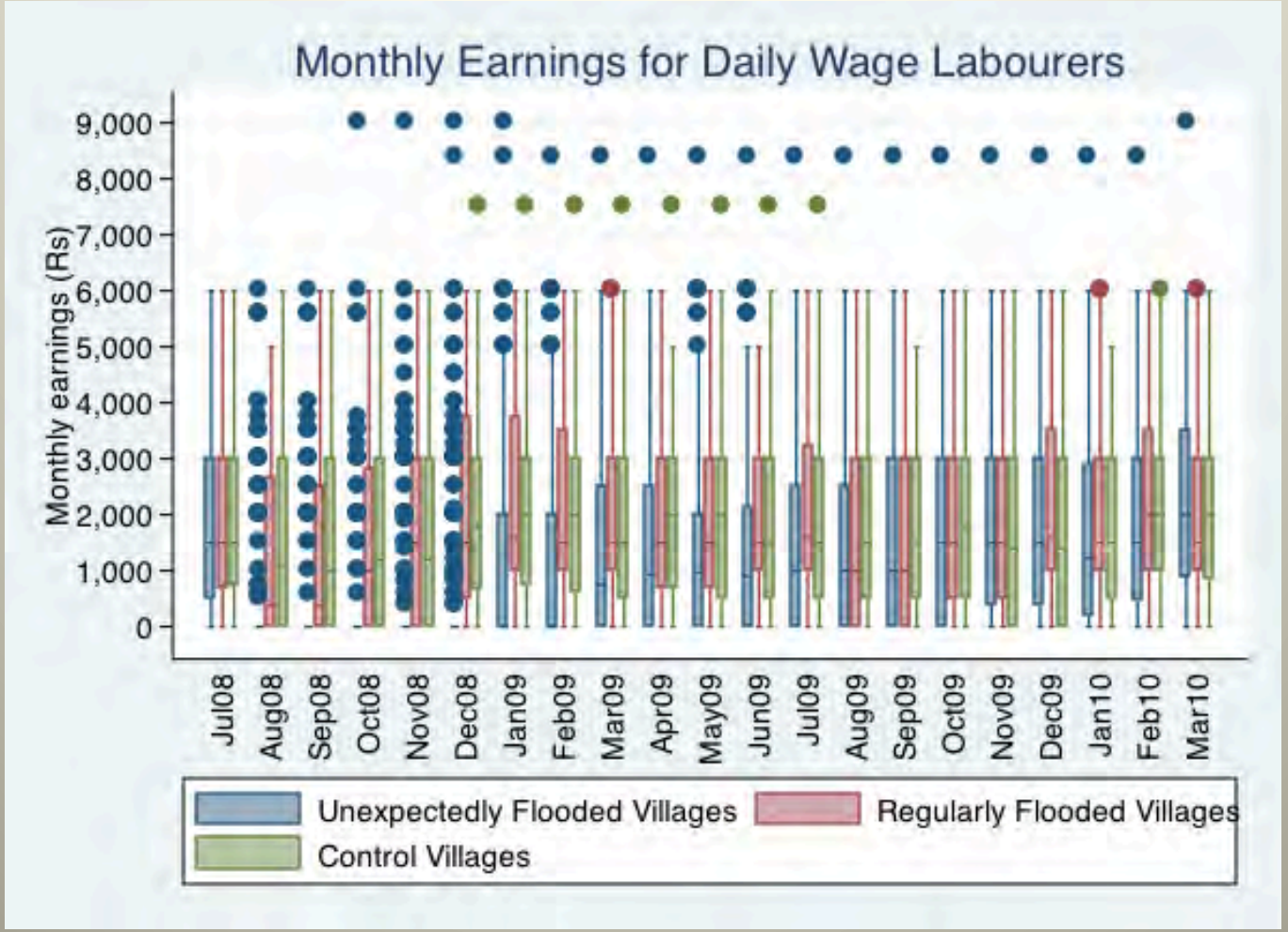

Monthly earnings of Male Agricultural Workers
Mean Monthly Earnings - Rs
3000
2000
1000
0
Jul2008
Aug2008
Sep2008
Oct2008
Nov2008
Dec2008
Jan2009
Feb2009
Mar2009
Apr2009
May2009
Jun2009
Jul2009
Aug2009
Sep2009
Oct2009
Nov2009
Dec2009
Jan2010
Feb2010
Mar2010
Time
Regularly flooded villages
Unexpectedly flooded villages
Unexpectedly flooded villages
Regularly flooded villages
Control villages



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.

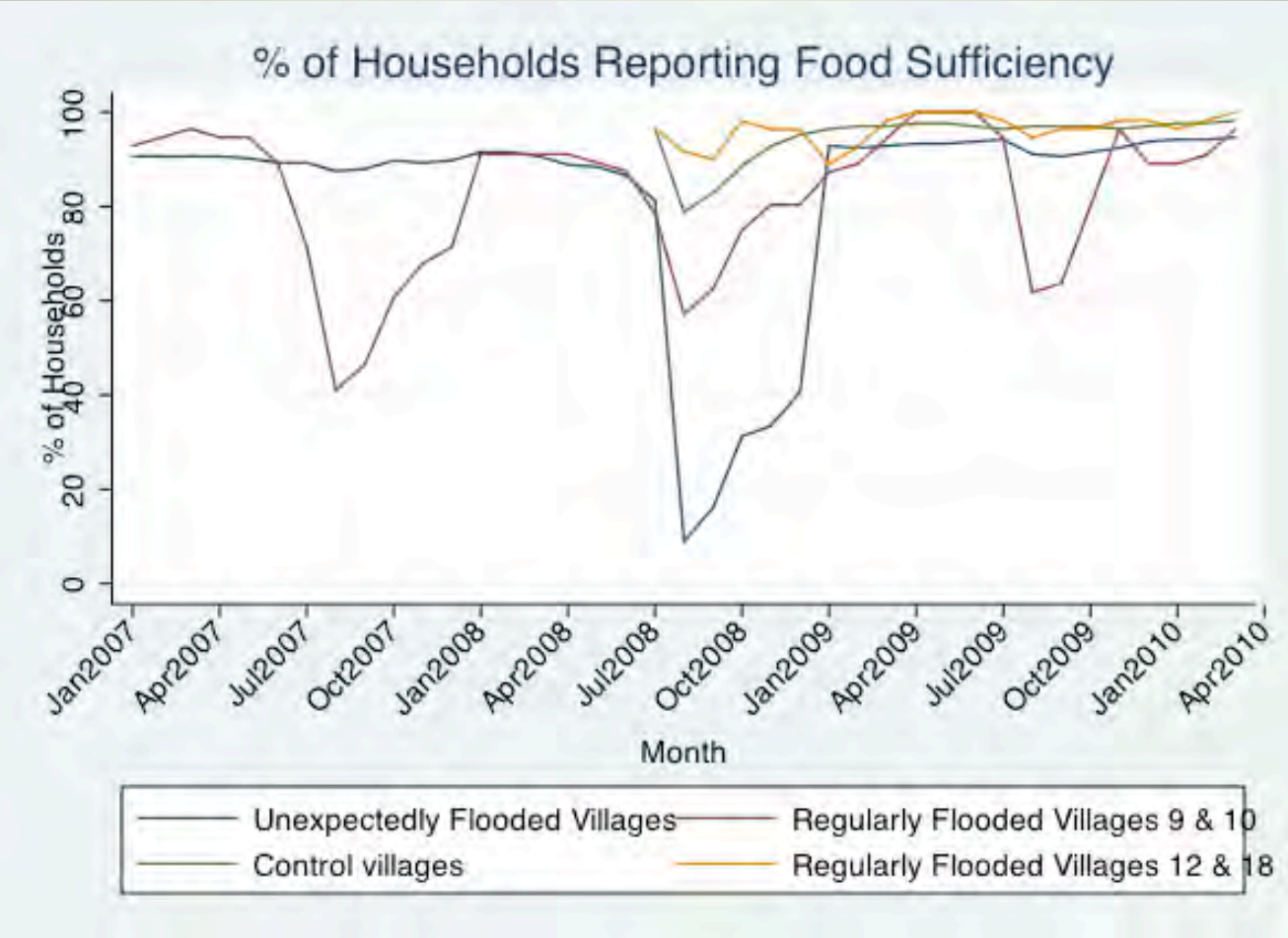


What this implies is that the loss of earnings during the monsoon in the flooded villages is likely to be unequally distributed with those failing to find work bearing the brunt of it. So we should look not just at mean earnings , but at the whole distribution of earnings.



During the monsoon of 2008, the worst affected workers in both regularly flooded and control villages saw their earnings fall to zero (they did not find employment). In 2009, although the regularly flooded villages did worse (at the bottom of the distribution) in August and September, they did better in November and December than the controls

Food sufficiency



- Two of the villages inside embankments are clearly worse off in terms of food sufficiency.
- But the other two regularly flooded villages are no worse than the controls (one inside an embankment, and the other flooded by river overflow).

Other outcomes - Schooling

- No statistically significant differences between the three types of villages.
- The mean levels are low, about 2 years for adult women and 4 years for adult men.

Health

- The data are self-reported 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 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.
- The unexpectedly flooded villages, however, have a higher incidence of diarrheal and infectious diseases than the controls. The differences are significant at 5% and 1% for diarrheal and all infectious diseases respectively.

Health

- These results hold, 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.

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.
- 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.

Assets

- The total value of agricultural equipment and vehicles 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 types, with the differences being statistically significant at the 1% level.

Financial assets

- 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.

Livestock

- 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 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.

What have we learnt?

- One of the two major points in the case for embankments --- agricultural productivity --- is called into question by these findings.
- We also see that flooding leads to a loss of food sufficiency. This seems to happen in some of the villages inside embankments, some of the time. The one regularly flooded village that is not inside an embankment does not appear to have this problem.

What's not in this study

- Would it be more expensive to improve embankment infrastructure to prevent breaches that cause enormous damage?
- Or to replace them with dispersed infrastructure, by raising buildings and roads above flood level. (Also social security such as NREGA in the flood season).

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