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The Effect of Weather Shocks on Women's Labor Supply and the Income of Women-Headed Households in Lesotho.

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Abstract

This study examines the effect of weather shocks on labor-supply decisions and income for rural farming households in Lesotho. We examine how these shocks affect women and households headed by women relative to their male counterparts. We use the Lesotho Agricultural Survey data, merged with the Standardized Precipitation Evapotranspiration Index (SPEI) data. We then employ a multinomial logit model of labor-supply choice as well as the Heckman selection models to study the income effects of these shocks. Our identification relies on the fact that weather shocks are plausibly exogenous once we control for time and community fixed effects. We find that women are more vulnerable to weather shocks and have more limited coping strategies than men. However, men have the option of intensifying their participation in relatively shock-resistant farming as a coping strategy in the presence of the weather shock. Drought increases the probability that men will choose farming, but it does not affect labor-supply choices for women. Therefore, more opportunities for women in rural non-farming sectors—tourism, for example—as well as increased access to and ownership of productive assets such as land would mitigate weather shocks as well as the additional effects of the pandemic.

Key words: Climate shocks, Off-farm, rural farming households, agricultural production

JEL Classification : Q12 ; Q13 ; etc.

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I. Introduction

Climate change is a growing global concern. The rise in global temperatures since the early 20th century has resulted in an increased risk of such weather shocks as floods, drought, and heat waves. The effects of these shocks may be especially severe in low-income countries, despite their minimal contribution to climate change (International Monetary Fund, 2017; Taraz, 2018), leading to considerable drop in economic output, partly as a result of declines in both agricultural output and labor productivity (Burke, Hsiang & Miguel, 2015). Following a climate shock, individuals may or may not be able to cope with the effects associated with the shock. Studies of various coping mechanisms have appeared in the literature, including migration internally or abroad (Cattaneo et al., 2019), sale of assets and livestock (Kazianga & Udry, 2006), recourse to credit markets (Skoufias, Bandyopadhyay & Olivieri, 2016), labour reallocation across sectors (Colmer, forthcoming), and adoption of drought-resilient seeds (Cacho et al., 2020). Labor-supply adjustments are another mitigation strategy in which the number of working hours is increased or labor is shifted to off-farm activities (Branco & Feres, forthcoming).

Not all sociodemographic groups have the same chance to adapt, however. Because of economic constraints and cultural norms that favor men, women may be particularly unable to adjust their labor supply, thereby making them more vulnerable to weather shocks. Little evidence exists regarding the effect of gender-based resilience to climate shocks on income-generating activities. Developing policies to address weather shocks requires a better understanding of how rural farmers and household's cope.

We investigated the role of labor-supply options as a possible adaptation to weather shocks in rural Lesotho, a strategy that may be particularly critical for rural communities in developing countries where insurance options for poor households are limited (Branco & Feres, forthcoming). We argue that substitution between on-farm and off-farm activities can mitigate the negative effects of weather shocks. Amare and Shiferaw (2017), for example, showed that participation in alternative labor-supply options such as non-farming activities, could provide insurance against weather shocks. Demeke and Zeller (2012) and Mathenge and Tschirley (2015) argued that weather shocks affect off-farm

employment, resulting in increased off-farm labor participation. These studies, however, did not analyze the consequences of those labor-supply choices on household income.

As a result, understanding how labor-supply options may alleviate economic losses caused by weather shocks is essential (Burke & Emerick, 2016; Taraz, 2017, 2018) for effective implementation of labor-market and agricultural policies that target vulnerable households in developing countries where the role of agriculture is significant (Branco & Feres, forthcoming). Some studies have examined consumption dynamics (for example, Asfaw & Maggio, 2018) as well as the ways in which weather shocks influence household income sources, from on-farm or off-farm employment (for example, Chuang, 2019).

Studies that have explored the gendered effects of weather shocks (Asfaw & Maggio, 2018 and Flato, Muttarak & Pelser, 2017, e.g.) have shown that households headed by women are more adversely affected by weather shocks, though the effects of weather shocks on individual labor-supply choices have not been examined. By and large, little is known about men's and women's (potentially different) labor-supply strategies when they face weather shocks.

The development of adaptation strategies and well-targeted social safety nets requires this knowledge. We therefore evaluated the effects of weather shocks on household labor income, further extending the literature by introducing gender dynamics and analyzing the differential effects of weather shocks on men and women. We have also provided insights into how mitigation strategies affect men and women who face weather shocks. Specifically, we have focused on answering the following questions: What is the effect of weather shocks on the labor-supply decisions of women and men? What is the effect of weather shocks on the income of households headed by women or by men? Through what channels are the gendered effects of weather shocks transmitted?

To answer these questions, we used household level data from the 2015-2016, 2016-2017, 2017-2018, and 2018-2019 Agricultural Production Surveys from the Lesotho Bureau of Statistics. We used GPS coordinates to merge this data with the Standardized Precipitation Evapotranspiration Index (SPEI), a multiscalar drought index that was first introduced by Vicente-Serrano, Beguería, and López-Moreno (2010) to measure spatial and temporal weather patterns.

In our empirical strategy, we first applied a multinomial logit model to analyze the effects of weather shocks on men's and women's labor-supply options—whether they chose the off-farm sector, the on-farm sector, home production (homemakers and housewives), unemployment, or remaining outside the labor market. Our identification strategy relied on the assumption that, once we controlled for time and community council fixed effects, weather shocks were plausibly exogenous. Second, we assessed the effect of weather shocks on the income of women- and men-headed households. We first used the simple fixed effects model, accounting for unobserved heterogeneity across councils and time. Because individuals within a household may have self-selected into specific sectors, we next accounted for this potential endogeneity by employing the Heckman selection approach and estimated the decision to participate in various labor-supply options and the likely income gaps between those labor-supply regimes.

We found significant gender differences in the effects of weather shocks on labor-supply choices. Weather shocks had no influence on women's labor-supply options, while drought increased men's participation in farming, likely in the livestock sector (an activity in which men engage predominantly). We also found that floods had a significant negative impact on the income of households headed by women and that their participation in non-farming offered no security against weather shocks. Conversely, drought had no significant effect on the income of men-headed households in farming only, those engaged in farming only, and those engaged in non-farming only but significantly reduced the income of men-headed households engaged in both farming and non-farming.

Exploring potential mechanisms, we found that these results were likely the result of the fact that women engaged in climate-vulnerable farm and off-farm activities such as selling grains and food compared to men who sold livestock and livestock products. Further, drought significantly increased the chance that adolescent girls (12–16-year-olds) in households headed by women would be homemakers or housewives. We also showed, using Lesotho Demographic Health Survey data, that drought actually reduced the likelihood that a girl would marry young. We therefore argue that the weather effects on the income of households headed by women cannot be explained by child marriage. In an alternative strategy, we argue that young girls' labor may substitute that of their mothers

and other adult women within the household as the latter intensify their search for employment and reduce the time dedicated to household chores. Overall, the results suggest that weather shocks have a highly significant effect on rural labor markets and household income in Lesotho. Women and adolescent girls are most vulnerable to these shocks in terms of income and labor-supply decisions.

The rest of the paper is organized as follows. Section 2 discusses the context; section 3 discusses the data and measurement of key variables and presents some descriptive analysis. Section 4 outlines the methodology; section 5 discusses the empirical results while section 6 concludes the paper and provides policy implications.

II. Context

Over the past three decades, the overall structure of Lesotho's economy has changed significantly, from an agriculture-dominated economy to one in which manufacturing, retail, and services became dominant in contributing to the GDP and to employment. According to the World Bank's World Development Indicators DataBank, between 2009 and 2019, the share of agriculture in the GDP declined from 6.04% to 4.53% while that of manufacturing increased to over 16%. During the same period, the share of employment in agriculture to total employment was around 10% while that of manufacturing was above 40%. However, agriculture remains important for rural livelihoods in Lesotho. More than half of Lesotho's population (58%) is concentrated in rural areas in which more than 70% of households are dependent on subsistence farming for survival (Government of Lesotho, 2018).

Lesotho's agriculture landscape comprises primarily rain-fed cereal production and livestock farming. Only 10% of the land in Lesotho is arable. The majority of smallholder farmers cultivate an average of 1.5 hectares of land. The main crops include maize, wheat, and sorghum, which occupy 60%, 20%, and 10% of agricultural land, respectively. Summer

crops (maize and sorghum) are mostly grown between August and January while wheat is mostly grown in the mountainous areas between July and February.

Livestock farming dominates the agricultural sector, accounting for 62% of total agricultural output. The sub-sector is dominated by men and consists of extensive animal grazing, wool and mohair production, and aquaculture. The Household Budget Survey (Lesotho Bureau of Statistics, 2017) showed that around 56% of men (compared to 44% of women) obtained off-farm income from selling livestock.

According to the Lesotho National Strategic Development Plan 2018-2019 to 2022-2023, the agricultural sector has been characterized by large fluctuations in productivity and production in recent years, mainly because of severe climate conditions, including recurrent droughts, heavy rains, floods, hail, strong winds, and progressive environmental degradation (Government of Lesotho, 2018). For example, during the El Niño drought, which took place during the 2015-2016 agricultural year, the arable land allocated for maize crops within the four districts of Lesotho (Leribe, Berea, Maseru, and Mafeteng) declined from between 13,000 and 22,000 hectares in the 2014-2015 agricultural year to between 4,000 and 13,000 hectares in 2015-2016 (Lesotho Bureau of Statistics, 2016). Farmers experienced a huge drop in grain harvest, which led to early shortages of food stocks for farming households and increased food prices, leaving many households food insecure.

During the 2016-2017 agricultural year, however, there were heavy rains (La Niña) throughout the country and, as a result, the planted area increased to between 21,000 and over 30,000 hectares (Lesotho Bureau of Statistics, 2018). The harvest also increased by 173.8%. This was mainly the result of the adoption of various flood-resilient methods during that year by the majority of farming households, including the use of hybrid seeds (the proportion of households that used hybrid seeds increased by 53.6% in 2016-2017), implementation of conservation agriculture to prevent soil erosion, and the creation of terraces that drain water during floods.

Uncertainty in agricultural production and productivity as a result of changing weather conditions has also affected migration patterns in Lesotho. In recent years, rural-urban migration has increased as occupational choice in the garment and textile industry has improved, creating more job opportunities, particularly for women. The 2016

population census indicated that over 90% of the total population had moved from their districts of birth (Lesotho National Strategic Development Plan, 2018-2019 to 2022-2023). About 62% of the internal migrants were absorbed by the private sector (as workers) and private households (as domestic workers). The census also shows that 8.9% of the population (179,579) have migrated outside the country. The Republic of South Africa is the major destination for rural men and women, accounting for 78% of emigrants. The changing patterns of migration has also led to an increase in the number of women migrating from rural Lesotho to South Africa to work in factories or farms or to take up domestic work (Lesotho Bureau of Statistics, 2016). The remaining 22.5% is absorbed by the rest of Africa and the United Kingdom.

Traditionally, women have been engaged largely in homemaking (home gardens, childcare, housework) while men are engaged in both farming and non-farming (Lesotho Bureau of Statistics, 2008). The custom of bride price is universally practiced in Lesotho (the bride price is paid to the family of the bride to show appreciation by the groom's family and to strengthen the union; see Boshego, 2006). Being a patriarchal society, Lesotho determines its lineage along the male line (Government of Lesotho, 2018). This leads to important decisions in the lives of Lesotho residents, including succession, property rights, and land allocation; it likely also produces significant effects on productivity and coping mechanisms that benefit men (and households headed by men).

Lesotho also practices a dual legal system that includes customary law (a system that codifies the customs of the Basotho people) and common law. Although there is progress in the review and implementation of legal reforms, the constitution explicitly recognizes customary law and therefore still undermines gender and social equality (Government of Lesotho, 2018). The practice of customary law often denies women access to productive assets, such as land, while compromising their economic independence. Women may participate in agricultural activities, but their access to resources associated with the exploitation of agricultural land (e.g., fields, farming equipment, livestock) is generally through men. This suggests that women's participation in socioeconomic decision-making remains deficient in Lesotho.

III. Data and Descriptive Statistics

3.1. Household Income and Labor-Supply Data

Our main source of data was the Agricultural Production Survey (hereafter, APS), which is carried out by the Lesotho Bureau of Statistics on an annual basis. The APS is a nationally representative survey, covering both crop and livestock farmers in Lesotho. Households are selected using two-stage sampling: the first stage involves selection of Primary Sampling Units (PSUs), and the second stage involves stratification of households by type of farming. A sample of households from each farming category—crop farming and livestock farming—is selected. These households are followed throughout the agricultural year to collect information on individuals, households, location, and community, including such household characteristics household size, number of adults, number of children and infants, savings status, access to credit, land holding and use, sources of household income, and marital status of head of household. The survey also collects socioeconomic data (age, gender, education level, employment status, participation in off-farm activities, and income earned, e.g.) for all household members. Finally, the survey records the GPS coordinates of households and agricultural plots. We used the 2015-2016, 2016-2017, 2017-2018, and 2018-2019 surveys.[1]

3.2. Weather Data

In line with published approaches (e.g., Harari & La Ferrara, 2018; Vicente-Serrano, Beguería & López-Moreno, 2010), we measured drought using the Standardized Precipitation Evapotranspiration Index (hereafter, SPEI). The SPEI is a multi-scalar drought index that was first introduced by the Vicente-Serrano group as an improved measure of the Standardized Precipitation Index (SPI). The SPEI considers the monthly or weekly difference between precipitation and potential evapotranspiration (PET) to reflect climatic

[1] We did not include the 2014-2015 survey because there were no climate shocks that season. More importantly, it was a year of heightened political instability, which may have influenced our results.

water balance and determine the severity of drought. Unlike drought indicators based on precipitation only, the SPEI accounts for the extent to which the soil retains water and combines the joint effects of precipitation, evaporation, and temperature. Given our focus on agriculture and rural areas, our drought variable is defined based on the average SPEI score for the years 2015 to 2018 between November (of the previous year) and April, which corresponds to the rainy season and the onset of the crop-growing season in rural Lesotho.

We merged household survey data (that is, the APS data) with the SPEI dataset using the GPS coordinates of the closest geographic units, which were recovered for both datasets (the grid and council level, respectively). For the household survey, the councils where the plots are situated were used.

3.3. Defining Outcomes and Construction of Weather Shocks

The main outcome variables in this study are labor supply (i.e., labor-market participation) and household income. We assumed that individuals within a household could choose to be in any of the five labor-supply regimes: (1) farm labor; (2) non-farm labor; (3) seeking employment (i.e., unemployed); (4) housewife/homemaker; and (5) outside the labor market. Based on labor-supply decisions of individual household members, we classified households into three labor-supply regimes: (1) farming, (2) non-farming, and (3) both farming and non-farming. For instance, we classified a household as a farming household if at least one household member participated in farming and no member worked in the off-farm sector. Household income is constructed by summing up the income of individual household members. In our empirical analysis, we used the two categories of "farming regime" and "farming-and-non-farming regime" because our focus was on rural areas, and the few observations in the off-farm only regime did not allow meaningful regression analysis.

The main treatment variable is weather shocks (or drought), which we measured using the SPEI.[2] According to the University of Nebraska-Lincoln National Drought Mitigation Center (2021), drought is conceptually defined as "a protracted period of deficient precipitation resulting in extensive damage to crops, and a consequential loss of yield." The severity of drought can be categorized using the SPEI variable, where SPEI≤-2 indicates dry seasons and SPEI ≥2 indicates wet seasons. Table A1 presents a detailed categorization. We defined weather shocks as drought (i.e., SPEI<-1, which indicates moderately dry climate) and flood (i.e., SPEI>1.5, which indicates a very wet climate).

3.4. Summary Statistics

Table 1 presents individual and household characteristics by gender of head of household. The sample consists of 4,131 individuals in households headed by women and 8,953 in households headed by men. Households headed by men were larger and included more infants and fewer elderly people compared to households headed by women. The average age of individuals in households headed by men was 35 vs. 34 for women-headed households. Average education in households headed by women was slightly higher, however (6.8 years), compared to households headed by men (6.6 years). Also, women heads of household were more educated than men who headed households. Both women- and men-headed households experienced almost the same normal weather conditions, with an SPEI of -1.1.

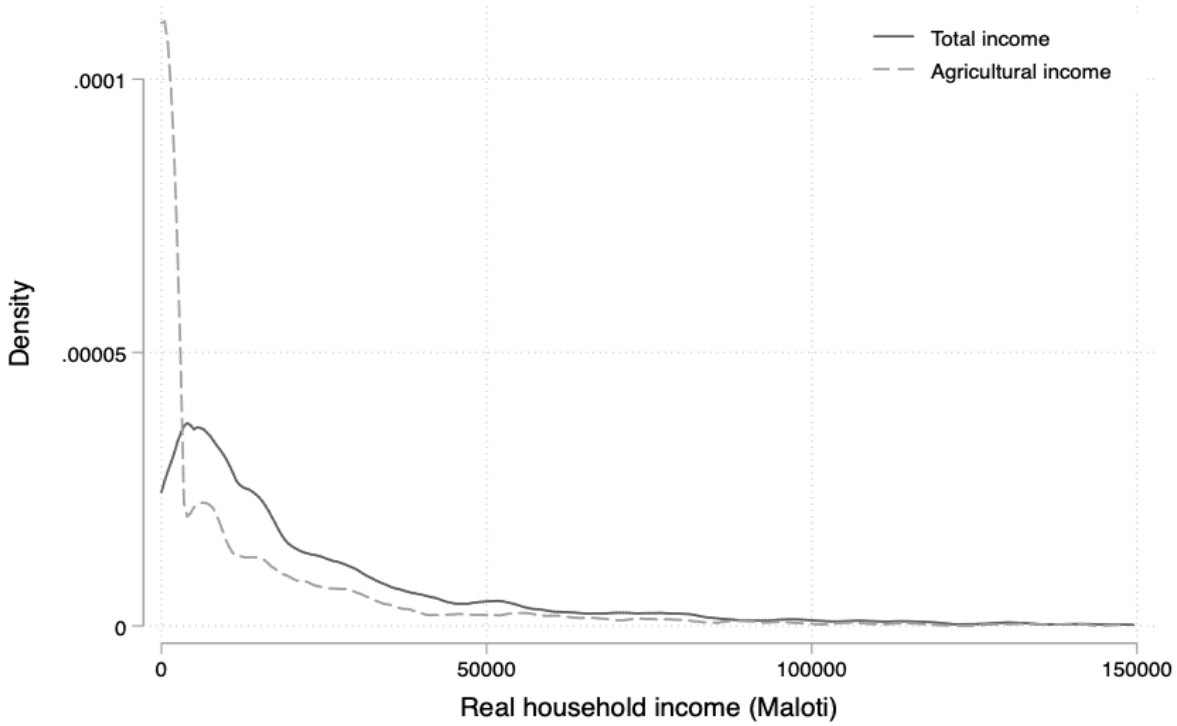
In terms of labor-market participation, fewer individuals (38%) in households headed by women participated in farm-labor compared to 46% of those in households headed by men. Therefore, 73% of men-headed households were classified as farming households compared to 54% of households headed by women. However, participation in non-farming in households headed by women was higher than in households headed by men. Finally, individuals in households headed by women were more likely to be housewives/homemakers, unemployed, or outside the labor force.

[2] A detailed description of variables is provided in Table A2.

These differences in labor market participation could therefore explain the relatively high (individual and household-level) income in households headed by men in contrast to households headed by women. Average (real) household income was M21,168 and M31,597 in households headed by women and households headed by men, respectively. Similarly, average household farming income was M10,939 in households headed by women vs. M16,496 in households headed by men.

Household farming income, however, is based upon a relatively small sample compared to total household income, possibly because a number of households did not engage in farming and some farming households did not sell their farm produce. Despite this, the distributions of total and farming household income are very similar, as shown in Figure 1. The difference between the two distributions is the result of the presence of many zeros in agricultural income. Given this similarity in distributions, therefore, we used total household income in our analysis because it was calculated on the basis of a larger sample.

Figure 1: Total Household Income vs. Household Agricultural Income



Notes: Household agricultural income is the sum of income from subsistence farming, cash crops, livestock, and livestock products.

Table 1: Summary Statistics by Gender of the Head of Household

Women						Men				
Variable	**N**	**Mean**	**SD**	**Min**	**Max**	**N**	**Mean**	**SD**	**Min**	**Max**
Individual-level variables						*Individual-level variables*				
Age	4131	34.54	16.61	15	70	8953	35.20	15.74	15	70
Years of education	4080	6.775	3.173	0	17	8782	6.558	3.450	0	18
Farm-employed	4131	0.380	0.485	0	1	8953	0.458	0.498	0	1
Nonfarm employed	4131	0.109	0.311	0	1	8953	0.086	0.280	0	1
Housewife/Homemaker	4131	0.278	0.448	0	1	8953	0.256	0.437	0	1
Unemployed	4131	0.063	0.243	0	1	8953	0.044	0.204	0	1
Outside labor force	4131	0.170	0.376	0	1	8953	0.156	0.363	0	1
Individual income (M)	4130	6,070	34072	0	1,480,000	8943	7,944	23,572	0	693,000
Household-level variables						*Household-level variables*				
Household Size	990	4.863	2.777	1	24	2247	5.066	2.768	1	24
Infants (0-5 years)	990	0.542	0.872	0	6	2247	0.597	0.862	0	6
Children (6-9 years)	990	0.443	0.721	0	4	2247	0.456	0.726	0	7
School children (6-18 years)	990	1.708	1.623	0	10	2247	1.635	1.641	0	12
The elderly (65+ years)	990	0.279	0.559	0	4	2247	0.194	0.537	0	6
Education of head of household	990	5.900	3.016	0	17	2247	4.693	3.789	0	18
Age of head of household	990	54.21	12.45	15	70	2247	46.94	13.37	15	70
Education of men in household	990	4.057	4.093	0	16	2247	5.104	3.480	0	16
Education of women in household	990	6.453	2.885	0	17	2247	6.167	3.726	0	17
Age of men/boys in household	990	17.61	15.76	0	95	2247	40.44	12.56	0	82
Age of women in household	990	48.84	12.85	0	90	2247	31.16	18.13	0	90
Workers per household	990	1.635	1.375	0	12	2247	1.941	1.301	0	12
Farming household	990	0.551	0.498	0	1	2247	0.739	0.439	0	1
Non-farming household	990	0.103	0.304	0	1	2247	0.066	0.248	0	1
Farming/Non-farming household	990	0.116	0.320	0	1	2247	0.131	0.337	0	1

Household Income (M)	990	21702	76945	0	1820000	2247	30339	55743	0	955000
Household Farming Income (M)	657	13569	76676	0	1650000	1512	15324	34858	0	472000
SPEI	990	-1.132	1.830	-3.254	2.774	2247	-1.140	1.849	-3.254	2.774

Source: Lesotho Agriculture Production Surveys 2015-2016 through 2018-2019, Lesotho Bureau of Statistics. Notes: Sample is all those aged 15-70 years from 64 rural community councils. All monetary variables are in Maluti and adjusted for inflation. 1 loti = 14.22 USD as of 15th April 2021.

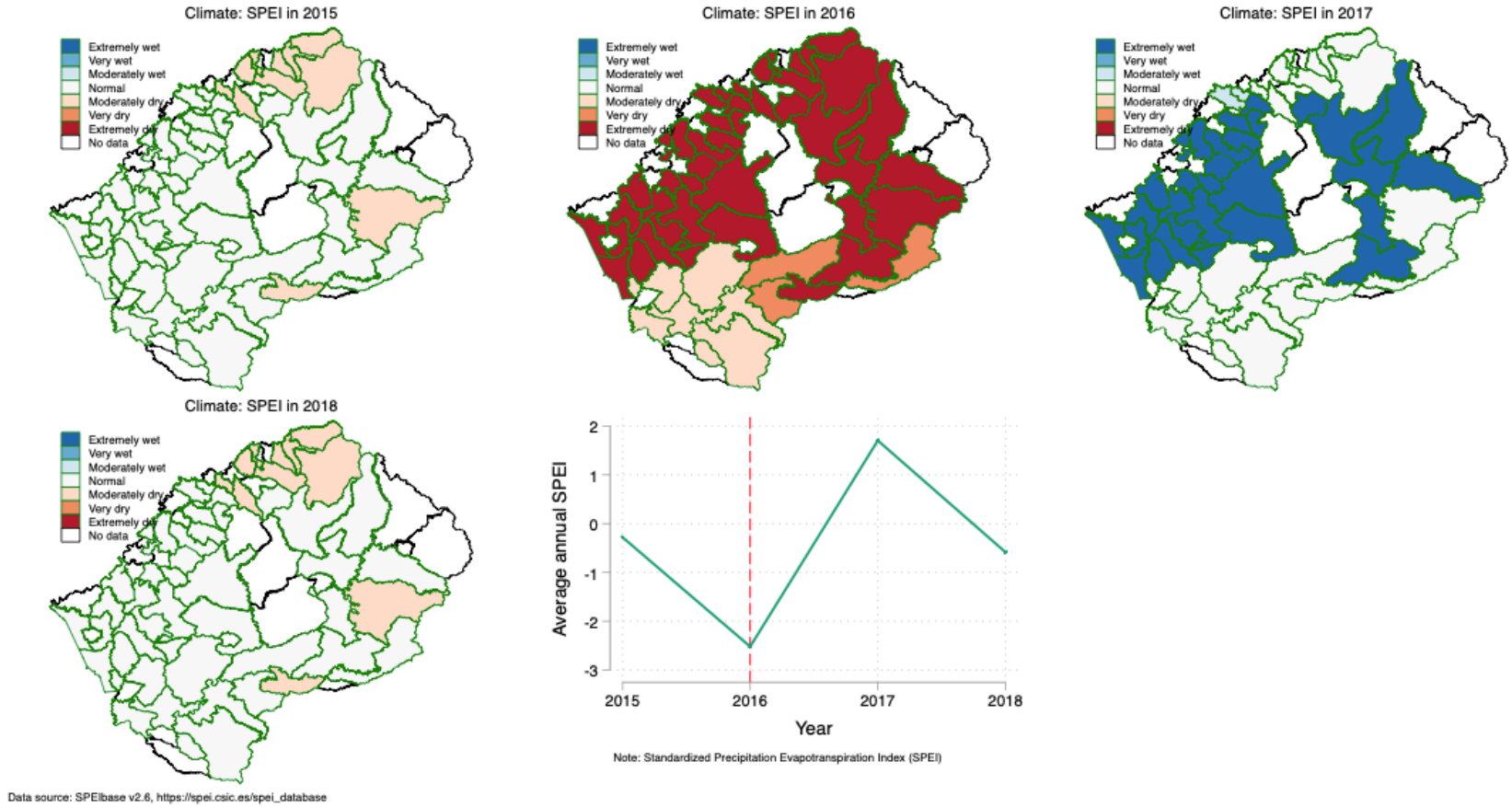
3.5. Descriptive Analysis

Figure 2 shows spatial and temporal weather changes in Lesotho and makes clear the significant variation in weather patterns over geography and time. During the agricultural years 2014-2015 and 2017-2018, weather conditions were largely normal, with few community councils (about eleven) experiencing moderately dry weather conditions (i.e., with SPEI scores that ranged between -1.5 and -1) in the 2014-2015 and 2017-2018 planting seasons. During the 2015-2016 El Niño, all but a few councils in the southern region of the country were very or extremely dry. Therefore, the entire country experienced drought (i.e., SPEI <-1) in the 2015-2016 agricultural year.

In the 2016-2017 agricultural year, weather changes moved from one extreme to the other. Most of the community councils that were extremely dry in the 2015-2016 season experienced floods in 2016-2017. Weather patterns only normalized during the 2017-2018 season. The last graph in Figure 1 shows this extreme volatility: significant variation in weather patterns between 2015 and 2018, with the biggest, country-wide shocks taking place during the 2015-2016 and 2016-2017 planting seasons.

These changes in weather conditions likely caused a decline in the incomes of farming households, potentially forcing them to seek employment in the off-farm sector or to concentrate their labor supply in farming, making them less vulnerable, at least in the immediate term, to shocks. The effects of these weather shocks were likely gendered.

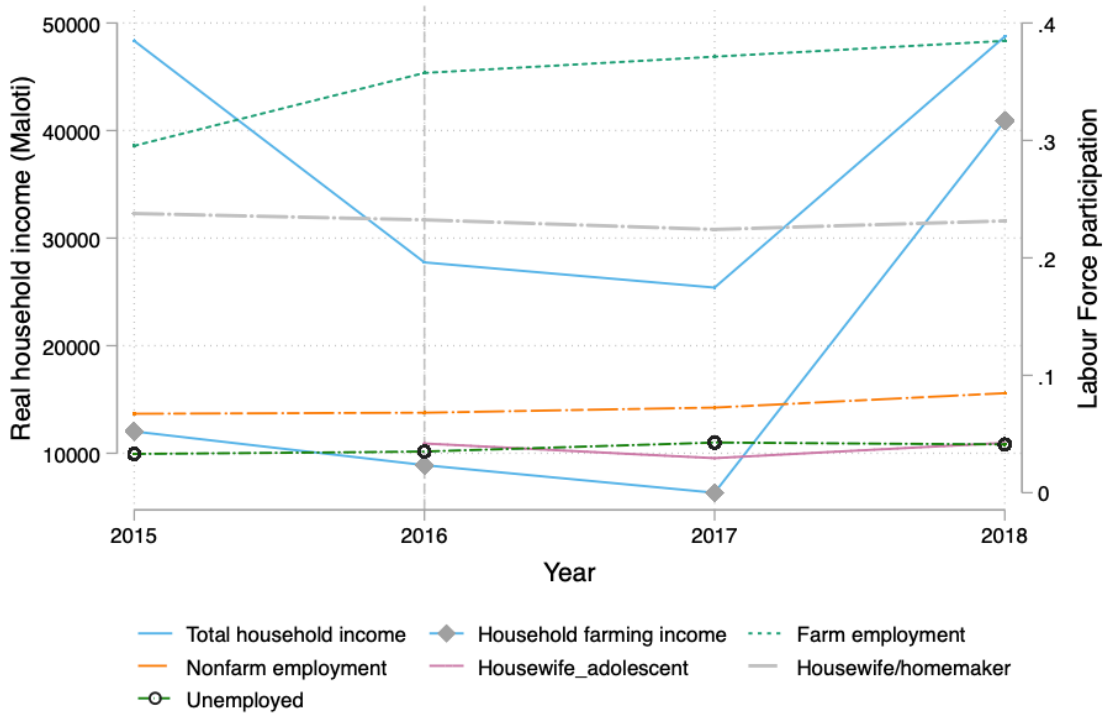
Figure 2: Spatial and Temporal Changes in Weather



Notes: Showing weather patterns of sixty-four rural councils. *Source*: Lesotho Agriculture Production Surveys 2015-2016 through 2018-2019, Lesotho Bureau of Statistics.

Figure 3 illustrates significant variations in household income and labor supply over the 2015-2018 period. There was a steep decrease in 2016, potentially associated with the extremely dry weather conditions of the 2015-2016 planting season. Household income further declined between 2016 and 2017, potentially because of floods but began to increase in 2017. Similarly, household agricultural income significantly declined between 2015 and 2017, after which it sharply increased. Parallel shifts show that household income closely reflected changes in farm income, therefore underscoring the use of total household income in our analysis.

Figure 3: Change in Household Income and Labor Supply Over Time



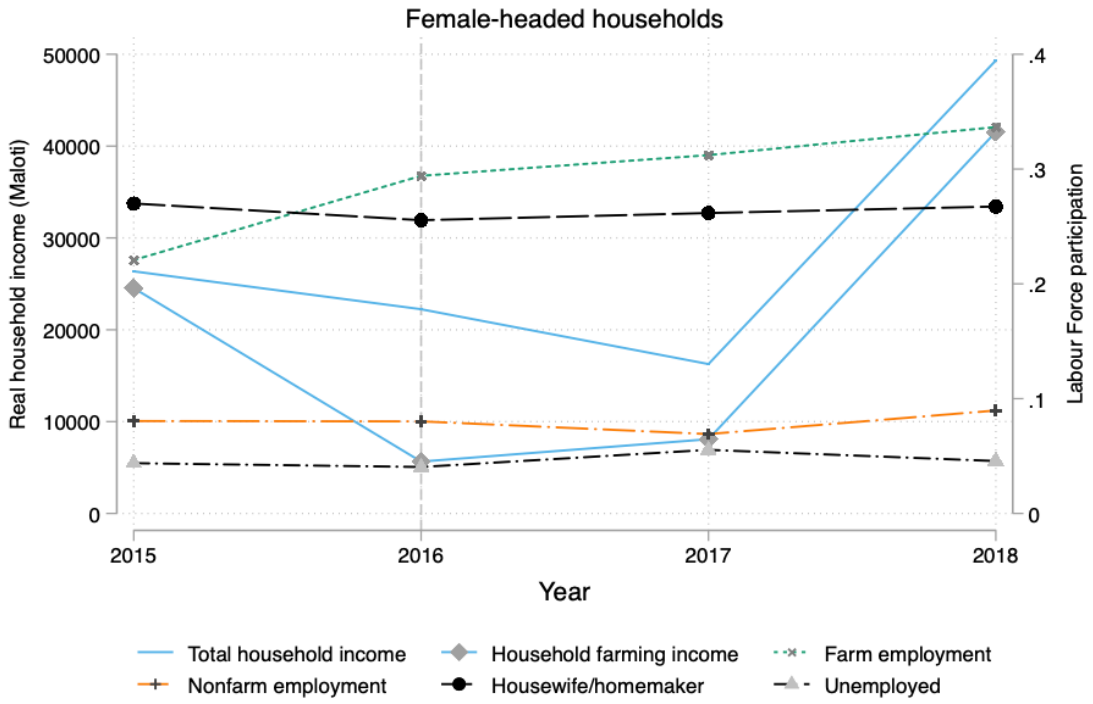
Source: Lesotho Agriculture Production Surveys 2015-2016 through 2018-2019, Lesotho Bureau of Statistics.

Labor-force participation is significantly higher in the farm sector compared to the non-farm sector, but growth in farm employment slowed from 2016 onward potentially because of the 2015-2016 drought, which negatively affected crop production. Drought reduces pastureland which, in turn, increases farmers' need for hay; that, in turn, is likely to cause an

increase in hay prices. The combination of reduced household income and increased hay prices may force farmers, mostly men and young boys, to herd their animals for longer hours in search of pastureland. The figure further shows that, while the proportion of housewives/homemakers declined between 2015 and 2016 for the overall sample, it increased for 12 to 16-year-olds.

A further disaggregation of the sample by gender (see Figures 4a and 4b) reveals that the participation rate in the farming sector was higher for households headed by men than for households headed by women. Participation in the non-farming sector, however, was higher for households headed by women.

Figure 4a: Change in Household Income and Labor Supply for Households Headed by Women

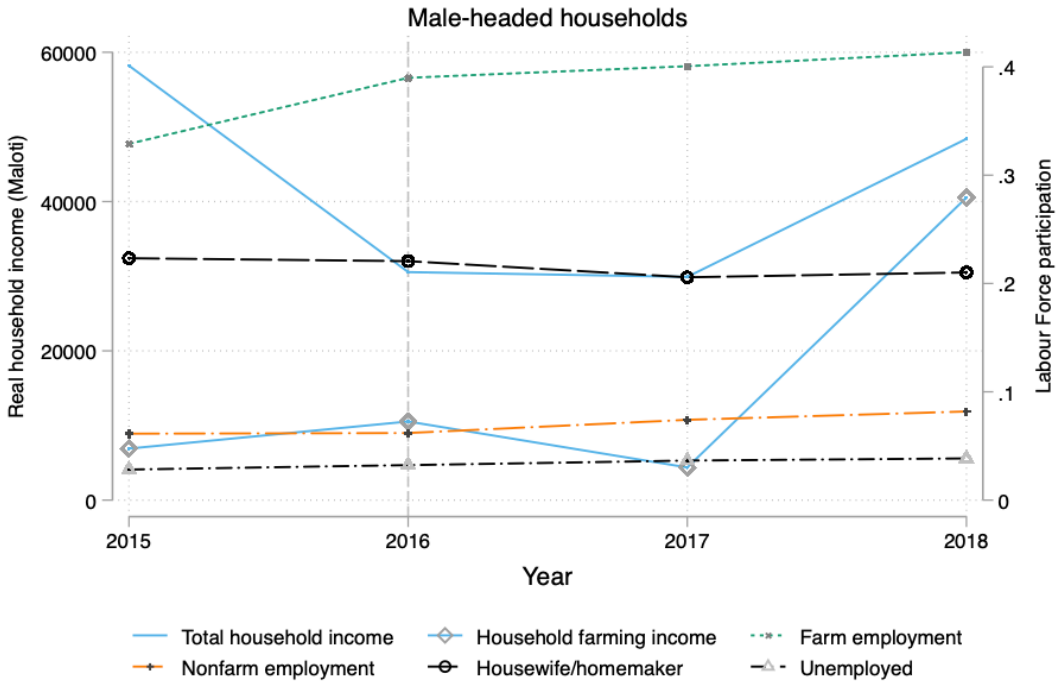


Source: Lesotho Agriculture Production Surveys 2015-2016 through 2018-2019, Lesotho Bureau of Statistics.

Considerable differences exist between households headed by men and households headed by women. In women-headed households, total household income was in decline between the 2015-2016 and 2016-2017 agricultural seasons, while farming income first dropped and then began a slow upward trend. For households headed by men, conversely,

farming income increased as total income dropped between the 2015-2016 and 2016-2017 agricultural seasons. Then from the 2016-2017 agricultural year, which was also a drought year, farming income began to move in sync with total household income. This increase (decrease) in farming income of households headed by men (women) between the 2015-2016 and 2016-2017 agricultural seasons suggests that these households employed different coping strategies in the face of weather shocks. Specifically, this suggests that households headed by men intensified (decreased) their participation in farming activities while households headed by women decreased their participation in farming activities as a form of insurance against the weather shock.

Figure 4b: Changes in Household Income and Labor Supply for Households Headed by Men



Source: Lesotho Agriculture Production Surveys 2015-2016 through 2018-2019, Lesotho Bureau of Statistics.

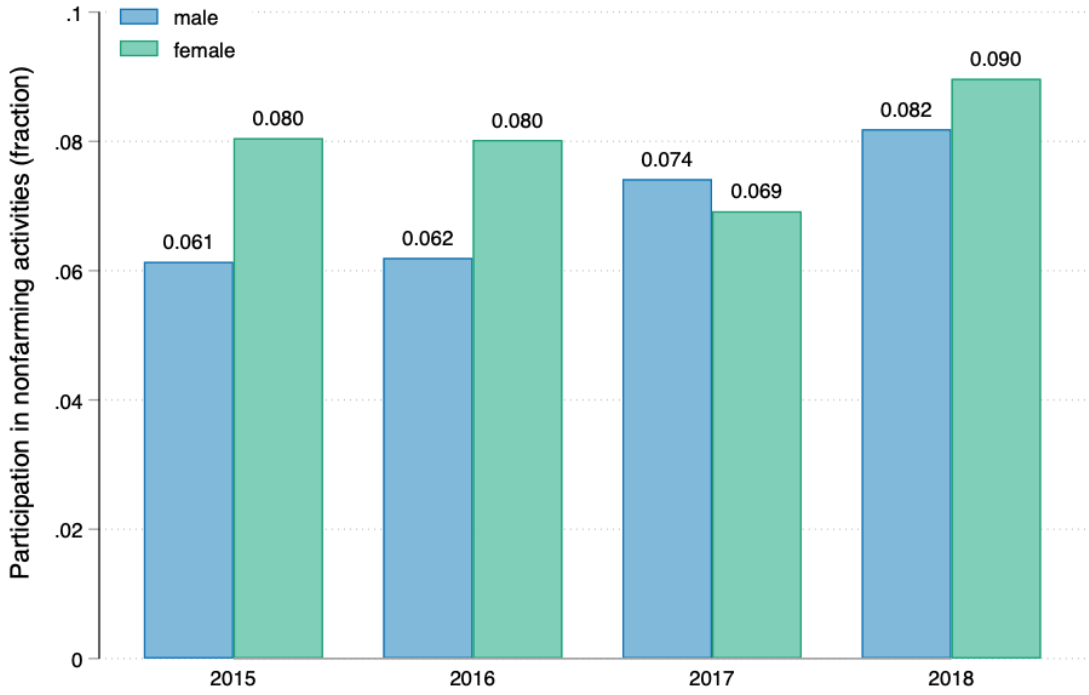
Household income for various labor regimes appears in Figure 5. Trends in income largely paralleled each other over the 2015-2016 and 2018-2019 periods, though the income trends of the unemployed remained flat throughout. The largest source of income was in the "farming and non-farming" category. Trends in income of households that participated in farming only or in non-farming only tracked each other closely. While drought seems to have

decreased income from all sources between 2015 and 2016, only farming household income increased between 2016 and 2017 following the 2016-2017 floods.

Figure 6 shows on-farm participation rates by gender over time. Generally, men's participation rate in on-farm activities is higher than women. Between 2015 and 2018, men's participation in farming increased from 33% to 41%, while that of women increased from 22% to 34%. Therefore, despite the drought during the 2015-2016 planting season, both men and women increased their participation in farming. The increase in farm-labor participation tapered off following the 2017 floods. For example, men's participation in farming increased by one percentage point between 2016 and 2017 compared to five percentage points between 2015 and 2016.

Figure 7 indicates that off-farm labor-participation rates were far lower than farm labor-participation rates. Further, unlike farm labor participation, off-farm labor participation was largely dominated by women. But, as Table 1 makes clear, there were more households headed by men than by women in the farm and off-farm labor-force participation regime. Between 2015 and 2018, off-farm labor participation increased from a paltry 6.1% and 8% to 8.2% and 9% for men and women, respectively. Further, the off-farm labor participation of men increased throughout the period while women's participation dropped by 1.1% between 2016 and 2017, potentially because of floods during the 2016-2017 planting season. The largest increase in off-farm labor participation happened between 2017 and 2018 when women increased their participation by 2.1 percentage points, 1.3 percentage points higher than the increase by men during that period. Despite the 2015-2016 drought, moreover, off-farm labor participation continued to increase between 2015 and 2016, albeit at a much slower pace.

Figure 5: Participation in Non-Farming Activities by Gender Over Time



Source: Lesotho Agriculture Production Surveys 2015-2016 through 2018-2019, Lesotho Bureau of Statistics.

There are three important take-aways from Figures 6 and 7. First, participation in farm and non-farm labor increased over time. Second, drought and floods did not deter farm labor participation, despite potentially reduced returns from farming. Third, floods discouraged women, but not men, from participating in off-farm labor. This implies that weather shocks (floods and drought) encourage men to intensify their participation in both farming and non-farming labor. The differential gender effects of floods on off-farm labor participation possibly imply that men and women engage in different off-farm labor and that women are engaged in those that are more vulnerable to floods such as the sale of grains, vegetables, and fruit (Lesotho Household Budget Survey, 2017). Because off-farm employment acts as an insurance against adverse weather shocks, the results imply that women, and possibly households headed by women, cannot insure themselves against floods, which could decrease in their incomes.

IV. Empirical Framework

4.1. Estimation Strategy

To develop a model of the way weather shocks influence individuals' labor-supply options and affect household income, we first specified the multinomial logit labor-supply-choice model in which we assumed that each individual in the household would choose one of M mutually exclusive labor-supply options to cope with climate shocks. Second, we modeled the effects of climate shocks on household income by estimating two variants of a linear model—one that did not control for possible non-random selection into employment in any of the labor-supply regimes and another one which accounted for potential selection. In all the models, we controlled for council and year fixed effects.

The Individual Labor-Supply Choice Model

Individuals within a household may choose to be in any of the five labor-supply regimes. Therefore, let Y^*_{ictj} be the latent expected income of individual i living in community council c at time t as a result of the choice of labor-supply option j ($j = 1,\ldots,M$). The model is specified as

$$Y^*_{icti} = \sum_{l=0}^{1} \gamma_{lj} Drought_{ct-l} + \sum_{l=0}^{1} \theta_{lj} Flood_{ct-l} + \boldsymbol{Z}_{ict}\psi_j + \lambda_t + \delta_c + \eta_{icti} \qquad (1)$$

where $Drought_{ct-l}$ and $Flood_{ct-l}$ are dummies for contemporaneous ($l = 0$) and previous ($l = 1$) council/region-specific weather shocks, $\boldsymbol{Z}_{ict}$ is a vector of other covariates (such as education, age, gender, region of residence, household composition) for individual i living in community council c at time t that influence the probability of choosing labor-supply option j $\lambda_{t,}$ and δ_c are either time or council fixed effects, respectively(, and η_{ictj} is an idiosyncratic unobserved error term. The parameters of interest are γ_{lj} and θ_{lj}.

In response to weather shocks, individual i in community council c at time t chooses labor-supply option j over other alternatives $k \neq j$ whenever j is expected to yield higher income than k.

Weather Shocks and Household Income Model

Depending on what individual household members choose, a household is classified into three labor-supply regimes: (1) farming, (2) non-farming, and (3) both farming and non-farming. The fourth option is "outside the labor force." The household income model for each possible labor-supply regime is defined as:

$$Y_{ictr} = \sum_{l=0}^{1} \gamma_{l1} Drought_{ct-l} + \sum_{l=0}^{1} \theta_{l1} Flood_{ct-l} + \boldsymbol{X}_{ict}\boldsymbol{\beta}_1 + \lambda_t + \delta_c + u_{ictr} \quad (3)$$

where Y_{ictr} is the income of household i in community council c and year t from labor-supply regime r, ($r = 1, \ldots, 3$), and $\boldsymbol{X}_{ict}$ is a vector of covariates that influence household income (labor market returns) such as the difference in the mean age of men and the mean age of women within the household; differences in the mean education of men and the mean education of women within the household; household size, etc. u_{ictr} is the stochastic error.

In this study, we were interested solely in two labor regimes: farming only and combined farming and off-farm activities. The reasons for this were two. First, few rural households were engaged solely in off-farm activities. Second, the farming and non-farming labor regime choice is a diversification option, which enabled us to examine whether this sort of income diversification mitigated the effects of weather shocks on agriculture. Therefore, we estimated Equation 3 (performed separately for each labor regime and by gender of the head of household), using a linear fixed effects model to account for unobserved heterogeneity across councils and time.

The probability that a household would participate in either farm activities only or in both farm and off-farm activities was likely correlated with the level of earnings expected from either labor regime. That is, if labor-supply regime selection model (1) errors (η_{ictj}) are correlated with the income model errors (u_{ictj}), that is, if $\rho_j = E(\eta_{ictj}, u_{ictj}) \neq 0$, then estimating the household income model (3) via a linear fixed effects model yields inconsistent parameter estimates.

To address this problem, we employed the Heckman Two-Step selection model (Heckman, 1979). In the first stage, we used a probit model to examine a household's decision to participate in farming alone or in combined farming and off-farm activities as two separate decision-making processes:

$$Y_{ictj} = \begin{cases} 1 & if\ Y^*_{ictj} > 0 \\ 0 & if\ Y^*_{ictj} \leq 0 \end{cases}$$

where Y^*_{ictj} is the latent income from labor-supply regime $j = \{farm\ only, farm\ and\ off-farm\}$, and is specified as in equation (1).

In the second stage, using Ordinary Least Squares, we estimated household income equations separately for those in farming only and those in combined farming and off-farm activities. For each labor-supply regime j, the selection-bias-corrected household income equation is given as

$$Y_{ictj} = \sum_{l=0}^{1} \gamma_{lj} Drought_{ct-l} + \sum_{l=0}^{1} \theta_{lj} Flood_{ct-l} + \boldsymbol{X}_{ict}\boldsymbol{\beta}_j + \sigma\left[\boldsymbol{Z}_{ict}\widehat{\psi_j}\right] + \lambda_t + \delta_c + v_{ictj} \quad (4)$$

where σ is the inverse Mills ratio (Heckman, 1979).

4.2. Identification Strategy

To identify the effect of weather shocks on household income from labor-supply regime j, γ_j, some exclusion restrictions or selection instruments were required. That is, we needed variables that influenced selection of labor-supply regime but not household income. We used as instruments the number of children younger than 10 and the number of elderly (65+) in the household. These are valid instruments for the following reasons. First, schooling reduces household farm labor, and this may influence the labor-supply options of household members. The number of children younger than ten, however, does not directly affect household income.

Second, the elderly, just like school-age children, are dependents and do not contribute to household income. Therefore, the number of elderly persons within the household may influence the labor-supply options by household members but not household income.

After controlling for time and council fixed effects and given the plausibly exogenous temporal and spatial variation in weather shocks, the gamma (γ_{ij}) and theta (θ_{ij}) coefficients identify the causal effects of weather shocks (drought and floods, respectively) on individual or household labor-supply decisions and on household income. The standard errors are clustered at the council level to account for the potential serial correlation of the shock episodes within the same community council.

V. Results

5.1. Effect of Weather Shocks on Individual Labor Supply

Table 3 presents the results for the effect of weather shocks on individual labor supply. Column 1 shows the results for the men, while Column 2 shows those for women. Column 1 shows that drought increased the probability that mean would be engaged in farming by twenty percentage points and decreased the probability that they would be non-farm laborers by eleven percentage points relative to being outside the labor market. Similarly, if there was drought in the previous year, men were sixteen percentage points more likely to be involved in farming than to be outside the labor market. The increased likelihood of being a farm laborer during drought could imply that individuals in rural areas have no coping strategies other than to concentrate their participation in farming even when the potential returns from farming are low. Men potentially concentrate their participation in more shock-resistant (at least in the short-run) livestock farming during droughts.

On the contrary, during floods, men are thirteen percentage points less likely to engage in farming. This is in line with expectations that because floods are destructive, farming is no longer a profitable activity. Previous floods did not affect individuals' labor choices.

Column 2 shows that contemporaneous drought reduced women's participation in non-farm activities by 9.6 percentage points and increased the likelihood of being unemployed by seven percentage points. All other weather shocks—previous drought and contemporaneous and previous floods—had no significant effect on women's labor-supply choices. However, the signs of the coefficients were largely consistent with those of the men's sample. This implies that, in the face of adverse weather conditions, women were indifferent to the choice of either leaving the labor force or engaging in any other labor-supply option, potentially because none of the available labor-supply options offered better security during weather shocks. This indicates that women and households headed by women are more vulnerable during adverse weather conditions. Women also have fewer coping strategies against weather shocks.

Table 2: Marginal Effects of Weather Shocks on Labor-Supply Decisions

	(1) Men	(2) Women
Drought		
1. Farm labor	0.196***	0.0989
	(0.0634)	(0.0687)
2. Non-farm labor	-0.108***	-0.0958*
	(0.0350)	(0.0538)
3. Unemployed or seeking work	0.00302	0.0709**
	(0.0372)	(0.0290)
4. Housewife/Homemaker	-0.0881	-0.0248
	(0.0555)	(0.0818)
Lag drought		
1. Farm labor	0.161***	0.0769
	(0.0620)	(0.0579)
2. Non-farm labor	-0.0160	-0.00308
	(0.0446)	(0.0419)
3. Unemployed or seeking work	-0.0245	0.0413
	(0.0318)	(0.0388)
4. Housewife/Homemaker	-0.0959*	-0.0534
	(0.0495)	(0.0590)
Flood		
1. Farm labor	-0.131**	-0.0589
	(0.0547)	(0.0577)
2. Non-farm labor	0.0370	0.00553
	(0.0344)	(0.0359)
3. Unemployed or seeking work	0.0267	0.0160
	(0.0269)	(0.0168)
4. Housewife/Homemaker	0.0612	-0.0255
	(0.0461)	(0.0608)
Lag flood		
1. Farm labor	-0.00747	0.00849
	(0.0493)	(0.0489)
2. Non-farm labor	-0.00287	-0.00649
	(0.0329)	(0.0317)
3. Unemployed or seeking work	0.0133	0.0254
	(0.0307)	(0.0304)
4. Housewife/Homemaker	0.0151	-0.0575
	(0.0286)	(0.0647)
N	6967	5324

Notes: Standard errors, in parentheses, are clustered at the council level. For the men's (women's) model, the sample is all 18-70 (18-60) year olds, in rural councils observed for at least three years. "Farm labor," "non-farm labor," "Unemployed or seeking employment," and "housewife/homemaker" are labor-supply options. The base category is "not in the labor force." All models control for numbers of infants (0–5-year-olds), 6–9-year-olds, school-age children (6–18-year-olds), and the elderly (65+ year olds) in the household, and council and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Source*: Lesotho Agriculture Production Surveys 2015-2016 through 2018-2019, Lesotho Bureau of Statistics.

5.2. Differential Effect of Weather Shocks on Household Income by Gender

The results are presented in Table 4. Columns 1 to 4 show the linear FE model results, and Columns 5 to 8 show the Heckman selection model results. The odd-numbered columns present the effects for households headed by women and the even-numbered columns present those for households headed by men.

Generally, the linear FE model results are like the Heckman selection model results. We can see from Columns 1, 2, 5, and 6 of Table 4 that contemporaneous and previous drought had no significant influence on household income of men and women engaged in farming. On the other hand, contemporaneous drought reduced the income of households headed by women by 128% (see Columns 3 and 7 of the table) if the women were simultaneously engaged in farming and off-farm activities. However, the same weather shock had no statistically significant effect on the income of men-headed households performing the same labor see Columns 4 and 8.

Further, contemporaneous (and not previous) floods had a significant negative effect on the incomes of farming households headed by women and on the incomes of households headed by women who were engaged in both farming and non-farming (see Columns 3, 5, and 7). For instance, during floods, the income of farming households headed by women dropped by up to 62% and that of farming and non-farming households headed by women declined by about 77%. Previous floods reduced the income of men-headed households who participated in both and farm and off-farm activities by 63% (see Columns 4 and 8). Conversely, both current and previous floods had no influence on the income of men-headed households engaged in farming. This implies that contemporaneous floods represented a huge income shock to households headed by women and that being in off-farm employment provided no security against this shock but rather intensified income loss.

These results are largely consistent with what can be observed in Figures 3 and 4 as well as with evidence that women engage in off-farm activities that are more susceptible to weather shocks. During the La Niña period, we know that agricultural production increased in

Lesotho (2017-2018 Crop Forecasting Report). The negative effect of floods on the income of households headed by women is potentially the result of suppressed prices of agricultural produce (e.g. vegetables and grains).

By and large, the results in Table 4 indicate that women are more vulnerable to weather shocks than are men. More importantly, the effect of previous floods is twice as high on the income of households headed by women than on those headed by men.

Table 3: Effect of Weather Shocks on Income in Households Headed by Women and by Men

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Linear Fixed Effects model				Heckman selection model			
	Farming Women	Farming Men	Farming and Non-Farming Women	Farming and Non-Farming Men	Farming Women	Farming Men	Farming and Non-Farming Women	Farming and Non-Farming Men
Drought	0.0864	0.352	-1.278*	-0.230	0.273	0.414	-1.254**	0.171
	(0.332)	(0.270)	(0.706)	(0.540)	(0.319)	(0.275)	(0.581)	(0.573)
Lag drought	0.169	0.181	-0.820	0.251	0.170	0.213	-0.844	0.134
	(0.310)	(0.229)	(0.717)	(0.429)	(0.303)	(0.229)	(0.581)	(0.475)
Flood	-0.578**	-0.258	-0.775	-0.392	-0.622**	-0.276	-0.770*	-0.303
	(0.290)	(0.224)	(0.493)	(0.364)	(0.274)	(0.224)	(0.393)	(0.382)
Lag flood	0.145	0.0487	-0.319	-0.627**	0.195	0.0536	-0.325	-0.582*
	(0.277)	(0.185)	(0.384)	(0.280)	(0.265)	(0.183)	(0.308)	(0.353)
N	808	2021	164	379	1461	2637	1026	2539

Source: Lesotho Agriculture Production Surveys 2015-2016 through 2018-2019, Lesotho Bureau of Statistics. *Notes*: Robust standard errors in parentheses. Sample is all households headed by women in rural councils observed for at least three years. In all regressions, the dependent variable is log of household income. The reference labor option is unemployment. Control variables are council and year fixed effects, household size, average education, and average age of women and men in the household. Selection instruments in the Heckman selection model are the number of children under 10 and the number of the elderly (65+ in the household. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5.3. Potential Mechanisms

What explains the differences between men's and women's labor-supply choices and, hence, differences in the incomes of households headed by women in response to weather shocks? Some possible explanations are that: (1) households headed by women engage in different off-farm activities than do men and these activities cushion their incomes differentially during weather shocks; (2) men- and women-headed households may engage in different (short-term resilient) farming activities such as raising livestock; (3) households headed by women are likely to substitute young girls to do household chores so that their mothers or other adult women in the household can engage in income-generating activities; and (4) in households headed by men, young girls may be married off in order to collect the bride price, a form of insurance against weather shocks (see Corno, Hildebrandt, & Voena, 2020).

We initially examined two potential explanations: that differences in the effects of weather shocks on labor supply and household income are the result of men's and women's different farm and off-farm activities. Unfortunately, we do not have enough data to provide causal evidence. According to the Lesotho Household Budget Survey of 2017 (see Table 5), women's farm and off-farm activities mostly involved the sale of grains (sorghum, maize, etc.), firewood, traditional herbs, home-brewed beer, and food, while men mostly sold livestock and animal products and were involved in housing construction. Therefore, farm and off-farm activities by women were more susceptible to weather shocks. During droughts, for example, the sale of cattle and animal products may increase because cattle are used less for ploughing, while the sale of grains likely declines because of lack of grain supply.

We next explored a second mechanism to explain negative drought and previous drought effects on the income of women-headed (and not men-headed) households for those engaged simultaneously in farm and off-farm activities. According to Yaya, et al. (2020), there is a higher incidence of child marriages in households headed by men relative to those headed by women in sub-Saharan Africa, and this may explain the negative effect of contemporaneous and previous drought on the income of households headed by women in farm and off-farm activities. The bride price from marrying young daughters

during droughts may offset the negative effects of weather shocks in households headed by men.

The APS data include information on whether individuals are homemakers and/or housewives. We argue that adolescent girls replace older women in the household in household chores to allow older women household members to increase their labor supply to farming or to seek income-generating employment (consistent with the labor supply model for households headed by women). Because we cannot separate these two categories, we first used this information to investigate the child-marriage channel and the within-household-labor-substitution channel. Table 6 presents results of the impact of drought on the likelihood that an adolescent girl (12-16) would be a homemaker or housewife.

Table 4: In What Farm and Off-Farm Activities Did Individuals Engage During the Previous Twelve Months?

	Women (%)	Men (%)	Total
Sell livestock			
No	50.60	49.40	100.00
Yes	43.83	56.17	100.00
Total	50.56	49.44	100.00
Sell grains			
No	50.56	49.44	100.00
Yes	57.26	42.74	100.00
Total	50.56	49.44	100.00
Sell/gather firewood			
No	50.56	49.44	100.00
Yes	50.52	49.48	100.00
Total	50.56	49.44	100.00
Sell traditional herbs			
No	50.52	49.48	100.00
Yes	59.85	40.15	100.00
Total	50.56	49.44	100.00
Sell animal products			
No	50.57	49.43	100.00
Yes	25.37	74.63	100.00
Total	50.54	49.46	100.00
Sell home-brewed beer			
No	50.32	49.68	100.00
Yes	55.87	44.13	100.00
Total	50.56	49.44	100.00
Sell food			
No	50.36	49.64	100.00
Yes	60.98	39.02	100.00
Total	50.56	49.44	100.00
House building (Construction sector)			
No	50.64	49.36	100.00
Yes	42.95	57.05	100.00
Total	50.55	49.45	100.00

Source: Authors' computations from the Lesotho Household Budget Survey of 2017 (Lesotho Bureau of Statistics, 2017.

Table 5: Marginal Effect of Drought on the Probability that an Adolescent Will Be a Homemaker or a Housewife

	(1) Men	(2) Women
Drought	-0.0829	0.176*
	(0.106)	(0.0968)
Lag drought	-0.0769	0.0799
	(0.0632)	(0.0684)
Flood	-0.0488	-0.0112
	(0.0671)	(0.0523)
Lag flood	-0.0965	0.0649
	(0.106)	(0.0466)
N	478	952

Source: Lesotho Agriculture Production Surveys 2015-2016 through 2018-2019, Lesotho Bureau of Statistics. *Notes*: Standard errors, in parentheses, are clustered at the council level. The sample is all 12-

16 year olds, in rural councils observed for at least three years. All models control for numbers of infants (0-5-year olds), 6-9 year olds, school-age children (6-18 year olds), and the elderly (65+ year olds) in the household, and council and year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

While weather shocks reduced off-farm employment and increased the unemployment of adult women who were in the labor force, they significantly increased the labor supply of adolescent girls (12–16-year-olds). Table 6 illustrates that drought increased the likelihood that an adolescent girl would be a homemaker or a housewife by eighteen percentage points relative to non-adolescents. That is, during drought, young girls were likely to drop out of school and get married and/or to do household chores to enable their mothers or other adult women in the household to engage in income generating activities.

Table 6: Effect of Drought on Timing of Marriage

	(1)
VARIABLES	Timing of marriage
Drought	-0.00460***
	(0.00141)
Observations	98,945
Adjusted R-squared	0.064

Source: Authors' replication of the results reported by Corno, Hildebrandt, and Voena (2020) for Lesotho using 2004, 2008, and 2014 Demographic Health Survey data. *Notes*: OLS regression (with grid cell fixed effects) results in a sample of women aged 25 or older at the time of interview. Observations are at the level of × age (from 12 to 24 or age of first marriage). The dependent variable is binary for marriage, coded to 1 if the woman was married at the age corresponding to the observation. Standard errors (in parentheses) are clustered at the cell level. A drought is defined as annual rainfall below the fifteenth percentile of local rainfall distribution. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

If households headed by women were marrying off their young daughters as a form of insurance against drought-induced weather shocks, we would expect the bride-price, which is paid to the family of the bride, to offset the negative effect of drought. It is, therefore, unlikely that this result is explained by child-marriage. The results in Table 7, in fact, show that drought reduced (rather than increased) the likelihood that young girls would be married. These results are based on our replication of the results of Corno, Hildebrandt, and Voena (2020) for Lesotho.

Taken together, the results in Tables 6 and 7 imply that, during and following droughts, adult women lose their off-farm jobs. As they intensify their search for

employment, they reduce time spent in household chores, and younger daughters become substitute labor within the household. This strategy, however, is not successful in mitigating the negative effects of climate shocks because such families still experience a significant decline in their incomes. Adopting this strategy may actually have a negative, longer-term impact on investment in women's human capital, thereby making women even more vulnerable to future shocks.

VI. Conclusions and Policy Implications

Our results show that women are more vulnerable to weather shocks and have more limited coping strategies than men. While men have the option to intensify participation in farming as a coping strategy in the presence of a weather shock, women do not. Contemporaneous and previous droughts led to increased participation in farming for men but not for women, and contemporaneous floods negatively affected the farm labor supply decisions of men but not women.

We analyzed the gender-differentiated effects of weather shocks on household income. The results reveal that floods reduced the income of farming households headed by women by up to 62%, and that contemporaneous drought reduced the income of households headed by women that engaged in farming or in farming and non-farming activities by up to 128%, while both contemporaneous and previous floods had no significant impact on the income of counterpart households headed by men.

Finally, we explored two potential mechanisms that may generate differentiated effects of weather shocks: first, that women-headed and men-headed households engage in different off-farm activities that may or may not attenuate the effects of weather shocks; and, second, that households headed by men may complement income with bride-price money from marrying their young daughters given the high incidence of child marriages and child labor in such households.

Our evidence shows that women and men engaged in different off-farm activities, and that women participated in off-farm activities that were more susceptible to weather shocks. Further, we found that drought increase the probability that an adolescent girl in a women-headed household would be a homemaker or housewife by about 18%. Two possible explanations underpin this result. First, young girls are subjected to early marriage in exchange for bride price, which could cushion against weather shocks. Second, girls could become homemakers as their mothers or adult women within the household seek income-generating activities to cushion themselves against weather shocks.

Child marriage cannot explain our results for two reasons. First, because only adolescent girls in households headed by women are more likely to be homemakers/housewives, we would expect this to dampen the negative effect of drought in these households, especially those engaged in simultaneous farm and off-farm activities. Second, and more importantly, we used the Demographic Health Survey data for Lesotho to show that drought reduced the chance of getting married young in Lesotho. Therefore, the more plausible mechanism for these results is that young girls in households headed by women take the place of adult women in household chores as the adults increase their search for employment.

Taken together, the results suggest that climate change has a highly significant effect on rural labor markets and household welfare in Lesotho. The income and labor-supply decisions of women and adolescent girls are most vulnerable to weather shocks. The COVID-19 pandemic amplifies the gendered effects, making women even more vulnerable to the shocks. Men, on the other hand, are less affected by climate shocks. Therefore, extensive use of climate-smart agricultural technologies and inputs, such as hybrid seeds, by rural households would provide the necessary self-insurance against weather shocks for rural farming households. Further, more opportunities for women in the rural non-farming sector, including access to and ownership of productive assets such as land, would mitigate the effects of weather shocks. Lastly, increasing women's participation in such women-dominated non-farm activities as rural tourism could cushion both against weather-related shocks and the likely effects of the pandemic.

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Appendices

Appendix A

Table A1: Categorization of Dry and Wet Conditions According to the SPEI

Categorization	SPEI
Extremely dry	Less than -2
Severely dry	-2 to -1.5
Moderately dry	-1.5 to -1
Normal	-1 to 1
Moderately wet	1 to 1.5
Severely wet	1.5 to 2
Extremely wet	Greater than 2

Table A2: Description of Variables

Variable	Definition	Source
Individual-level variables		
Age	Variable that identifies the age in years of members of the household	Agricultural Production Survey
Years of education	Measures head of household's level of education	Agricultural Production Survey
Farm-employed	Binary variable that takes the value 1 if the individual is employed in farming and 0 otherwise	Agricultural Production Survey
Nonfarm employed	Binary variable that takes the value 1 if the individual is employed in non-farm activities and 0 otherwise	Agricultural Production Survey
Housewife/Homemaker	Binary variable that takes the value 1 if an individual is a housewife/homemaker and 0 otherwise	Agricultural Production Survey
Unemployed	Binary variable that takes the value 1 if an individual is unemployed and 0 otherwise	Agricultural Production Survey
Outside labor force	Binary variable that takes the value 1 if an individual is outside the labor force and 0 otherwise	Agricultural Production Survey
Individual income (M)	Receipts in cash and in-kind income by individuals within the household	Agricultural Production Survey
Household-level variables		
Household Size	Total number of persons living permanently within the household	Agricultural Production Survey

Infants (0-5 years)	Number of infants aged 0-5 within the household	Agricultural Production Survey
Children (6-9 years)	Number of children aged 6-9 within the household	Agricultural Production Survey
School children (6-18 years)	Number of school children aged 6-18 in the household	Agricultural Production Survey
The elderly (65+ years)	Number of individuals aged 65+ in the household	Agricultural Production Survey
Head of household's education	Measures head of household's level of education	Agricultural Production Survey
Head of household's age	Identifies the year of age of the head of household	Agricultural Production Survey
Education of men in household	Measures the education level of men in the household	Agricultural Production Survey
Education of women in household	Measures the education level of women in the household	Agricultural Production Survey
Age of men in household	Identifies the age of men in the household	Agricultural Production Survey
Age of women in household	Identifies the age of women in the household	Agricultural Production Survey
Workers per household	Number of hired individuals (workers) in the household	Agricultural Production Survey
Farming household	Dummy variable that takes the value 1 if the household participates in farm employment and 0 otherwise	Agricultural Production Survey
Non-farming household	Dummy variable that takes the value 1 if the household participates in non-farm employment and 0 otherwise	Agricultural Production Survey
Farming/Non-farming household	Dummy variable that takes the value 1 if the household participates in both on-farm and non-farm employment and 0 otherwise	Agricultural Production Survey
Household Income (M)	Sum of agricultural income, non-farm wage income, self-employment or entrepreneurial income, property income, transfers, and any other income by the individuals in Maluti	Agricultural Production Survey
Household Farming Income (M)	Income that is generated from agricultural sector in Maluti	Agricultural Production Survey
SPEI	Index that takes into account the difference in climatic water balance between precipitation and potential evapotranspiration (PET)) to determine the severity of drought	SPEI database