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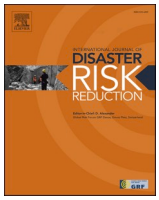

Do catastrophic floods change the gender division of labor? Panel data evidence from Pakistan

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ABSTRACT

This study examines how large-scale environmental shocks alter the gender division of labor in traditional rural societies. Using individual-level time allocation data from the Pakistan Rural Household Panel Survey 2012, 2013, and 2014, I compare hours spent per week across productive and reproductive activities of more than 8000 adult men and women after the 2011, 2012, and 2013 floods in 76 villages from three provinces of Pakistan. Individual-level panel data is combined with village-level flood inundation depth data collected using remotely sensed (MODIS) satellite imagery. The panel fixed-effects regression results reveal a significant shift in the gender division of labor for both paid and unpaid work in the flood-affected villages. For a 1-m flood inundation depth, men's and women's weekly time use as hired labor increased by ~2 and ~1 h, respectively, women's weekly time allocation on child and elderly care decreased by ~1.5 h, and men's weekly labor allocation for reproductive work and fuel collection increased by ~2 h. Overall, a 1-m inundation depth increased the weekly time allocation for all activities for men by ~6 h and women by ~2 h. Women's time allocation changes were most pronounced for landless and marginal agricultural landowners (<0.5 ha), when compared with medium and large landowners. The favorable shift in the gender division of reproductive work was positively associated with women's decision-making power. Men who believed that both men and women should equally participate in income generation activities were more likely to increase their reproductive work time.

1. Introduction

The promotion of shared responsibility for unpaid domestic and care work between the sexes is one of the six targets of the United Nation's goal to achieve gender equality and empower women and girls [1]. Household division of labor is a critical issue for understanding gender equality and for designing policies and programs to promote women's empowerment. Globally, women spend at least 2.5 times more time doing unpaid household and care work than men [2,3]. In rural societies of some Asian countries (e.g., Pakistan, India, Cambodia), women spend as much as ten times more time in household work than men [4]. The gender gap in unpaid work is expected to widen with environmental change, increased frequency and intensity of climatic hazards, and growing scarcity of clean water and energy [5–9].

Large-scale natural hazards such as floods and cyclones adversely affect people's lives and livelihoods. As critical services such as water, sanitation, and energy supply are disrupted by natural hazards, households spend more time on domestic activities accessing these essential services [10–12]. As natural hazards also invoke considerable economic and livelihood damage [13], households allocate more time to productive or income-generating activities to recover from income and consumption losses [14,15]. These responses affect intra-household time allocation across productive and reproductive (household) activities with a likely net increase in aggregate household labor supply. How this burden of higher time allocation is shared among men and women and how it alters the gender division of labor is poorly understood. Is the burden of natural hazard recovery borne disproportionately by women? Do men and women change their time allocation between productive and reproductive activities during the recovery phase? How rigid or flexible is gender role in the aftermath of a natural hazard? Is a change in a gender role consistent with gender norms?

There is a plethora of studies that examine the welfare effect of natural hazards, such as how natural disasters impact intra-household resource allocation, food production, food security, nutrition, children's education, intimate partner violence, and so on [16–21]. Several studies examine gendered vulnerability to natural disasters and gender differences in disaster mortality [22,23]. These studies highlight that women and girls bear the brunt of economic shocks invoked by natural

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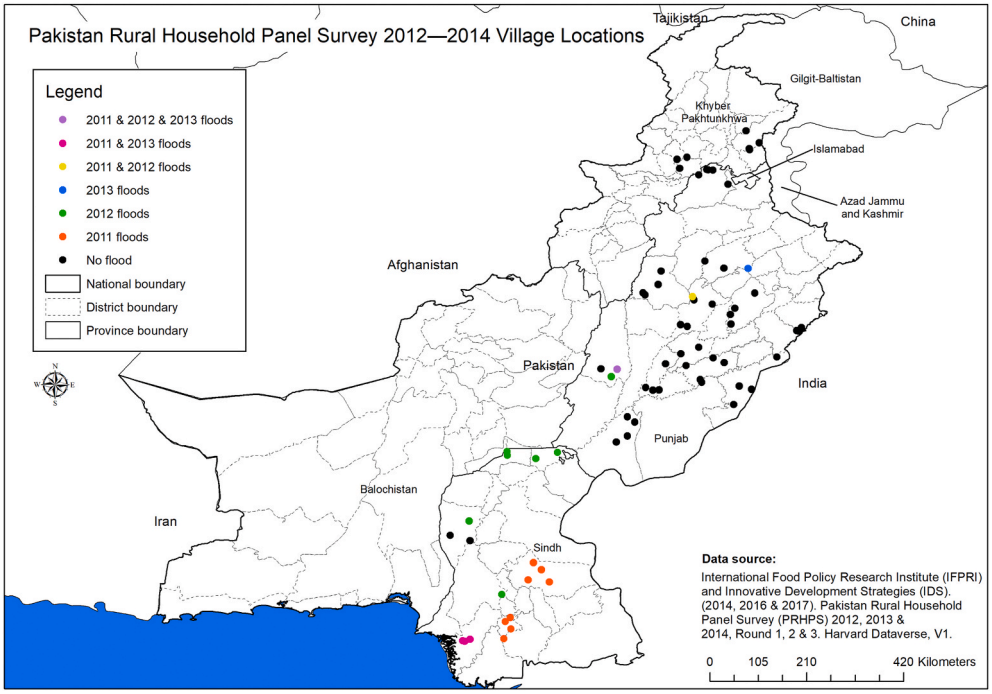

Fig. 1. Location of the PRHPS villages and their flood exposure.

hazards, as households reduce family resources allocated to women's and girls' wellbeing to smooth consumption during good and bad times. No study has investigated how natural disasters impact the gender division of labor across productive and reproductive work.

Time use has important implications for welfare and human development. Time poverty limits men's and women's opportunities to access education and participate in community and political institutions [24]. Time poverty also adversely affects health, wellbeing, and nutrition [24–26]. As the planet warms, the number of catastrophic climatic hazards is growing worldwide at an alarming rate, mostly affecting the lives and livelihoods of rural communities in low-income countries where women's time poverty is most pronounced [4]. Development interventions and disaster response and recovery programs focus primarily on material poverty and rarely account for the time poverty dimension of welfare with the potential of creating 'weak winners' (i.e., improve welfare in one domain while considerably reducing welfare in others) [24,27]. Therefore, time-use studies can contribute to the design of development policies and programs that strike a balance between material and nonmaterial wellbeing.

The conventional narrative suggests that women's wellbeing significantly declines after a natural disaster because they are burdened by productive and reproductive work [5,28–30]. Using country-level data from 127 developing states from 1981 to 2010, Eastin [5] shows that greater temperature variability and increased incidence of climatic hazards will exacerbate pre-existing gender discrepancy (e.g., labor market opportunities, access to resources) in low-income countries. Other studies show that climate change-driven male outmigration has increased women's share of productive work in climate change hotspots, leading to women's time poverty [9,31–33]. However, no study has examined how men and women change their time allocation between productive and reproductive work during the recovery phase of a large-scale natural hazard.

This study examines the impact of catastrophic flooding on the gender division of labor using individual-level panel data in the context of the 2011, 2012, and 2013 floods in rural Pakistan. This is the first study examining the effect of large-scale flooding on household time allocation across productive and reproductive activities and exploring how a shift in time allocation as a flood coping mechanism varies between men and women. It also explores the correlation between time-use change and perceptions of gender role and women's decision-making power. These interlinkages shed light on the mechanism or potential pathways through which the shifts in gender role are likely to occur. The study uses the Pakistan Rural Household Panel Survey (PRHPS) [34–36]. The PRHPS is an open access panel dataset covering 2090 rural households and more than 8000 adult men and women from 76 villages in Punjab, Sindh, and Khyber Pakhtunkhwa (KPK) provinces of Pakistan. The PRHPS comprises three waves: March–April 2012 (Wave 1), April–May 2013 (Wave 2), and May–June 2014 (Wave 3). Individual-level panel survey data are combined with the village-level inundation depth data for the 2011, 2012, and 2013 floods collected using MODIS satellite imagery.

2. Background

Pakistan, located in South Asia with a geographical area of 796,096 km^2 and 216 million population [37], is a low-income country ranked as the most vulnerable country to climate change-related extreme events [38]. The country is divided into four provinces (Balochistan, Punjab, Sindh, KPK), one federal territory (Islamabad Capital Territory), and two autonomous territories (Azad Jammu & Kashmir and Gilgit–Baltistan). More than 60% of Pakistan's population live in rural areas, and close to half of the total labor force relies on agriculture for livelihood [35,37]. The rural societies follow patriarchal traditions where patriarchal norms strongly guide the gender division of labor. Women spend as much as ten times more time in household work than men and contribute unpaid family labor in agricultural and non-agricultural enterprises [4,39]. Women face a gender asset gap, have low education, lack decision-making power, and face limited physical mobility due to the religious-cultural practice of 'purdah' [39]. Around one-quarter (27%) of Pakistan's rural labor force is women [40]. Rural women's labor force participation varies across provinces. In KPK and Sindh, women comprise around 17% of the rural labor force, while in Punjab, the proportion is almost double (34%) [40]. The age group of most active women in the labor market is 15–60 [40].

Pakistan has endured 20 severe flood events and a cumulative economic loss of US$38 billion since 1947 [41]. The 2010 flood was a

one-in-100-year event that killed more than 1985 people and affected 18 million people [42]. After the catastrophic 2010 flooding, three large-scale floods occurred in 2011, 2012, and 2013. While not as catastrophic as the 2010 flooding in terms of fatality, number of people affected, and economic damage, they were among the 20 most severe floods in Pakistan's history and significantly more damaging than seasonal floods [42]. The 2011 flooding inundated southern Sindh and the adjoining areas of Punjab and north-eastern Balochistan in August 2011 [43], affecting 9.6 million people, killing 516 people, and destroying more than one million acres of crops [44]. The 2012 flooding inundated southern Punjab, northern Sindh, and north-eastern Balochistan in early August 2012 [45], affecting approximately 5 million people, killing 571 people, and destroying more than one million acres of crops [41]. The 2013 flood was smaller than the 2011 and 2012 floods, affecting more than million people and killing 333 people [42].

The Pakistan federal and provincial governments launched a series of emergency relief operations to alleviate the suffering of flood victims after each flood episode. This involved distributing tents, blankets, food, water, medical supplies, and livestock vaccinations [46]. Pakistan's federal government rolled out its flood recovery and response plan to support disaster recovery. The United Nations Development Program (UNDP) launched the Monsoon Humanitarian Operational Plan (MHOP) in October 2012 to supply urgently needed water, food, shelter, and healthcare [46]. The MHOP continued in 2013 offering rehabilitation assistance to flood victims by building homes and livelihoods [46].

A significant component of the disaster management strategy involved generating livelihood and income opportunities for men and women, access to credit, skills training, etc. [47]. The programs within this component mandated equal and, in many cases, higher access to opportunities and resources for women [48]. Hence, women and vulnerable families were targeted as the primary beneficiaries of the livelihood grants, skills development training, and distribution of livelihood start-up kits [47]. The UN's Monsoon Humanitarian Operational Plan offered rehabilitation assistance through the 'Cash for Work' program in flood-affected villages, with one-quarter of the direct beneficiaries of the program being women [39]. Various other NGOs and humanitarian actors ran gender-inclusive interventions to assist flood victims during the recovery phase [49].

3. Data, measurement, and empirical strategy

The PRHPS data were collected by the International Food Policy Research Institute (IFPRI) and Innovative Development Strategies (IDS) from 2012 to 2014 [34–36]. The surveys were conducted in 76 villages and 19 districts of Punjab, Sindh, and KPK. The locations of the sampled villages and their exposure to the 2011, 2012, and 2013 flooding are presented in Fig. 1. Thirteen districts of KPK were excluded from the sampling frame due to safety concerns for the enumerators. Therefore, the sample is representative of the rural population of Punjab and Sindh but not of KPK. Appendix 1 presents a list of the districts and union councils (Tehsils) included in the survey.

The PRHPS dataset comprises three waves: (1) Wave 1, conducted from March–April 2012, interviewed 2090 households from three provinces of Pakistan; (2) Wave 2, conducted from April–May 2013, re-interviewed about 96% of Wave 1 households; and (3) Wave 3, conducted from May–June 2014, re-interviewed about 90% of Wave 1 households. The sampled households were selected using a multistage stratified random sampling strategy. The 2011 flood occurred in August 2011, the 2012 flood occurred in September 2012, and the 2013 flood occurred in August 2013. The analysis sample contained 4176 women (age group 15–60) and 4145 men (age group 15–65). The age groups for men and women were based on men's and women's labor market participation data [40].

3.1. Measurement of time use

The surveys collected detailed time allocation data for each household member across 20 productive and reproductive activities. Respondents were asked about the number of hours spent on each activity over the previous seven days. The activities were grouped under the following categories: (1) family labor in agricultural and non-agricultural activities, (2) hired labor in agricultural and non-agricultural activities, (3) care work, (4) domestic chores, (5) reproductive activities (care work and domestic chores), (6) water collection, and (7) firewood collection. Productive work (as hired or family labor) in the agricultural sector includes crop plantation, weeding, threshing, and seed management (selection and preservation). The most common form of nonfarm work includes employment in a village shop, working as a construction and transportation worker, jobs in small-scale crop/food processing businesses, local schools, health centers, and government agencies [35]. Domestic chores include cooking, cleaning, washing, pressing clothes, stitching/sewing, crafts work, and preparing dung cakes (fuel). Care work includes caring for children and the elderly. For men, data for domestic chores and care work are aggregated under one activity. For women, the time spent on firewood and fodder collection is merged into one activity.

3.2. Measurement of flood exposure

The PRHPS collected flood incidence (flood occurred or not) for four flood events (i.e., 2010, 2011, 2012, and 2013). Since flood incidence treats all flood-affected villages homogenously regardless of their severity, flood incidence is a weak indicator of flood exposure. Therefore, village-level inundation depths were used as an indicator of flood exposure. This indicator is less prone to the endogeneity of flood severity at the household level [14]. Inundation depths are measured using MODIS satellite imagery (methodology discussed in Appendix 2). A high level of correspondence was observed between flood severity captured by MODIS satellite imagery and flood incidence data in the household survey. The correspondence levels were 87%, 93%, and 95% for the 2011, 2012, and 2013 floods, respectively.

3.3. Empirical strategy

3.3.1. Baseline model

A panel fixed-effects regression model was used to estimate the impact of flooding on time use separately for working-age adult women (15–60 years) and men (15–65 years). More specifically:

$$Hours_{ihjt} = \beta_0 + \beta_1 FloodDepth_{jt} + \beta_2 X_{ihjt} + \beta_3 Z_{hjt} + \beta_4 V_{jt} + t + \theta + \varepsilon_{ihjt} \quad (1)$$

In Equation (1), i is individual, h is household, j is village, t is time. $Hours_{ihjtk}$ is the number of hours spent per week on one of the six activity groups by individual i in household h in village j in year t. $FloodDepth_{jt}$ is inundation depth measured in meter in village j in year t. β_1 is the coefficient of interest. It captures the effect of flooding on time allocation. t represents year fixed-effects, and θ is the interaction of year and province fixed-effects. Year fixed-effects capture time-varying but unit invariant unobserved characteristics that may affect labor allocation decisions (e.g., national-level policy change to influence men's and women's labor force participation). The interaction of year and province fixed-effects accounts for time-varying unobserved factors specific to province. For example, the level of economic development and government expenditure may vary across time and province.

X_{ihjt}, Z_{hjt} and V_{jt} are vectors of time-varying control variables at individual, household and village levels that may influence time-use decisions. The individual-level controls are marital status and education. The household-level controls are education and gender of the household head, household size, household composition across age and gender, and

Table 1
Correlation between flood depth and adult women's and men's time allocation 2012–2014 (fixed effects panel regression models).

	Family labor[a]	Hired labor[b]	Care work[c]	Household chores[d]	Reproductive work[e]	Water collection[f]	Firewood collection[g]	all activities[h]
	(1)	(2)	(3)	(4)	(3)+(4)=(5)	(6)	(7)	(8)
Panel A: Women's time use (15–60 years)								
FloodDepth[i]	0.453	1.391**	−1.752***	1.631*	−0.120	0.184	0.0849	1.992
	(0.368)	(0.585)	(0.526)	(0.891)	(1.156)	(0.130)	(0.183)	(1.261)
Observations (individual)	4182	4182	4182	4182	4182	4182	4182	4182
R-squared	0.020	0.057	0.047	0.072	0.036	0.015	0.020	0.058
F-statistics (df = 25, $p <$ 0.0001)	3.990	6.230	8.710	18.110	17.490	4.810	3.380	13.530
Panel B: Men's time use (15–65 years)								
FloodDepth[i]	−0.601	2.195**	–	–	2.005***	0.509	1.561**	5.805***
	(0.815)	(0.956)	–	–	(0.634)	(0.451)	(0.647)	(1.485)
Observations (individual)	4004	4004	–	–	4004	4148	4148	4004
R-squared	0.016	0.017	–	–	0.037	0.089	0.066	0.031
F-statistics (df = 26, $p <$ 0.0001)	3.140	3.400	–	–	5.440	14.040	11.070	5.770

Notes.
All regression models include individual, household, and village controls; individual, time, and time-province fixed-effects. Individual controls are marital status and education. Household controls are household head's age, gender, education, household size and household composition across age and gender, and post-disaster relief. Village control includes the number of NGO programs in a village. Observations with missing values have been dropped. Robust standard errors clustered at the household-level in parenthesis; *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

[a] Hours/week spent on agricultural and non-agricultural activities as family labor.
[b] Hours/week spent on agricultural and non-agricultural activities as hired labor.
[c] Hours/week spent on child and elder care.
[d] Hours/week spent on household chores (cooking, cleaning, ironing, washing, and pressing clothes, preparing dung cake).
[e] Hours/week spent on child and elder care and household chores.
[f] Hours/week spent on water collection.
[g] Hours/week spent on firewood and fodder collection (women); firewood collection (men).
[h] Hours/week spent on all activities.
[i] Inundation depths of 2011, 2012, and 2013 floods in meters.

amount of financial assistance received after the flood. The household composition variable accounts for male outmigration, either as a result of flooding or other reasons. A reduction in the number of working-age adults is expected to increase women's time use for productive work. Likewise, women's time use for reproductive work is likely to be higher in households with young children and elderly adults. Access to flood relief programs is likely to reduce the number of hours spent on productive work for both men and women. Time-invariant control variables (such as age, religion, caste) are not included in the model because they are nullified due to lack of variation over time. The village-level control variable is the number of non-government organizations (NGOs) in a village. This variable is a proxy for post-flood relief and rehabilitation assistance received by villages through non-government sources. ε_{ihjt} is an error term clustered at the household level.

3.3.2. Endogeneity in flood depth

Since flooding is a regular phenomenon in Pakistan and a series of catastrophic flooding occurred within 10 years, one can argue that village-level inundation depth is endogenous. More specifically, villages that were repeatedly affected by severe flooding were more likely to have low economic development, fewer employment opportunities, and poor infrastructure conditions, which would influence men's and women's time use during the flood recovery phase. To account for potential endogeneity bias in Equation (1), the deviation between historical average (from 2007[1] to most recent flood event[2]) inundation depth and inundation depth in the 2011, 2012, and 2013 floods was used. The historical flood inundation level represents people's experience of dealing with similar events in the past. The deviation between the current and historical average flood inundation depth represents the 'novelty' factor or the unexpected hazard [50]. The following equation was estimated:

$$Hours_{ihjt} = \beta_0 + \beta_1 FloodDepth\_Deviation_{jt} + \beta_2 X_{ihjt} + \beta_3 Z_{hjt} + \beta_4 V_{jt} + t + \theta + \varepsilon_{ihjt} \quad (2)$$

In Equation (2), *FloodDepth_Deviation* is the difference between historical average and current year flooding in village *j* and year *t*.

3.3.3. Intra-household bargaining and gender norms

The expansion of labor market opportunities for women after the floods may enhance women's intra-household bargaining or decision-making power [51]. An individual's relative bargaining power within the household determines intra-household resource and time allocation [51,52]. The social exchange theory predicts that an individual's share of household work is determined by their relative income contribution [53]. A woman's relative share of reproductive work decreases with an increase in her relative income [54–56]. Gender norms play a crucial role in determining the extent to which women can leverage their bargaining power [57,58]. Some men consider it an insult to their masculinity and feel ashamed if they perform reproductive work, which is viewed as 'women's work' [59]. It is possible that the shift in the gender division of labor was aligned with an individual's attitude toward gender norms.

I tested these two hypotheses using the following empirical specifications:

$$Decisions_{ihjt} = \beta_0 + \beta_1 HiredHours_{ihjt} + \beta_2 X_{ihjt} + \beta_3 Z_{hj} + t + \theta + \varepsilon_{ihjt} \quad (3)$$

$$HiredHours_{ihj} = \alpha_0 + \alpha_1 GenderNorms_{ihj} + \alpha_2 X_{ihj} + \alpha_3 Z_{hj} + \theta + \varepsilon_{ihj} \quad (4)$$

$$ReproductiveHours_{ihj} = \alpha_0 + \alpha_1 GenderNorm_{ihj} + \alpha_2 X_{ihj} + \alpha_3 Z_{hj} + \theta + \varepsilon_{ihj} \quad (5)$$

In Equation (3), *Decisions* represents two indices (Index A and B) of

[1] The major flood incident in Pakistan before 2007 was 1995 [60,61].
[2] Latest flood events for 2011, 2012 and 2013 floods were 2010, 2011 and 2012, respectively.

Table 2
Correlation between flood depth and adult women's and men's time allocation 2012–2014 across agricultural land ownership (fixed effects panel regression models).

	Family labor[a]	Hired labor[b]	Care work[c]	Household chores[d]	Reproductive work[e]	Water collection[f]	Firewood collection[g]	All activities[h]
	(1)	(2)	(3)	(4)	(3)+(4)=(5)	(6)	(7)	(8)
Panel A: Landless and marginal landowners (Women's time use (15–60 years)								
FloodDepth[i]	−0.080	2.299**	−2.157***	0.234	−1.924	0.366*	0.082	0.744
	(0.418)	(0.911)	(0.691)	(0.936)	(1.268)	(0.203)	(0.221)	(1.456)
Observations (individual)	3088	3088	3088	3088	3088	3088	3088	3088
Panel B: Medium and large landowners (Women's time use (15–60 years)								
FloodDepth[i]	0.909	−0.229	−1.556	2.620	1.064	0.026	0.079	1.849
	(0.684)	(0.682)	(0.958)	(1.838)	(2.391)	(0.160)	(0.349)	(2.563)
Observations (individual)	1448	1448	1448	1448	1448	1448	1448	1448
Panel C: Landless and marginal landowners (Men's time use (15–65 years)								
FloodDepth[i]	−0.300	2.325*	–	–	2.369***	0.109	1.620**	6.256***
	(0.996)	(1.332)	–	–	(0.854)	(0.674)	(0.798)	(1.988)
Observations (individual)	2996	2996	–	–	2996	3109	3109	2996
Panel D: Medium and large landowners (Men's time use (15–65 years)								
FloodDepth[i]	−0.601	2.230**	–	–	1.596*	1.073***	0.508	4.982**
	(1.596)	(1.102)	–	–	(0.890)	(0.367)	(0.946)	(2.171)
Observations (individual)	1364	1364	–	–	1364	1409	1409	1364

Notes.
All regression models include individual, household, and village controls; individual, time, and time-province fixed-effects. Individual controls are marital status and education. Household controls are household head's age, gender, education, household size and household composition across age and gender, and post-disaster relief. Village control includes the number of NGO programs in a village. Observations with missing values have been dropped. Robust standard errors clustered at the household level in parenthesis; *p < 0.10, **p < 0.05, ***p < 0.01.

[a] Hours/week spent on agricultural and non-agricultural activities as family labor.
[b] Hours/week spent on agricultural and non-agricultural activities as hired labor.
[c] Hours/week spent on child and elder care.
[d] Hours/week spent on household chores (cooking, cleaning, ironing, washing, and pressing clothes, preparing dung cake).
[e] Hours/week spent on child and elder care and household chores.
[f] Hours/week spent on water collection.
[g] Hours/week spent on firewood and fodder collection (women); firewood collection (men).
[h] Hours/week spent on all activities.
[i] Deviation between historical average flood inundation depth (2007–latest flood event) and inundation depths of 2011, 2012, and 2013 floods in meters.

women's decision-making power. Index A is a sum score of women's decision-making power for boys' and girls' education, regular household expenditure, and purchasing small household durable items. Index B is a sum score of women's control over all kinds of household expenditure, including food, clothing, medicine, and small and large durable items. The hypothesis is that when women spend more time as hired labor, they have greater decision-making power. For Index A, data were available in Waves 2 and 3. For Index B, data were available only in Wave 3.

Equations (4) and (5) tested whether women's weekly time allocation for paid work (*HiredHours*) and men's time allocation for household work (*ReproductiveHours*) were consistent with their respective attitudes toward the gender division of labor. In Wave 1, male and female respondents were asked their alignment with the following two statements: (1) A woman should devote almost all her time to in-house chores; (2) A wife and husband should share the load of generating income for the household. In Equations (4) and (5), *Gender Norm* was coded 1 if respondents chose the second statement and 0 otherwise.

4. Results

4.1. Results of the baseline model

Columns 1–8 of Panels A and B in Table 1 present the panel fixed-effects regression results of time-use change across six activity categories, separately for adult women and men, using Equation (1). In Panel A and Column 2, the coefficient of *FloodDepth* is positive and significant ($p < 0.05$) for hired labor, indicating that a 1-m inundation depth in the 2011, 2012, and 2013 flooding events increased adult women's weekly time use as hired labor by 1.391 h in 2012, 2013, and 2014. The coefficient of *FloodDepth* is negative and significant ($p < 0.01$) for care work (Panel A, Column 3), indicating that a 1-m inundation depth decreased adult women's weekly time use for care work by 1.752 h. In Panel A and Column 4, the coefficient of *FloodDepth* is positive and significant ($p < 0.10$), implying that a 1-m increase in inundation depth increased women's labor supply in domestic chores by 1.631 h. The decrease in women's labor supply for care work and increase in household chores offset each other, causing no significant change in women's labor supply in domestic activities (Panel A, Column 5). No significant change was observed for women's time allocation for water or firewood collection (Panel A, Columns 6 and 7). In Panel A and Column 8, the impact of flooding on women's aggregate labor supply for productive and reproductive work is positive but not significant at the 10% level. The magnitude of the change is approximately 2 h.

Columns 1–8 of Panel B in Table 1 present the impact of inundation depth on men's time use. The coefficient of *FloodDepth* is positive and significant ($p < 0.05$) for hired labor (Panel B, Column 2), indicating that a 1-m flood inundation depth in the 2011, 2012, and 2013 flooding events increased adult men's weekly time use as hired labor in 2012, 2013, and 2014 by approximately 2.2 h. Additionally, men's weekly time allocation for reproductive work and firewood collection increased by 2 h ($p < 0.01$) and 1.561 h ($p < 0.01$), respectively. As men's weekly labor supply increased in three categories of activities, the net change in aggregate labor supply due to flooding for men was unambiguously positive ($p < 0.01$). The magnitude of the net change in aggregate labor supply for men was approximately 6 h.

Heterogeneity analysis was used to explore self-sorting tendency across several household and village characteristics (expenditure, wealth, land and non-land asset, distance of the village from a

Table 3
Correlation between flood depth deviation and adult women's and men's time allocation 2012–2014 (fixed effects panel regression models).

	Family labor[a]	Hired labor[b]	Care work[c]	Household chores[d]	Reproductive work[e]	Water collection[f]	Firewood collection[g]	All activities[h]
	(1)	(2)	(3)	(4)	(3)+(4)=(5)	(6)	(7)	(8)
Panel A: Women's time use (15–60 years)								
FloodDepth[i]	0.499	1.186**	−1.374***	1.518**	0.144	0.257**	0.054	2.140**
	(0.330)	(0.491)	(0.449)	(0.771)	(1.002)	(0.112)	(0.158)	(1.090)
Observations (individual)	4182	4182	4182	4182	4182	4182	4182	4182
R-squared	0.020	0.057	0.043	0.072	0.076	0.015	0.015	0.058
F-statistics (df = 26, $p <$ 0.0001)	4.020	6.240	8.580	18.120	17.420	4.930	3.380	13.560
Panel B: Men's time use (15–65 years)								
FloodDepth[i]	−0.682	2.023**	–	–	1.701***	0.285	1.315**	4.776***
	(0.688)	(0.822)	–	–	(0.525)	(0.392)	(0.550)	(1.262)
Observations (individual)	4004	4004	–	–	4004	4148	4148	4004
R-squared	0.016	0.018	–	–	0.037	0.089	0.066	0.030
F-statistics (df = 26, $p <$ 0.0001)	3.170	3.430	–	–	5.460	13.940	11.060	5.750

Notes.
All regression models include individual, household, and village controls; individual, time, and time-province-fixed-effects. Individual controls are marital status and education. Household controls are household head's age, gender, education, household size and household composition across age and gender, and post-disaster relief. Village control includes the number of NGO programs in a village. Observations with missing values have been dropped. Robust standard errors clustered at the household level in parenthesis; *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

[a] Hours/week spent on agricultural and non-agricultural activities as family labor.
[b] Hours/week spent on agricultural and non-agricultural activities as hired labor.
[c] Hours/week spent on child and elder care.
[d] Hours/week spent on household chores (cooking, cleaning, ironing, washing, and pressing clothes, preparing dung cake).
[e] Hours/week spent on child and elder care and household chores.
[f] Hours/week spent on water collection.
[g] Hours/week spent on firewood and fodder collection (women); firewood collection (men).
[h] Hours/week spent on all activities.
[i] Deviation between historical average flood inundation depth (2007–latest flood event) and inundation depths of 2011, 2012, and 2013 floods in meters.

commercial center, rail station, and nearest city). The most significant heterogeneity was observed across agricultural land ownership (see Table 2). The effect of flooding on women's labor supply (productive and reproductive work) was most pronounced for landless and marginal agricultural landowners (<0.5 ha). For households that owned >0.5 ha agricultural land, flood inundation depth did not significantly affect women's time use in those households. Men's time-use change did not vary considerably across households' agricultural land size.

The impact of flood depth on boys' and girls' time use across all activity groups was tested (see Appendix 4). No noteworthy impact of flood depth on children's time use was observed. In most cases, boys' and girls' time use either remained unchanged or significantly declined, showing no evidence of the use of child labor as a flood damage coping strategy.

A robustness test was undertaken to check whether the results were sensitive to the operationalization of flood exposure. Equation (1) was re-estimated for female and male samples using a dummy variable as an indicator of flooding (i.e., presence or absence of flooding) instead of flood inundation depth. The flood incidence data were taken from the household survey. The results are highly consistent with the main results (Appendix 5), implying that, regardless of the way flood exposure is measured, there is (a) a significant increase in women's time use as hired labor, (b) a significant decrease in women's time use for care work, (c) a significant increase in men's time use as hired labor and reproductive work, and (d) a significant net increase in men's aggregate time use for productive and reproductive work.

4.2. Results after accounting for endogeneity in flood depth

Columns 1–8 of Panel A and B of Table 3 present the panel fixed-effects regression results of time-use change across six activity categories for adult women and men using Equation (2). In this model, flood depth was measured as a deviation from the flooding depth in 2011, 2012, and 2013 and the historic average flood depth. The results were largely consistent with the findings presented in Table 1. The results revealed a significant increase in women's time use as hired labor and a significant decrease in women's time use for care work. The only difference with Table 1 is that the findings presented in Table 2 reveal a small (0.257 h) but significant increase in women's time use for water collection. The magnitude of the net change in women's aggregate labor supply in Tables 1 and 3 was similar (~2 h). The net effect in women's aggregate labor supply was significant at the five percent level in Table 3, while in Table 1 it was not significant at the ten percent level.

As for men's time use, consistent with the findings presented in Table 1, the results presented in Table 3 showed a significant increase in men's time use as hired labor, reproductive work, and fuel collection with a net increase in men's aggregate labor supply across all activities and a significant change in men's aggregate labor supply relative to that of women.

4.3. Time use, intra-household bargaining, and gender norms

The regression results from Equation (3)−(5) are presented in Tables 3 and 4. The coefficients of *Decision* in Columns 1 and 2 of Table 3 were positive and statistically significant at the five and one percent levels, respectively. These findings imply that women's weekly time allocation as hired labor had a significant positive correlation with women's decision-making power.

Table 5 presents the correlation between men's and women's attitudes toward gender norms and their time use as hired labor and reproductive work. Women who believed that men and women are equally responsible for earning income for the household (i.e., statement 2), on average, spent approximately an additional hour as hired labor in 2012 compared to those women who believed that women should spend time doing only household chores. Likewise, men who believed in an equal responsibility of men and women for productive work, on average, spent approximately one additional hour on reproductive work compared to those men who believed women should devote all their

Table 4
Correlation between women's weekly time allocation as hired labor and women's decision-making power in 2014 (panel fixed effects and OLS regression models).

	Women's decision-making power (Index A)[a]	Women's decision-making power (Index B)[b]
Women's weekly time use as hired labor[c] (15–60 years) (in hours)	0.005** (0.003)	0.036*** (0.012)
Observations (individual)	2922	2619
R-squared	0.201	0.256
	Wald Chi^2 (df = 32, $p < 0.001$) 1337	F-statistics (df = 28, $p < 0.001$) 28.200
Control variables		
Individual controls	Y	Y
Household controls	Y	Y
Village controls	Y	Y
Individual FE	Y	N
Time FE	Y	N
Province FE	Y	Y
Province and Time FE	Y	N

Notes.
Individual controls are marital status and education. Household controls are household head's age, gender, education, household size and household composition across age and gender, annual expenditure, assets, and weighted dietary diversity index. Village controls are distances of the village from the nearby city, commercial center and Afghan border, number of years of electricity and handphone connections, elevation, number of GO and NGO programs, population size and safety, and security index. Robust standard errors clustered at the household level in parenthesis; $^{**}p < 0.05$, $^{***}p < 0.01$.

[a] Women make decisions on boys' and girls' education, household expenditure, and purchase decision of small, durable items. Panel fixed-effects regression model using observations from Waves 2 and 3.

[b] Women make decisions on expenditure on food, clothing, medicine, boys' and girls' education, and purchase of small and large household durable items. OLS regression model using observations from Wave 3.

[c] Hours/week spent on agricultural and non-agricultural activities as hired labor.

time to domestic work.

5. Discussion and conclusion

This study tested the impact of large-scale flooding on the gender division of labor. Using individual-level panel data, a series of panel fixed-effects regression models were used to estimate the correlations between flood depth and hours spent per week on four categories of activities. The results revealed a significant (a) increase in men's and women's time use as hired labor; (b) decrease in women's time use in care work; and (c) increase in men's time use in domestic work. Additionally, the findings revealed that the net aggregate change in women's time use for all activities (~2 h) was substantially lower than that of men (~6 h). The findings remained robust when flood incidence was used as an alternative measure of flood exposure. Possible endogeneity in flood exposure was addressed using the deviation between current and historical average flood inundation depth. Heterogenous effects of flood depth on men's and women's time use were tested across various household and village characteristics. The most prominent heterogenous effect for women was observed across household land ownership status. The observed changes in women's time use in various activities were driven primarily by landless households and households that owned less than 0.5 ha agricultural land.

These findings differ from the conventional narrative, which overwhelmingly suggests that women's welfare declines after a natural hazard due to their double burden of productive and reproductive work. The conventional narrative was formed largely based on the pre-existing gender gap in unpaid work and assumed that a natural hazard would inevitably exacerbate the gap. However, the gender dynamic in the aftermath of a natural hazard can vary depending on the economic opportunities available to men and women in the hazard recovery phase and the gender norms that govern the gender division of labor in society.

Table 5
Correlation between gender role and attitude towards gender norm.

	Women's weekly time use as hired labor[a] (15–60 years) (in hours)	Men's weekly time use in reproductive work[b] (15–65 years) (in hours)
	(1)	(2)
Gender norm[c]	0.910***	0.983**
	(0.337)	(0.479)
Observations	2007	1865
R-squared	0.065	0.066
F-statistics (df = 28, $p < 0.001$)	2.840	3.480
Control variables		
Individual controls	Y	Y
Household controls	Y	Y
Village controls	Y	Y
Time FE	N	N
Province FE	Y	Y

Notes.
This variable reflects individual's attitude toward gender norms. 'A woman should devote almost all her time to her in-house chores' = 0; 'A wife and husband should share the load of generating income for the household' = 1. Results are based on the sample for which gender norm information is available. Individual controls are marital status and education. Household controls are household head's age, gender, education, and household size and household composition across age and gender. Village controls are distances of the village from the nearby city, commercial center and Afghan border, number of years of electricity and handphone connections, elevation, number of GO and NGO programs, population and safety, and security index. Robust standard errors clustered at the household level in parenthesis; $^{**}p < 0.05$, $^{***}p < 0.01$.

[a] Hours/week spent on agricultural and non-agricultural activities as hired labor in 2012.

[b] Hours/week spent on reproductive activities in 2012.

[c] Measured in Wave 1 (2012).

The closing of the gender gap in unpaid work in the current study most likely was facilitated by labor market opportunities available for women due to the gender-inclusive flood recovery and rehabilitation programs. Consistent with the bargaining power theory and theory of social exchange [51,53], the results show a positive correlation between women's bargaining power and their time use as hired labor. Given the economic opportunities available for women in the post-flood rural labor market, women seemed to have negotiated a slightly favorable gender division of labor with the male members of their households. The results reinforce the relevance of gender norms in mediating the shift in gender roles [57,58]. Women who believed in an equal gender responsibility for generating household income were more likely to allocate time as hired labor than other women. Likewise, men who believed in an equal gender role were more likely to spend additional time performing household work than other men. This implies that the shift in gender role was conditional on men's and women's attitudes toward gender norms.

This study's findings contribute to the development of disaster recovery policies that promote gender equality and improve women's wellbeing. This is particularly important for Pakistan, one of the most vulnerable countries to climate change and frequent natural hazards. The results reveal that a natural disaster like a large-scale flood does not necessarily increase women's work burden. Indeed, a natural disaster may alter the gender division of labor if labor market opportunities for women are expanded during the flood recovery phase.

One limitation of the data is that men's time allocation in domestic work is not disaggregated by activity (i.e., cooking, cleaning, childcare, etc.). Hence, it is unknown whether men were bridging the shortfall in

labor supply for care work or predominantly performing household chores; that is, did child and elderly care suffered the most due to the floods. Another limitation of the study is that it uses data from a series of flood events instead of a single flood event. Despite new areas being flooded each year, the flood events had some overlaps. Isolating the effect of each flood event on time use would require large spatial variation in flood inundation depth which was absent in the data. Future studies should investigate the time-use effect of a singular flood event using data from flood-affected and unaffected communities before and after a flood.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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