Food and Agriculture Organization of the United Nations

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FAO AGRICULTURAL DEVELOPMENT ECONOMICS WORKING PAPER 18-07

ISSN 2521-1838

November 2018

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Valentina Conti, Nicholas J. Sitko and Ada Ignaciuk

Food and Agriculture Organization of the United Nations

Rome, 2018

Required citation:

Conti, V., Sitko, N. & Ignaciuk, A. 2018. *How do extreme weather events affect livestock herders' welfare? Evidence from Kyrgyzstan.* FAO Agricultural Development Economics Working Paper 18-07. Rome, FAO. pp. 28. Licence: CC BY-NC-SA 3.0 IGO.

ISBN 978-92-5-131144-8

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Valentina Conti[1], Nicholas Sitko[1] and Ada Ignaciuk[1]

[1] Food and Agriculture Organization of the United Nations, Agricultural Development Economics Division (ESA), Viale delle Terme di Caracalla, 00153 Rome, Italy

Abstract

This paper examines the impact of the harsh 2012 winter on livestock herding households in Kyrgyzstan and identifies policy options to increase household resilience to such shocks. While existing studies mostly focus on rainfall shocks in tropical or dry climate areas, this analysis examines the exceptionally harsh winter that hit Kyrgyzstan in 2012, which resulted in the death of 25 000 animals. Using a unique household panel survey, merged with observed temperature data, the analysis finds that, on average, the negative effects of the winter shock on household welfare are significant and persistent over time, leading to a 5 percent and a 8 percent decrease in households' food consumption expenditure in the short- (2011–2013) and medium-run (2011–2016), respectively. When disaggregating by income quantiles, the evidence shows that negative impact is concentrated in the upper quantiles of the welfare distribution. Several policy options are identified as effective in mitigating the negative welfare impacts of the weather shock. First, supporting households to restock their herds following weather shocks is found to significantly improve medium-term welfare by 10 percent relative to those that did not restock. Restocking efforts can be addressed in a holistic manner that takes into account immediate household needs, while simultaneously building long-term resilience in the livestock sector. This may include mitigating animal losses through the development of local forage markets that increase the availability of winter forage, combined with efforts to improve the genetic pool of livestock species through breeding programmes that select for resiliency traits. Second, results show that households living in regions with higher access to public veterinary services had significantly better welfare outcomes following the winter shock. Improvements of veterinary services and strengthening community-based organizations focusing on livestock and pasture development may help herding households to cope with weather shocks.

Keywords: livestock; weather shocks; Kyrgyzstan; agricultural policies.

JEL codes: Q12; Q18; O12; Q54.

Acknowledgments

This paper is produced in the context of the programme of work on Economic and Policy Analysis of Climate Change (EPIC) within FAO's Agricultural Development Economics Division (ESA) (see www.fao.org/climatechange/epic).

We would like to acknowledge the founder of the "Life in Kyrgyzstan" study, Professor Tilman Brück, and Damir Esenaliev for their support during the preparation of this paper. A special acknowledgment goes to Aslihan Arslan for her feedback and comments at the early stages of the project. We are grateful to Roman Mogilevsky from the University of Central Asia in Bishkek (UCA), to the attendees of the 2017 Life in Kyrgyzstan conference for their comments, and to the staff at the Kyrgyzstan office of FAO for their inputs.

The authors would also like to thank geospatial analysts at FAO for their support with the extraction of the climate data, and all ESA colleagues for their comments and suggestions provided during the internal review of the paper.

Errors are the responsibility only of the authors, and this paper reflects the opinions of the authors, and not the institutions which they represent or with which they are affiliated.

Corresponding author: valentina.conti@fao.org

1 Introduction

In Kyrgyzstan, 66 percent of the population lives in rural areas, where livestock production constitutes an important source of livelihood (World Bank, 2015). Livestock plays critical economic, social, and cultural roles for rural Kyrgyz people (Schoch, Steimann and Thieme, 2010).[1] Yet livestock rearing is increasingly imperilled by the effects of climate change (IPCC, 2007). Indeed, heavy reliance on the livestock sector is an important reason why the country is ranked third among all Central Asian and Eastern European countries in terms of overall vulnerability to climate change (Fay, Block and Ebinger, 2010).

This vulnerability was highlighted in 2012, when a harsh winter, followed by destructive spring run-off, led to considerable livestock mortality and food price rises (WFP, 2012). According to an advisory bulletin released by the Kyrgyz Ministry of the Emergency Situations, the regions of Osh, Jalal-Abad, Batken and Naryn experienced abnormally low temperatures in February and March which resulted in a significant loss of assets, food, and income sources for livestock owning households in the affected areas. Moreover, the loss of animals contributed to a rapid rise in prices for animal products. The World Food Programme estimated that as a result of the harsh winter, beef and mutton prices increased by 19 percent and 12 percent, respectively, relative to the previous year, while milk prices increased by 15 percent (WFP, 2011).

This study seeks to expand our understanding of the implications of weather shocks on the welfare of livestock owning households in Kyrgyzstan and to identify policy options that can enhance the resilience of these vulnerable households. More specifically, the study has three objectives. First, it examines the short (one year) and medium-term (four years) impacts of the harsh winter on the welfare of livestock owning household (measured in terms of food consumption expenditure) using a unique, multi-year panel data set. Measuring the impact at two points in time can help determine if weather shocks of this nature contribute to a temporary or persistent change in the welfare of livestock owning households.

Yet, the magnitude and duration of the impact of the harsh winter is likely to vary considerably, depending on the pre-shock socio-economic conditions of the household (Carter *et al.*, 2007). Thus, the second objective is to examine the heterogeneous impacts of the shock on different socio-economic segments of the livestock owning population—for which a difference-in-difference quantile approach estimation is deployed.

Third, in order to help identify policy options for enhancing the resilience of the livestock owning households to weather related shocks, the study examines the impact of two potential policy options: herd restocking and investment in public veterinary services. Herd restocking is a common post-disaster response, which aims to mitigate short-run asset liquidation and can help smoothen household consumption and incomes (Ouma, Obando and Koech, 2012; Speranza, 2013). Public investments in veterinary services, on the other hand, represents a longer-term investment in the sector, which can help to improve resilience to whether shocks through improved herd management.

[1] Milk products are just as important as meat. They include butter, milk, yogurt, cream and dried yogurt as well as *kymyz*, which is fermented mare's milk and it is mainly consumed during the summer pastures (jailoo) (Steimann, 2011).

The analysis shows that the harsh winter leads to a statistically significant decline in household welfare both in the short- and medium-term. Moreover, this impact was particularly acute for households that prior to the shock were in the upper end of the food consumption expenditure distribution. This suggests that the loss of animals caused by the winter shock pushed these households into a more vulnerable welfare status, which they have struggled to escape from. The study shows that households that invested in restocking their herd following the shock increased their food consumption by 10 percent in the medium-term relative to those that did not. In regions with a higher density of public veterinary services, following the shock, households were able to increase their food consumption relative to those without these services by 28 percent in the short-term and 34 percent in the long-term.

The paper is organized as follows. In the next section, we present the dataset and describe the variables used in the study. A brief discussion of the conceptual framework is presented in Section 3. Section 4 presents the descriptive analysis whereas Section 5 discusses the empirical strategy used. Section 6 presents the results and discusses the policy implications. Section 7 provides concluding remarks.

2 Conceptual framework

Livestock offer rural households, particularly those with limited access to credit or social protection systems, a tool to mitigate the consumption effects of transitory income or livelihoods shocks, such as those associated with weather-induced disasters (Deaton, 1991; Dercon, 2004). Poor households in particular may benefit from selling livestock in order to smoothen consumption (Carter *et al.*, 2007). However, the empirical evidence on the use of livestock to smoothen consumption following a transitory shock is mixed. Households show different behavioural responses to shocks in terms of asset utilization, which depend on their level of welfare. Empirical evidence on Ethiopia and Kenya reveals a pattern of asset-smoothing among poor households indicating that, in presence of weather-related losses in agricultural production, households at the bottom of the welfare distribution prefer holding their asset rather than selling it to smoothen their consumption (Carter *et al.*, 2007; Barrett and Swallow, 2006). On the other hand, well-off households are found to sell livestock so as to smooth consumption in the face of drought-related income losses (Hoddinott, 2006). This suggests that the impact of a climate shock on consumption is likely to be heterogeneous, and may vary by socio-economic group.

More to this point, while existing studies mostly focus on smoothing consumption as opposed to asset behaviour in the presence of agricultural-related income losses, this study analyses a climatic shock that resulted into massive animal deaths, thus leading to impoverished asset base of pastoralist households in Kyrgyzstan[2]. In this context, the shock has likely moved even wealthier herding households into more vulnerable condition, leading to a decline in their risk management capacity, particularly the sale of livestock to insulate their consumption, as found in the existing literature. In this respect, for herding households, weather shocks that directly affect livestock numbers are qualitatively different from other sorts of income or livelihood shocks. Households that lose animals due to a weather shock may not be able to rely on livestock sales to smoothen their consumption, as this would further erode household capacity to replenish their animal herds through reproduction, and thus potentially undermines their future livelihoods options. In this way, shocks that contribute to livestock mortality can considerably limit the coping capacity of even the better-off herding households. This study, therefore, examines not only the short- and medium-term effects of a harsh winter shock on household food consumption expenditure to assess the extent to which the effect is transitory or has led to a longer term erosion of household welfare, but also investigates if the shock has produced heterogeneous impacts for households at different points of the welfare distribution.

[2] To our knowledge one exception to existing literature is the study by Groppo and Kraehnert (2016) that analyses the effect of the winter shock (*dzud*) on child nutrition in Mongolia.

3 Data and variables

Three sources of data are used in this analysis. The first is the Life in Kyrgyzstan Study (LiK) survey, which is a nationally representative panel household data collected in 2011, 2012, 2013 and 2016. It is carried out by the Leibniz Institute of Vegetable and Ornamental Crops (IGZ) in Germany (Brück *et al.*, 2014). A collaboration with the Food and Agricultural Organization (FAO) started in 2016. FAO has developed a detailed agricultural questionnaire for the LiK 2016 wave with specific issues regarding agricultural and livestock practices. The LiK collects data in all seven oblasts (regions), as well as in the cities of Bishkek and Osh. The focus of the analysis is on the sub-sample of households owning livestock assets that are referred to as herders throughout the analysis. LiK is a multi-topic surveys, which are collected under three domains: a *household* questionnaire submitted to the most informed household member; an *individual* questionnaire addressed to all family members aged 18 and above, and; a *community* questionnaire, which is filled in by a representative of the local administration. The survey includes information on animal assets, expenditures and various sources of income, along with household demographic characteristics. The survey consists of 4 361 and 4 316 households in short and long-run samples, respectively.

LiK panel data is merged with climatic data on temperature collected by the European Centre for Medium-Range Weather Forecasts (ECMWF) which provides information on 10 daily raster at a pixel resolution of 0.25 degree for Asian countries (25 kilometres at the equator). Temperature data are used to detect extremely cold temperatures across districts during February and March 2012, which showed unusually low temperatures and heavy snowfall Temperature data were merged at district level as it represents the most disaggregated geographical unit of analysis available. According to the bulletin released by the Kyrgyz Ministry of Agriculture in April 2012 the regions of Osh, Jalal-Abad, Batken and Naryn were effected by abnormally low temperatures in February and March, leading to significant animal losses.[3] Usually during the months of February/August farmers send their livestock to the mountain pastures, where animals are set free to look for food, but animals (especially sheep and cows) could not pierce the snow to reach the spring grass due to extreme cold temperatures. The Ministry of Agriculture specified that at the end of March 2012 about 26 000 animals died because of the lack of feed in the country. Precisely, 3 300 cows and bulls, 21 800 sheep and 1 640 horses. To test the impact of the winter shock on household herders' welfare, ECMWF temperature data are used to create a dummy variable indicating districts hit by extreme cold temperature. Districts experiencing the winter shock are identified as those with an average temperature in February/March 2012 which falls below two times the standard deviation of district-specific historical average temperature (years 1989–2011). Treated households are defined as those living in districts hit by the harsh winter. Furthermore, shocked districts belong to the regions listed in the bulletin mentioned above, which confirms the validity of the methodology used.[4]

[3] The Bulletin was released on the 19th April 2012 and it is available in Kyrgyz language.

[4] The districts hit by the winter 2012 and identified through the temperature dataset are the following: Ak-Bashy, Ak-Suu, Karakol, Ak-Tala, Alai, Batken, Chaktal, Chon-Alai, Issyk-Kul, Issyk-Kul Balykchy, Jeti-Oguz, Kara-Julja, Kochokor, Naryn, Talas, Talas city, Ton. The listed districts belong to the oblast of Osh, Jalal-Abad, Batken and Naryn. In addition to this, by mean of the temperature data, we were enabled to identify some additional districts where exceptionally low temperatures occured, and they belong to the oblast of Issyk-Kul and Talas.

Finally, panel data is merged with district relevant variables on private and public veterinary services availability as well as on animal population in order to control for factors that may have a role on household vulnerability and risk management strategies. Public and private veterinary services are still quite inefficient in Kyrgyzstan, from both a quantitative and qualitative perspective, as shown in Table 1 that reports regional level statistics released by the Kyrgyz Republic's veterinary services department. Beside the low numbers of services available, adequate changes to strengthen the activities of public veterinary services are needed since they are still targeted to large-scale livestock production typical of the Soviet era (FAO and EBRD, 2011).

Table 1 Mean and standard deviation (in parenthesis) of veterinary services by region

Regions (oblast)	Issyk-Kul	Jalal-Abad	Naryn	Batken	Osh
Number of public veterinary services	6.85 (2.52)	3.47 (3.68)	4.41 (6.84)	7.98 (2.12)	1.59 (2.71)
Number of private veterinary services	35.56 (5.03)	24.36 (12.05)	32.86 (3.8)	29.91 (4.41)	40.97 (19.03)
N households	176	314	102	175	344
N districts (rayon)	5	7	4	3	7
	Talas	**Chui**	**Bishkek city**	**Osh City**	
Number of public veterinary services	9.08 (1.44)	9.06 (1.57)			
Number of private veterinary services	19.49 (3.97)	27.96 (6.16)			
N households	81	240	15	25	
N districts (rayon)	3	7	-	-	

Note: Info on veterinary services in the cities of Bishkek and Osh is not available.

Source: Authors' elaboration based on veterinary data released by the National Statistical Committee of the Kyrgyz Republic.

As a household welfare outcome variable of this analysis the value of per-capita weekly food consumption expenditure adjusted for 2016 prices is used, which is then transformed in logs.[5] It is constructed through the aggregation of food purchased in the market place and food from self-consumption that is home-produced, the latter one being valued using food item prices at village level provided in each wave of the LiK community questionnaire.

Herd size is expressed in livestock units which are provided by the Kyrgyz Ministry of Agriculture. Animal species owned by LiK sampled households include cows and bulls, sheep and goats, horses, donkey, chicken, and pigs. The analysis is entirely focused on the sample of both small and big herder households who owned at least one unit of cattle, sheep and goat, or horses in 2011 (pre-shock period).

[5] By means of robustness, the analysis is also carried out using value of food consumption per-adult equivalent units, and estimated results do not change.

4 A descriptive analysis of Kyrgyz herders

Tables 2 and 3 provide descriptive data on households in the control and treatment groups. They show that households in both the treatment and control groups have the same food consumption expenditure across the consumption quantile and are on average headed by an older individual (50-56 years), which is consistent with the high levels of youth out-migration in the country (Agadjanian, Nedoluzhko and Kumskov, 2008). A relatively high share of the populations have post-secondary educations, and this level increases with consumption values. While lower consumption households in the treatment group live slightly more remotely from main roads than their counterparts in the control (1.77 km compared to 0.78 km), the upper quantile is virtually identical (0.73–0.74 km). The share of female headed households in the two groups ranges from 15 to 27 percent, with no clear pattern across consumption groups. Finally, technology asset index scores, which measure ownership of cell phones, computers, TVs and other devices, are very low for consumption groups in both the treatment and control (-0.36 and -0.21 respectively), but increase considerably for the upper quantiles (0.14 to 0.19). This indicate that upper consumption quantiles have substantially more access to information than those in lower quantiles.

Table 2 Characteristics of herders hit by the shock (treatment group) by food consumption expenditure quantiles (2011–2016)

	Food consumption expenditure quintiles (N=1 274)				
	10th	25th	50th	75th	90th
Log food consumption expend	5.39	5.75	6	6.26	6.76
Age of Household head	49.94	53.41	53.1	53.82	56.74
Family size	6.63	6	5.53	4.96	3.86
Highest education (%)	17.9	17.2	22.9	30.2	29.9
Distance to main road (km)	1.77	1.2	0.97	0.72	0.74
Herd size (LU)	3.18	3.5	3.54	4.64	5.37
Number livestock species	2.36	2.51	2.53	2.54	2.41
% restocking soon after shock	45.7	47.4	50.4	52.1	45.6
Herd composition					
- cows and bulls (% sum to 100 column wise)	8.67	7.85	9.5	4.37	9
- sheep/goats	22.96	17.77	12.67	17.46	12
- horses	17.35	16.53	14.03	19.44	27
- poultry	37.24	47.93	55.2	48.41	44.96
- donkeys	13.78	9.92	8.6	10.32	7
Cultivates land	80.7	83.1	83.3	78.4	73.6
Average income shares					
- non-farm	67.39	75.83	77.77	72.34	73.08
- farm	32.61	24.17	22.23	27.66	26.92
% female headed	15	24.9	20	19.4	20.5
No. state veterinary services	5.21	5.72	5.07	5.3	5.2
Technology asset index	-0.36	-0.12	-0.01	0.16	0.14

Source: Authors' elaboration based on data of the *Life in Kyrgyzstan* (LiK) Study.

Regarding the share of income from farm and non-farm sources, households in both groups derive the majority of their income (67–73 percent in the treatment and 77 to 67 percent in control) from off-farm incomes sources. While this provides some buffer against climatic shocks, many of these off-farm jobs are tied to the rural economy and are causal in nature, thus mitigating their benefit in terms of livelihoods resilience. A t-test of the difference between the treatment and the control group by food expenditure quantiles has been performed for income shares. The difference in the average share of farm-income between treated and control households is not different from zero in a statistical sense across all quantiles except the bottom one. It suggests that the two groups report the same characteristics in terms of income share, except for the poorest exposed to the weather shock, who rely on a significantly higher share of farm income with respect to their counterpart in the control group.[6] The majority of households in both groups cultivate agricultural land in addition to owning livestock, with a greater average share in the treatment groups (73 to 80 percent) where cultivating land is more frequent among the poor (81 percent). This provides an additional source of food and income to households.

In terms of livestock ownership, several important patterns are evident. First, herd sizes in the treatment groups are higher at all quintile levels than those in the control. Moreover, in the treatment, herd sizes increase considerably between the bottom and top consumption groups (3.18 to 5.37 LU), while there is a less pronounced increase for the control (1.60 to 1.93 LU). Larger herd sizes in the upper consumption quantiles are indicative of both higher average asset levels, as well as potentially greater risk exposure to some climate events.

Table 3 Characteristics of herders not hit by the shock (control group) by food consumption expenditure quantiles (2011–2016)

	Food consumption expenditure quintiles (N=3 042)				
	10th	**25th**	**50th**	**75th**	**90th**
Log food consumption expend	5.35	5.74	6	6.26	6.7
Age of Household head	54.14	54.04	54.19	54.02	55.06
Family size	7.01	6.42	5.95	5.25	4.24
Highest education (%)	11.4	15.9	15.6	20.9	24.9
Distance to main road (km)	0.78	0.95	0.9	0.84	0.73
Herd size (LU)	1.60	1.81	1.98	1.87	1.93
Number livestock species	1.77	1.90	1.94	1.72	1.64
% restocking soon after shock	23.7	23.3	29.5	28.6	25.5
Herd composition					
- cows and bulls (% sum to 100 column wise)	13.3	11.4	13	14.7	10.5
- sheep/goats	17.2	14.3	14.6	16	16.9
- horses	2.3	2.1	2.4	3	2.7
- poultry	59.4	60.8	61	60.5	66.7
- donkeys	7.72	11.24	9	5.7	3.1
Cultivates land	57.7	62.3	73.8	70.3	68.5

[6] T-tests have been performed also for other variables. Treated and control households are not statistically different in terms of the mean age of the household head, in terms of highest education and share of female-headed households (except for the top quantile), and in terms of the technology asset index.

	Food consumption expenditure quintiles (N=3 042)				
Average income shares					
- non-farm	76.95	72.57	65.81	70.85	67.61
- farm	23.05	27.43	34.19	29.15	32.39
% female headed	20	20	18	23	27
No. state veterinary services	3.50	3.27	3.64	4.02	4.23
Technology asset index	-0.21	-0.07	-0.06	0.02	0.19

Source: Authors' elaboration based on data of the *Life in Kyrgyzstan* (LiK) Study.

Second, the composition of the herds shows some variations between treatments and control, as well as between food consumption quantiles. In both groups, poultry is the dominant livestock species, with higher concentrations in the control group. Poultry production in Kyrgyzstan is focused on both chicken and turkey production, carried out in pasture production systems with supplemental feeding and shelter in the winter (Ajibekov, 2005). Horse ownership is more concentrated in the treatment groups than the control. Moreover, there are significant differences in the share of horses in the overall herd between the lowest food consumption group in the treatment (17 percent) and the highest (27 percent). Horses are raised for meat, draught power, and transportation, and are thus a critical, and multidimensional element of many household's livelihoods. According to the Ministry of the Emergency Situations, horses were also particularly hard hit by the winter shock in 2012. Taken together, this suggests that wealthier households may have been particularly exposed to the effects of this winter shock.

Third, in terms of herd restocking and management behaviors, households in the control were less likely to add animals following the shock (23 to 25 percent added animals) compared to the treatment (45 to 52 percent). The high percentage of shocked households engaged in restocking (almost the double with respect to the control group) suggests that they featured a severe loss in their animal stock as a consequence of the shock.

Finally, the number of state veterinary service providers is low in both the treatment and control, although marginally higher in the treatment areas. The low level of veterinary support points to an important weakness in the government's support for the livestock sector, and suggests that households may not have sufficient access to information on effective management practices, including those related to the management of severe weather events.

5 The empirical strategy

We use a difference in difference estimation method (DID) in a natural experimental setting for a double purpose. Firstly, we measure the impact of the 2012 winter shock on the value of food consumption expenditure (adjusted for 2016 prices). We use a *standard* DID approach to estimate an average treatment effect by comparing food consumption before and after the shock for livestock owner households living in districts hit by the shock (treatment group) vs. districts not hit by the shock (control group). In addition, we move beyond mean impacts and see whether the shock effect leads to larger changes in specific parts of the distribution by using a quantile *non-linear* DID method that maps out the shock effects along the entire food consumption expenditure distribution of exposed households. Studying the effect of the shock along all the distribution quantiles well suits the Kyrgyz socio-economic situation, with a persistence of old and the emergence of new disparities between households in relation to livestock ownership – which is the most common wealth indicator in rural Kyrgyzstan (Steimann, 2011).[7]

Our basic empirical strategy tests for time-differential change in food consumption patterns of household herders who experienced the winter shock occurred in 2012, coincident with exceptional cold temperatures (average values ranged from -8 to -11 °C for shocked districts), relative to food consumption patterns of households living in areas not hit by the shock. Specifically, for household *i,* and years *t,* we estimate:

$$\log Y_{it} = \alpha + \delta_t + \beta\left(S_t^{post} * HShock_i\right) + X_{it}\delta + \varepsilon_{it} \qquad (1)$$

Where Y_{it} is the household-time specific per-capita food consumption adjusted for 2016 prices and expressed in logs. *HShock* is an indicator variable denoting households affected by the winter shock (treatment group), and S_t^{post} is a dummy variable indicating the year when the shock has occurred (2012). *X* is a vector of household- and region-level control variables. Year and region fixed effects are included to control for aggregate effects that may have affected food consumption independently from the shock. As standard in the DID literature, standard errors are clustered by district, which represents the entity based on which the treatment is identified (Angrist and Pischke, 2008). In addition, to study features of the distribution besides the mean, we also estimate specification (1) using quantile regressions for the 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} quantiles of the value of food consumption expenditure distribution (Meyer, Viscusi and Durbin, 1995).[8]

[7] As standard in this literature, we use a falsification test to confirm the validity of the shock identification. By fictitiously treating 2012 as the pre-shock period and 2013 as the year where the harsh winter shock occurred, we find insignificant effect of the falsified winter shock on the value of per-capita food consumption expenditure. It confirms the validity of our identification strategies (Angrist and Pischke, 2008). Results are available upon request.

[8] By means of robustness, a similar model to the one specified in eq. (1) has been performed only for the sample of treated households exposed to the winter shock and controlling for household fixed effects. Herd size is the main regressor used as well as its interaction with the dummy variable indicating the year where the climate shock occurred. Results confirm the validity of our results and are available upon request.

In a second step, we analyse post-shock coping strategies that may contribute to households' welfare increase after the climatic shock. We thus use the following difference-in-difference-in-difference (DDD) approach and run two separate models to test these effects:

$$\log Y_{it} = \alpha + \delta_t + Z_i^{cop} + \beta_1\left(S_t^{post} * HShock_i\right) + \beta_2\left(HShock_i * Z_i^{cop}\right) + \beta_3\left(S_t^{post} * Z_i^{cop}\right) + \beta_4\left(S_t^{post} * HShock_i * Z_i^{cop}\right) + \epsilon_{it}, \qquad (2)$$

where Z represents the two dimensions that we test in this study to evaluate if – and to what extent – they mitigate the detrimental effect resulting from the shock: i) restocking animal assets as a household's post-shock investment, and ii) the intensity of regional veterinary services as a measure of access to veterinary public infrastructures. In the first case, the key estimated coefficient is the interaction between the shock and a dummy variable indicating households engaging in restocking strategies in the aftermath of the shock; in the second case, the key estimated coefficient is the interaction between the shock and a continuous variable indicating the intensity of pre-shock regional veterinary services in the household's region of residence.[9] All other variables in equation (2) are defined as before, and β_4 is the main parameter of interest (positive estimates would suggest that herd replenishment and better access to public veterinary services are found to be mitigation strategies for households hit by the shock – that increased their value of food consumption expenditure (higher resilience).

[9] We use pre-shock availability of veterinary services to show if living in districts with more availability of public veterinary services before the shock is a mitigating factor on household's outcome in the presence of climate shocks.

6 Results

6.1 Short- and medium-term impacts of the winter shock

Figure 1 shows that the effect of the climatic shock on households' food consumption expenditure is significant and persistent in the short and medium-term (for detailed results see Annex 1, Tables 4 and 5). At the mean level, estimated coefficients of the shock are negative and statistically significant both in the short- and medium-run. Households effected by the winter shock experienced, on average, a 5 percent and 8 percent decrease in food consumption expenditure in the short and medium-term respectively. Furthermore, when focusing on distributional effects, estimates show that better-off households (75th and 90th quantiles) are most severely hit by the shock. At the 75th percentile, households affected by the harsh winter experience a 9–13 percent decrease in food consumption expenditure, while among the richest group the consumption decreases by about a quarter.

The somewhat paradoxical large negative shock impact on better-off households is likely the result of two interrelated dynamics. First, while selling livestock can help households to smoothen consumption following a livelihood shock, herding households may prefer to decrease consumption, when feasible, in order to avoid further asset depletion (Fafchamps, Udry and Czukas, 1998; Carter *et al.*, 2007; Hoddinott, 2006). Second, because the dietary composition of wealthier households in Kyrgyzstan is skewed toward the consumption of higher value foods, such as meats, fruits, and vegetables, they are capable of shifting the composition of their diets toward lower value foods. This is in line with Juarez-Torrez (2015), who finds heterogeneous effects of shocks in food prices across food consumption quantiles in Mexico, with food-poor households lowering their consumption when price shocks affect cereals, while top income quantile households change consumption in response to changes in prices of meats and dairy products.

However, while the short-term objective of decreasing food consumption expenditure in order to preserve livestock assets is likely intended to enable future accumulation, the persistence of the welfare decline is worrisome. It suggests that coping strategies employed by households are insufficient to address livelihood shocks of this magnitude. Thus, in the absence of effective policy responses, weather-shocks of this nature may push better-off households into a persistent state of lower food consumption and vulnerability (Carter *et al.*, 2007).

Coefficient estimates confirm the descriptive results highlighted in the previous section. Herd size shows that bigger livestock assets are positively correlated with food consumption expenditure, with coefficients being higher in magnitude for the 75th and 90th quantiles (see Annex 1, Tables 4 and 5). Estimates also show a positive association between the number of animal species and households' food consumption across all quantiles, with the results being higher in magnitude for the poor (10th and 25th quantiles).

The age and the highest level of educational attainment of the household head are positively associated with higher value of food consumption expenditure and this is true along all the distribution quantiles, as expected. Interestingly, highest educational achievements are correlated with higher food consumption expenditure for households from the bottom to the median quantiles, suggesting that education is an effective resiliency strategy particularly for the poor (see Annex 1, Tables 3 and 4, columns 1–3). Family size is negatively correlated with the value of food consumption reflecting scarcity of resources that need to be shared within the family (Bogale and Shimelis, 2009; Feleke, Kilmer and Gladwin, 2005). From the assessment of the technology assets it emerges that households with higher endowments of ICT devices (radio, video, camera, laptop, internet access, satellite, mobile, landline, internet network) are associated with higher value of food consumption and this is consistent in both the short- and medium-run across all quantiles, especially for worse-off households. ICTs are likely to increase information opportunities, including weather forecast information and advice on response (Asfaw, Palma and Lipper, 2016). In the medium run (see Annex 1, Table 5), cultivating farm land shows a positive and significant effect on food consumption expenditure for households at the bottom quantiles of the distribution, but not at the top. Crop production in Kyrgyzstan is focused on a combination of food crops, namely wheat and potatoes, as well as cash crops such as cotton, tobacco, and silk. Crop production serves as a source of income and food, and thus helps to increase the value of food expenditure, which includes the value of both purchased and retained foods. Moreover, crop production has relatively low entry barriers for poor households, and thus has a particularly beneficial effect at the low end of the welfare distribution.[10]

Regarding regional characteristics, the absolute number of animal heads available at regional level is included to measure the reliance of a region on livestock production. All else equal, higher regional herd sizes are correlated with lower food consumption expenditure, probably capturing higher poverty levels corresponding to areas with high livestock prevalence.[11] This is confirmed by several studies reporting higher incidence of poverty in mountainous areas where Kyrgyz pastoralists live thanks to favorable weather conditions and to high availability of livestock forage (see for instance Kerven *et al.*, 2011; World Bank, 2011).

Results show a statistically significant and negative correlation between the presence of public veterinary services and household welfare at the mean and across all quantiles only in the medium-run (see Annex 1, Table 5). As for regional animal size, this suggests that areas with higher concentration of veterinary services are correlated with lower food consumption expenditure, and this holds true for all quantiles except for better-off households (90th quantile). Private veterinary services show a marginally negative effect both in the short term and in the medium term.

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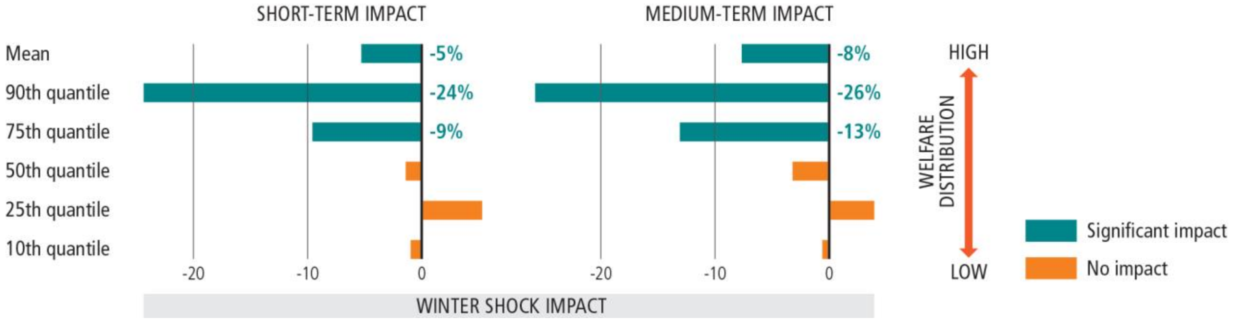
[10] It should be noted that February and March are the first months of the growing season for many crops in Kyrgyzstan. Therefore, the exceptional winter shock had a bad effect not only on livestock but also on crop production. Nevertheless, cultivating land may suggest access to food through non-market channels which helps mitigating the food security risks deriving from the shock (see WFP, 2011).

[11] Animal district and regional mortality rates are not made publicly available by the National Statistical Committee, therefore, we used the closest proxy to control for this aspect.

Figure 1 Rich herders experience the largest negative effect of the 2012 winter shock



Note: Short-term (2011–2013) and medium-term (2011–2016) impact of the 2012 harsh winter shock on household' food consumption expenditure (%). The figure shows the average impact of the shock as well as by quantiles of the food consumption distribution.

Source: Authors' elaboration.

6.2 Policy responses to the winter shock

Herd restocking

One potential policy response to mitigate the impact of weather shocks on the welfare of herder households is to support restocking efforts (Klein *et al.*, 2011; Kerven, Russel and Laker, 2002; Heffernan, Misturelli and Nielsen, 2001). In order to assess the effectiveness of this approach on short- and medium-term welfare outcomes, the impact of herd restocking following the winter shock is assessed. Results in the left panel of Figure 2 show that the benefits of restocking livestock following the winter shock accrue slowly over time, as confirmed by the statistically significant and positive coefficient indicating medium-term returns to this investment (see also Annex 2, Table 6). Once controlling for socio-economic characteristics, households hit by the winter shock who replenished their animal assets experience a 10 percent increase in food consumption expenditure in the medium-run (4 years later the shock occurrence) compared to households hit by the shock who do not engage in this *ex post* disaster recovering strategy. Evidence shows that positive effects of undertaking this strategy are not measurable in the short-term.

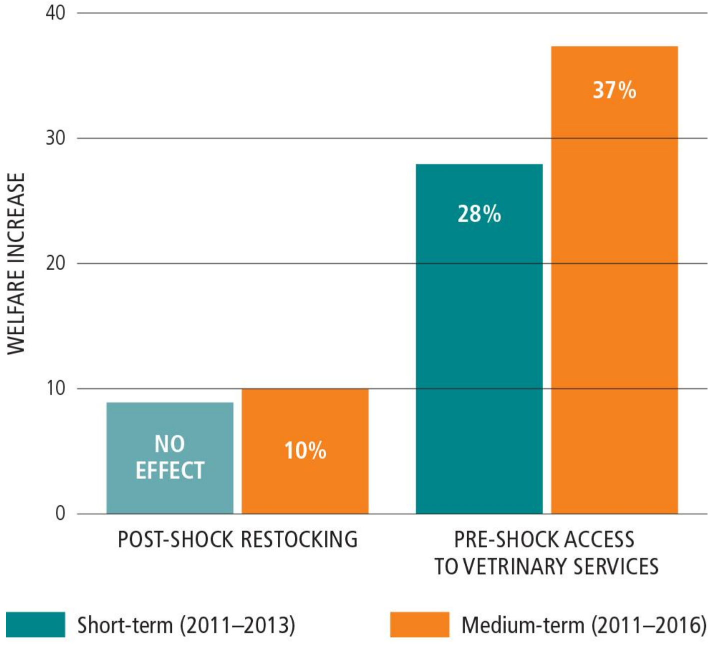
Supporting households through specific mechanisms (e.g. cash transfers or insurances) that allow to meet immediate needs during emergencies could be crucial to help household's restocking efforts and access to winter forage. This can be addressed in a holistic manner, while simultaneously building long-term resilience in the livestock sector. This may include mitigating animal losses through the development of local forage markets that increase the availability of winter forage. This will help to lower the rate of mortality resulting from the shock and will maintain herd productivity during and following the shocks, thus allowing rapid herd recovery. This can be combined with efforts to improve the genetic pool of livestock species through breeding programmes that select for resiliency traits. Improved animals can be incorporated into local herds through targeted breeding programmes and distributed to households affected by shocks to support restocking. In this way, policies can help support households to recover from the shock, while at the same time building resilience to future weather events.

Expanding public veterinary service provision

Long-term resilience to climate change in the livestock sector depends fundamentally on improving herd management. To this end, public veterinary services are important. However, recent assessments of the country's public veterinary services suggest that the current availability of health services is very low especially in rural areas, where neither veterinary nor sanitary inspection agencies provide adequate coverage (Kasymbekov, 2014).

Using information on the number public veterinary services available at regional level before the 2012 winter shock as a proxy for household's access to veterinary infrastructures and information on livestock management, Figure 2 (right panel) shows that, all else equal, households living in regions with a higher number of veterinary services are more resilient to the shock both in the short- and in the medium-run. More specifically, households in areas hit by the harsh winter, but with a high density of public veterinary officers, report a 28 percent and 37 percent higher food consumption expenditure relative to those with low access to veterinary services (see also Annex 2, Table 7). This suggests that public investment in veterinary services helps to improve herders' ex-ante risk management by increasing awareness of best practices to undertake in the face of climatic shocks, such as forage management and stocking, and helps to hasten post-shock recovery.

Figure 2 Targeting restocking and supporting access to veterinary services build climate resilience and food consumption



Notes: Short-term (2011–2013) and medium-term (2011–2016) percent increase in food consumption expenditure as a result of restocking and access to veterinary services before and after the harsh winter. Short-term restocking after the shock is not statistically significant, meaning that it does not have an effect on household's food consumption.

Source: Authors' elaboration.

7 Conclusions

Given the contribution of the livestock sector to the livelihoods of Kyrgyz people and to the country's economy, this paper analyses the impact of the harsh 2012 winter shock on herder households' food consumption expenditure and finds that the shock effects are severe especially for households in the upper quantiles of the welfare distribution. Furthermore, the negative effects of the shock are persistent over time, suggesting inadequate household level capacity to cope with and recover from the shock.

Several policy options for improving herder resilience to weather shocks are assessed. Evidence suggests that support for restocking herds that were affected by the shock can help to offset the medium-run decline in consumption caused by the shock. Forage market development combined with breeding programmes designed to improve the genetic resilience of livestock in the country should be considered as part of a holistic effort to mitigate animal losses and support households to restock their herds following a shock. In addition, as access to veterinary services is shown to be a crucial factor in coping with climate variability and climatic risks in the livestock sector. This study shows that a higher presence of public veterinary services helps mitigate the short and medium-term effects of the shock. Expanding access to veterinary services should be considered a priority policy objective for enhancing welfare resilience for herding households in the context of climate change.

More broadly, policies that support livelihood diversification and access to information, including improved access to extension services, improved diversification of livestock herds, access to information and communication technologies, and crop cultivation, all help to improve consumption outcomes for Kyrgyz herders. Taken together, these suggest the need for a diverse portfolio of public and private investments, and supportive policies, to help build more resilient livelihoods in the context of climate change.

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Annexes

Annex 1. The impact of the winter shock on households' consumption expenditure

Table 4 Short-term mean and quantile estimates of the winter shock on food consumption expenditure (logs) (2011–2013)

VARIABLES	(1) (mean)	(2) (q10)	(3) (q25)	(4) (q50)	(5) (q75)	(6) (q90)
Effect of 2012 Feb-March shock	-0.0532*	-0.00791	0.0533	-0.0124	-0.0938**	-0.243***
	(0.0314)	(0.0471)	(0.0373)	(0.0318)	(0.0368)	(0.0469)
Household characteristics						
Family size	-0.0913***	-0.0783***	-0.0872***	-0.0913***	-0.0888***	-0.0871***
	(0.00303)	(0.00468)	(0.00371)	(0.00316)	(0.00366)	(0.00466)
Head is female	0.0218	-0.0385	0.0271	0.0249	0.0193	0.0274
	(0.0222)	(0.0383)	(0.0303)	(0.0258)	(0.0299)	(0.0381)
Household head is widowed	-0.0706***	-0.0393	-0.0814**	-0.0812***	-0.0674**	-0.0940**
	(0.0241)	(0.0412)	(0.0327)	(0.0279)	(0.0322)	(0.0411)
Age of household head	0.00201***	0.00206**	0.00190***	0.00207***	0.00212***	0.00253***
	(0.000493)	(0.000805)	(0.000638)	(0.000544)	(0.000629)	(0.000801)
Highest education household head	0.0556***	0.0507*	0.0585***	0.0576***	0.0378*	0.0347
	(0.0159)	(0.0259)	(0.0205)	(0.0175)	(0.0202)	(0.0258)
Herd size (LU)	0.0110***	0.00596*	0.00628**	0.0118***	0.0149***	0.0210***
	(0.00208)	(0.00352)	(0.00279)	(0.00237)	(0.00275)	(0.00350)
Number livestock species	0.0395***	0.0506***	0.0528***	0.0366***	0.0232***	0.0261**
	(0.00610)	(0.0103)	(0.00813)	(0.00693)	(0.00801)	(0.0102)
Distance to main road (km)	-0.00187	0.00191	-0.000691	-0.00312	-0.00445	0.00106
	(0.00295)	(0.00545)	(0.00432)	(0.00368)	(0.00426)	(0.00543)
Household cultivates land	0.0162	0.0413*	0.0469**	0.00930	0.0147	-0.0137
	(0.0145)	(0.0241)	(0.0191)	(0.0163)	(0.0188)	(0.0240)
Technology asset index	0.0830***	0.0891***	0.0823***	0.0872***	0.0812***	0.0639***
	(0.00628)	(0.0109)	(0.00863)	(0.00735)	(0.00850)	(0.0108)
District-level variables						
Animal population	-0004***	-0004**	-0005***	-0005***	-0006***	-0004**
	(0.0001)	(0.0001)	(0.00031)	(0.00021)	(0.00051)	(0.00061)
No. state veterinary services	-0.00136	-0.00358	-0.000900	-0.00241	-0.00144	-0.000732
	(0.00175)	(0.00270)	(0.00214)	(0.00183)	(0.00211)	(0.00269)
No. private veterinary services	-0.000689	-0.000422	-0.00130**	-0.00182***	-0.000981*	0.000653
	(0.000433)	(0.000687)	(0.000544)	(0.000464)	(0.000536)	(0.000684)
Constant	7.249***	6.528***	6.917***	7.205***	7.640***	7.667***
	(0.211)	(0.372)	(0.295)	(0.252)	(0.291)	(0.371)

VARIABLES	(1) (mean)	(2) (q10)	(3) (q25)	(4) (q50)	(5) (q75)	(6) (q90)
Oblast fixed effects	YES	YES	YES	YES	YES	YES
Observations	4 361	4 361	4 361	4 361	4 361	4 361
R-squared	0.312					

Notes: We also control for the time dummy indicating the weather shock introduction as well as for the treatment group dummy. Robust standard errors in parenthesis; *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's elaboration.

Table 5 Medium-term mean and quantile estimates of the winter shock on food consumption expenditure (logs) (2011–2016)

VARIABLES	(1) (mean)	(2) (q10)	(3) (q25)	(4) (q50)	(5) (q75)	(6) (q90)
Effect of 2012 Feb-March shock	-0.0801***	-0.00560	0.0406	-0.0329	-0.137***	-0.268***
	(0.0294)	(0.0448)	(0.0369)	(0.0352)	(0.0377)	(0.0522)
Household characteristics						
Family size	-0.105***	-0.101***	-0.102***	-0.108***	-0.108***	-0.101***
	(0.00276)	(0.00435)	(0.00358)	(0.00341)	(0.00366)	(0.00506)
Head is female	0.0167	-0.0301	0.0136	0.00298	0.0316	0.0477
	(0.0223)	(0.0347)	(0.0285)	(0.0272)	(0.0292)	(0.0403)
Household head is widowed	-0.0620***	-0.0267	-0.0720**	-0.0640**	-0.0615*	-0.0717
	(0.0237)	(0.0376)	(0.0309)	(0.0295)	(0.0316)	(0.0437)
Age of household head	0.00261***	0.00236***	0.00280***	0.00297***	0.00256***	0.00228**
	(0.000472)	(0.000765)	(0.000630)	(0.000600)	(0.000643)	(0.000890)
Highest education household head	0.0554***	0.0390	0.0923***	0.0493**	0.0407**	0.0509*
	(0.0151)	(0.0244)	(0.0201)	(0.0191)	(0.0205)	(0.0284)
Herd size (LU)	0.00966***	0.00375	0.00524*	0.00978***	0.0117***	0.0150***
	(0.00210)	(0.00326)	(0.00269)	(0.00256)	(0.00275)	(0.00380)
Number livestock species	0.0240***	0.0260***	0.0309***	0.0256***	0.0202**	0.0283**
	(0.00614)	(0.00985)	(0.00811)	(0.00772)	(0.00829)	(0.0115)
Distance to main road (km)	-0.00116	0.0117*	0.00467	-0.00181	-0.00623	-0.00321
	(0.00353)	(0.00610)	(0.00502)	(0.00478)	(0.00513)	(0.00709)
Household cultivates land	0.0577***	0.110***	0.0812***	0.0373*	0.0370*	0.0227
	(0.0153)	(0.0245)	(0.0202)	(0.0192)	(0.0206)	(0.0285)
Technology asset index	0.0966***	0.104***	0.0918***	0.103***	0.0991***	0.0879***
	(0.00637)	(0.0104)	(0.00860)	(0.00819)	(0.00879)	(0.0121)
District-level variables						
Animal population	-0.0008	0.0003	0.00007	0.0006	0.00005	-0.0006**
	(6.67e-08)	(1.02e-07)	(8.42e-08)	(8.02e-08)	(8.60e-08)	(1.19e-07)
No. state veterinary services	-0.0052***	-0.00532**	-0.00380*	-0.00625***	-0.00531**	-0.00447
	(0.00156)	(0.00247)	(0.00204)	(0.00194)	(0.00208)	(0.00287)

VARIABLES	(1) (mean)	(2) (q10)	(3) (q25)	(4) (q50)	(5) (q75)	(6) (q90)
No. private veterinary services	0.0012	0.000737	0.0081	-0.00104*	-0.000882	0.000730
	(0.000453)	(0.000689)	(0.000567)	(0.000540)	(0.000580)	(0.000801)
Constant	6.444***	5.675***	5.754***	6.243***	6.900***	7.413***
	(0.127)	(0.197)	(0.162)	(0.154)	(0.166)	(0.229)
Oblast fixed effects	YES	YES	YES	YES	YES	YES
Observations	4 316	4 316	4 316	4 316	4 316	4 316
R-squared	0.411					

Notes: We also control for the time dummy indicating the weather shock introduction as well as for the treatment group dummy. Robust standard errors in parenthesis; *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's elaboration.

Annex 2. The impact of post-shock restocking and availability of public veterinary services on households' consumption expenditure

Table 6 Short- and medium-term impact of replenishing herds after shock on food consumption expenditure (logs)

VARIABLES	(1) Short-term	(2) Medium-term
Replenishing herd size	0.0958	0.103*
	(0.0870)	(0.0620)
Household characteristics		
Family size	-0.0822***	-0.104***
	(0.00512)	(0.00280)
Head is female	-0.0458	0.00963
	(0.0378)	(0.0222)
Household head is widowed	-0.0536	-0.0632***
	(0.0378)	(0.0237)
Age of household head	0.00238***	0.00295***
	(0.000760)	(0.000474)
Highest education household head	0.0146	0.0549***
	(0.0247)	(0.0152)
Distance to main road (km)	-0.00475	0.000833
	(0.00447)	(0.00369)
Household cultivates land	0.0392	0.0850***
	(0.0250)	(0.0150)
Technology asset index	0.0886***	0.107***
	(0.0100)	(0.00631)
Household lives in rural areas	-0.0113	0.0134
	(0.0402)	(0.0193)
District-level variables		
Animal population	-0.0007***	-0.0009
	(0.00023)	(0.0006)
No. state veterinary services	0.00223	-0.00504***
	(0.00299)	(0.00158)
No. private veterinary services	0.00132	0.000171
	(0.000856)	(0.000463)
Constant	7.469***	6.495***
	(0.444)	(0.126)
Oblast fixed effects	YES	YES
Observations	4 361	4 316
R-squared	0.275	0.403

Notes: We also control for the time dummy indicating the weather shock introduction, for the shock effect, and for all other additive interactions that guarantee a correct specification of the model. These variables are not added to ease the presentation of the results. Robust standard errors in parenthesis; *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's elaboration.

Table 7 Short- and medium-term impact of having access to public veterinary services after shock on food consumption expenditure (logs)

VARIABLES	(1) Short-term	(2) Medium-term
Presence of public veterinary services	0.281***	0.374***
	(0.0903)	(0.0932)
Household characteristics		
Family size	-0.0926***	-0.106***
	(0.00300)	(0.00276)
Head is female	0.0209	0.0166
	(0.0220)	(0.0221)
Household head is widowed	-0.0728***	-0.0634***
	(0.0240)	(0.0235)
Age of household head	0.00200***	0.00258***
	(0.000490)	(0.000468)
Highest education household head	0.0543***	0.0544***
	(0.0158)	(0.0150)
Distance to main road (km)	-0.00316	-0.00175
	(0.00289)	(0.00350)
Household cultivates land	0.0230	0.0611***
	(0.0144)	(0.0150)
Technology asset index	0.0858***	0.0984***
	(0.00626)	(0.00638)
Household lives in rural areas	-0.0465**	-0.0150
	(0.0206)	(0.0187)
District-level variables		
Animal population	-0.0005***	-0.0006
	(0.008)	(0.006)
Oblast fixed effects	YES	YES
Observations	4 361	4 316
R-squared	0.320	0.415

Notes: We also control for the time dummy indicating the weather shock introduction, for the shock effect, and for all other additive interactions that guarantee a correct specification of the model. These variables are not added to ease the presentation of the results. Robust standard errors in parenthesis; *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's elaboration.

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CONTACTS

Agricultural Development Economics Division (ESA)
Food and Agriculture Organization of the United Nations (FAO)

www.fao.org/economic/agricultural-development-economics
www.fao.org/economic/esa
ESA-Director@fao.org

ISBN 978-92-5-131144-8
9 789251 311448
CA2673EN/1/12.18