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Impact of Water Supply Disruption on Food Insecurity Experience: Evidence from Kyrgyz Farming Households

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Abstract

Farming households have to depend on uninterrupted water supply for their agriculture-based livelihood. Water supply disruption may endanger food security of farming households. However, there is not much evidence on the impact of water supply disruptions on food insecurity experience on farming households in Kyrgyzstan. Households with water supply disruptions can be systematically different from those without disruptions. The difference between treated and control units induce selection bias. To address potential selection biases arising from both observable and unobservable confounders, including geographic confounding where households in arid or infrastructure-poor areas face both higher water disruption and food insecurity, as well as other sources such as collider bias, this study applies fixed-effects models and reports random-effects estimates. The results suggest consistently that water supply disruptions can increase food insecurity of farming households. While this study focuses on the effect of water disruption on food insecurity rather than on evaluating specific interventions, the findings highlight the need for policies that promote uninterrupted water supply, for example through resilient infrastructure, maintenance, and contingency planning, whose effectiveness should be examined in future research.

Keywords: Water supply disruption, Food insecurity, Kyrgyz farming households, Irrigation and agriculture.

JEL classification: Q18, Q25, Q54, O13

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1. INTRODUCTION

Food insecurity—characterized by inadequate physical or financial access to safe, nutritious, and sufficient food—continues to be a key challenge addressed within the 2030 Agenda for Sustainable Development (Foini et al., 2023). Identifying the major reasons for food insecurity is the first step to address the global problem (Bari et al., 2024). Water resource scarcity can be considered as a major challenge to food security in developing countries. Studies (Maleksaeidi et al., 2015; Obeta & Nwankwo, 2015) show that the inadequate water supply is a major constraint in agriculture, particularly in regions dependent on irrigation systems. Lack of water often leads to decreased yield and nutritional outcomes for affected populations. Moreover, inadequate water supply has been identified as a critical factor reducing agricultural success and hindering food security in rural areas (Obeta & Nwankwo, 2015).

The water supply related issues are further affected by the climate change as the rising temperature and irregular rainfall patterns create the traditional water sources unreliable for irrigation. Studies (Datta et al., 2024; Duchenne-Moutien & Neetoo, 2021; Ahmed et al., 2023; Onyeaka et al., 2024) have established that climate change diminishes agricultural yields and creates pests and diseases related threats. According to panel-data estimates for Afghanistan, a 1 °C increase in mean temperature reduced wheat and barley yields by 271 kg/ha and 221 kg/ha, respectively (Sarwary et al., 2023). Climatic change and natural disasters such as drought and flooding also add to the problem and stress the importance of regular water supply (Stavi et al., 2021; Zhalil & Duishebaeva, 2024; Yildiz et al., 2022). Already vulnerable areas, such as semi-arid regions, face even more challenges as both precipitation extremes and increased temperature contribute to further instability (Lutta et al., 2020).

A substantial body of literature has examined the effects of chronic poverty, long-term water scarcity, and climate change on food security. However, the short-term, event-based disruptions of water supply and their direct implications for household food insecurity remain underexplored. This gap is particularly salient in regions such as Kyrgyzstan, where farming households are highly dependent on irrigation yet vulnerable to unpredictable interruptions.

Evidence from Indonesia further shows that farmers' risk aversion does not necessarily increase willingness to pay for climate-change adaptation; instead, land area, education, input costs, and experience shape WTP, underscoring low perceived climate risk and potential climate-driven production losses (Umayah & Suryanto, 2020). Nevertheless, these findings do not address how water supply disruptions directly affect household food insecurity, a gap that the present study seeks to fill.

We consider Kyrgyzstan, a landlocked central Asian country with a population of 6.5 million, continues to experience a high rate of headcount poverty and food insecurity challenges (Egamberdiev, 2023). In agropastoral communities in southern Kyrgyzstan, households often avert acute food insecurity yet remain chronically vulnerable, and shocks play an outsized role in shaping outcomes (Scott et al., 2024). Central Asia faces significant water management issues due to its arid climate and limited water resources (Ahn & Juraev, 2024). Kyrgyzstan faces extremely dry summers annually; leading to reduced water flow in irrigation facilities (Pradhan, 2021) so water shortage poses a critical threat to food security of Kyrgyzstan. Relatedly, Mehta et al. (2021) report frequent winter outages in Kyrgyzstan's hydro-dependent, loss-prone rural grids due to seasonal hydropower shortfalls and aging infrastructure. These outages may disrupt electric irrigation and household water supply, increasing food-security risks. This study examines the impact of water supply disruptions on food insecurity experience of farming households in Kyrgyzstan.

While existing evidence (Winsemius et al., 2018; Zhalil & Duishebaeva, 2024; Moahid et al., 2022) focuses primarily on chronic poverty or climatic droughts, this study focuses on event-based water disruptions and their relationship with household-level food stress. Unlike chronic scarcity, which tends to prompt structural adaptation, intermittent water supply disruptions are less predictable and harder to plan for (Erickson et al., 2020). They demand daily improvisation, which can erode resilience over time. By centering on these disruptions, this research offers a more policy-actionable entry point, especially for institutions working on infrastructure or food security interventions. Overall, the interplay between water supply disruptions and food insecurity in Kyrgyzstan's farming households highlights the need for integrated approaches that encompass water management, agricultural practices, and health considerations. In line with the call for integrated responses, Indonesian experience highlights that empowering food-crop farmers requires coordinated action across human resources, technology, institutions, and production with engagement from academia, the private sector, government, and farmer groups (Sumastuti, 2015). As climate change continues to exacerbate these challenges, adaptive strategies that enhance resilience are paramount. Therefore, it is a crucial policy question whether water supply disruptions impact food insecurity of farming households especially.

Households with water supply disruptions can be systematically different from those without disruptions. The difference between treated and control units induces selection bias. To address the selection bias, this study applies Fixed Effect model and Random Effect models. Fixed effects estimation eliminates the time invariant unobserved effect (Dieleman & Templin, 2014). Hausman test will be conducted to justify the appropriateness of choosing fixed effect model. The findings aim to provide actionable evidence for targeted infrastructure and policy intervention to boost water security and consequently increase food resilience among vulnerable farming households.

2. RESEARCH METHODS

2.1 Data and Variables

The study uses data from the World Bank's Listening to the Kyrgyz Republic survey. The Food Insecurity Experience Scale (FIES) was constructed following the methodology outlined by Ville et al. (2019), who utilized eight standardized questions to capture different dimensions of food insecurity. As presented in Table 1, these questions were originally developed by the Food and Agriculture Organization (FAO) (Cafiero et al., 2018) as part of a globally validated instrument designed to measure households' direct experiences of constrained food access. The items capture a range of food insecurity conditions, from worry about food availability to more severe situations such as going without eating for an entire day. For each household, responses to the eight items were coded as binary indicators, where an affirmative ("yes") response reflects the presence of that specific food insecurity experience. The FIES score was then generated by summing the number of affirmative responses, yielding a scale ranging from 0 to 8, with higher values indicating greater severity of food insecurity. This approach provides a consistent, experience-based measure of food insecurity that facilitates both within-sample comparisons and alignment with international standards.

The key outcome variable, water supply disruption, is coded as a binary indicator equal to 1 if the household reported experiencing any interruption in water access during the survey period, and 0 otherwise. For clarity, this variable encompasses disruptions in both drinking water and irrigation water used for household agricultural activities, as recorded in the survey questionnaire. Households that reported no interruptions in either source are coded as 0. This operational definition ensures that the variable captures the broader experience of water supply interruptions that could plausibly affect household food security.

Other covariates included in the analysis account for time-varying household and contextual characteristics, such as household income, landholding size, education of the household head, and geographic region. These covariates help control for potential confounders and reduce bias in estimating the effect of water supply disruptions on food insecurity.

Table 1. Food Insecurity Experience Questions

Item No.	Question List
Q1	Was there a time when you were worried you would not have enough food to eat because of a lack of money or other resources?
Q2	Was there a time when you were unable to eat healthy and nutritious food because of a lack of money or other resources?
Q3	Was there a time when you ate only a few kinds of food because of alack of money or other resources
Q4	Was there a time when you had to skip a meal because of a lack of money or other resources to get food?
Q5	Was there a time when you ate less than you thought you should because of a lack of money or other resources?
Q6	Was there a time when your household ran out of food because of a lack of money or other resources?
Q7	Was there a time when you were hungry but did not eat because there was not enough money or resources for food?
Q8	Was there a time when you went without eating for a whole day because of a lack of money or other resources?

Source: Ville et al. (2019)

2.2 Summary Statistics

Table 2 reports the summary statistics of the study. The summary is presented based on whether households experienced water disruptions or not. The summary report shows that food insecurity scale of Household with water disruptions are almost 100% more than that of households without water disruptions. The Household size of both groups is almost similar. The number of days water disruptions faced by the affected households is around 9 days per month. Electricity availability is quite similar across the two groups. Households with water disruptions consume much more cigarettes than households without water disruptions.

Table 2. Summary Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Household without Water Disruptions					
Food Insecurity Scale	2681	0.49	1.45	0	8
Household Size	2681	5.54	2.16	1	17
Number of Days (Water Disruption)	2681	0	0	0	0
Electricity Available (Hours)	2681	23.4	2.38	0	24
No of Cigarette Consumption (Per Week)	2681	6.11	11.99	0	140
Household with Water Disruptions					
Food Insecurity Scale	409	0.96	1.95	0	8
Household Size	409	5.97	2.17	1	13
Number of Days (Water Disruption)	409	8.67	10.21	0	30
Electricity Available (Hours)	409	22.74	3.09	0	24
No of Cigarette Consumption (Per Week)	409	9.17	39.69	0	400

2.3 Methodology

Households experiencing water supply disruptions may differ systematically from those without disruptions, creating the risk of selection bias in estimating the impact on food insecurity. To address this challenge in the absence of a randomized design, this study applies both fixed-effects (FE) and random-effects (RE) models. The fixed-effects model controls all unobserved, time-invariant household characteristics (e.g., long-term socio-economic status, cultural practices, or geographic conditions) that may jointly influence water disruptions and food insecurity outcomes (Djoumessi Tiague, 2023; Breuer & DeHaan, 2024; Imai & Kim, 2019; Bari et al., 2025). In contrast, the random-effects model treats household-specific effects as random and assumes that these unobserved effects are uncorrelated with the explanatory variables (Dieleman & Templin, 2014). While the FE estimator provides consistency under weaker assumptions, the RE estimator is more efficient when its assumptions are held. Given the limitations of both approaches, we employ them in a complementary manner. The FE model addresses time-invariant unobserved heterogeneity, while the inclusion of observed covariates—such as income, landholding size, education, and geographic characteristics—helps control for time-varying confounders. This dual strategy reduces the risk of omitted variable bias when estimating the causal effect of water supply disruptions on food insecurity. To determine which model is more appropriate in our study context, we conducted a Hausman test (Amini et al., 2012). The null hypothesis is that the unobserved individual effects are uncorrelated with the regressors, in which case the RE estimator is preferred. Rejection of the null indicates that the FE specification provides more reliable estimates. The model used as a fixed effect is given below:

$$\text{Outcome}_{it} = \alpha_i + \alpha_1 \text{Treatment}_{it} + \alpha_2 \text{Covariates}_{it} + u_{it} \quad (1)$$

Here, Outcome_{it} refers to food insecurity scale index for individual i at time t
α_1 is the coefficient for the independent variable Treatment_{it}
α_i is the individual-specific intercept (fixed effect), capturing the unobserved heterogeneity.
α_2 controls relevant covariates. The covariates include household size, monthly agriculture income and monthly saving.

The model used as a random effect is given below:

$$\text{Outcome}_{it} = \alpha + \alpha_1 \text{Treatment}_{it} + \alpha_2 \text{Covariates}_{it} + u_i + \varepsilon_{it} \quad (2)$$

u_i is the individual-specific random effect (which is assumed to be uncorrelated with the treatment variable. α_2 controls relevant covariates. The covariates include household size, monthly agriculture income and monthly saving.

3. RESULTS AND DISCUSSION

3.1 Main Results

Table 3 reports both fixed-effects and random-effects estimates. The random-effects model indicates that water supply disruptions increase the food insecurity score by 0.34 points (on an 8-point scale). Specifically, households without disruptions report an average score of 0.55, while those with disruptions report 0.89. This effect is statistically significant at the 1% level. The fixed effects model similarly shows that disruptions increase the food insecurity score by 0.22 points. Households without disruptions average 0.52, compared to 0.74 for those with disruptions. This effect is statistically significant at the 5% level. Importantly, the inclusion of covariates yields results consistent with those obtained without covariates.

Table 3. Model Estimations

Estimate of the Treatment Variable	Random Effect Estimation (Food Insecurity Scale)	Random Effect (Covariates Included)	Fixed Effect Estimation (Food Insecurity Scale)	Fixed Effect (Covariates Included)
Water Supply Disruption (=1 if a household encountered disruption)	0.34*** (0.08)	0.34*** (0.08)	0.22** (0.08)	0.22** (0.08)
Constant	0.55*** (0.04)	0.58*** (0.11)	0.52*** (0.02)	0.83*** (0.23)

Note: Standard errors are in parentheses. Significance levels use a robust method where ** for $p < 0.05$, and *** for $p < 0.01$

3.2 Hausman Test

Hausman Test result shows that P-value of the test whether random effect or fixed effect is more appropriate. The null hypothesis is rejected as the P-value is less than 0.05. Table 4 reports the result suggesting that fixed effect model is more appropriate in the present study.

Table 4. Hausman Test

Variable	P-Value
Water Supply Disruption (=1 if a household encountered disruption)	0.005

4. CONCLUSIONS

This study provides robust empirical evidence that short-term water supply disruptions significantly increase food insecurity among Kyrgyz farming households. Our fixed-effect model, controlling for unobserved time-invariant heterogeneity, estimates a 0.22-point rise ($p<0.05$) on the 8-point Food Insecurity Experience Scale. This represents a 44% increase relative to unaffected households' baseline mean (0.49). Random-effects estimates (0.34 points, $p<0.01$) suggest underlying time-invariant vulnerabilities (remote location, poorer soil quality) may amplify this impact. Crucially, descriptive statistics corroborate this causal link that households experiencing disruptions reported near-double mean food insecurity scores (0.96 vs. 0.49) despite comparable household size and electricity access. This disparity highlights water unreliability as a primary driver, not other factors such as broader socioeconomics issues.

Water supply disruptions raise the risk of food insecurity through multiple channels. In particular, they undermine irrigation reliability, lowering agricultural productivity and farm households' incomes (Pradhan, 2021; Sutcliffe et al, 2021; Khan et al, 2025). Severe disruptions of water supply can increase food insecurity, affecting household income and overall agricultural productivity (Bosire et al., 2019; Enfors & Gordon, 2008; Pradhan, 2021; Hadley et al., 2023). In addition, water supply disruptions can endanger adopting alternative sources of income like cattle farming. Furthermore, health implications associated with water quality in irrigation are also crucial as they are directly linked to the wellbeing of the farming households. Contaminated water can lead to a range of health issues, potentially reducing labor productivity and exacerbating food insecurity across the farming community. Rural areas, particularly those with limited access to properly managed water supply systems, are at heightened risk of experiencing these challenges (Bekturganov et al., 2016). In addressing these issues in Kyrgyzstan, the government and international bodies need to focus on the restoration and expansion of water supply systems for both consumption and agricultural use (Zhalil & Duishebaeva, 2024).

Using high-frequency panel data and causal methods, this study demonstrates that unpredictable water supply disruptions substantially elevate food insecurity risk among Kyrgyz farming households, increasing scale scores by 44% and manifesting in experiences of hunger, dietary compromises and anxiety. The channels are multifaceted, explained through lost income, reduced dietary quality and coping burdens. Addressing this requires a transition from traditional water scarcity solutions to actively enhanced supply predictability policies through targeted infrastructure, adaptive governance and integrated safety nets. In Kyrgyzstan, irrigation already accounts for about 89% of freshwater withdrawals, yet 35–37% of water supplied to agriculture is lost within distribution due to aging conveyance and poor allocation, and canals and reservoirs impose high operation and maintenance costs amid substantial transboundary outflows, so policy should prioritize efficiency and supply predictability rather than simple area expansion (Nuralieva, 2022). By mitigating this specific vulnerability, policymakers can significantly strengthen food resilience for Kyrgyzstan's agricultural communities facing water supply related uncertainty.

This study is subject to several limitations that warrant consideration when interpreting the results. First, while the fixed-effects specification addresses unobserved time-invariant heterogeneity, it does not fully account for potential time-varying confounders, such as seasonal shocks, policy interventions, or changes in community infrastructure, which may influence both water supply disruptions and food insecurity. Second, the absence of a clearly defined control group restricts the scope for rigorous causal inference, as comparisons are limited to variation within the observed sample. Third, the possibility of endogeneity remains a concern: water supply disruptions may not be strictly exogenous but instead correlated with unobserved household characteristics or locational vulnerabilities. Although the fixed-effects framework mitigates some sources of bias, it may not adequately resolve these endogeneity issues, thereby raising the possibility that the estimated effects overstate or understate the true causal relationship.

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