

## **Under irrigation water scarcity:** Exploring the behavioural responses of smallholders in Kyrgyzstan

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- Introduction (Heterogeneity of economic preferences due to environmental exposure)
- Research question
- Study area and data collection
- Methodology
- Results
- Conclusion and policy implications
- Lesson learns from the lab-in-the-field



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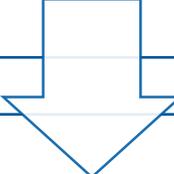


Environmental condition	Pattern	Study
Volcanic risk (Peru)	 Risk aversion	Bchir et al. (2024)
Rainfall variability (Ethiopia)	 Risk seeking	Di Falco & Vieder (2022)
Water scarce-farming (India)	 Risk seeking	Joshi et al. (2021)
Recurring droughts (Zambia)	 Risk aversion	Mulungu et al. (2023)
Climate vulnerabilities (Bangladesh)	 Impatience (r)	(Begho & Anik, 2022).

## ➤ *Can environmental framework play a role?*

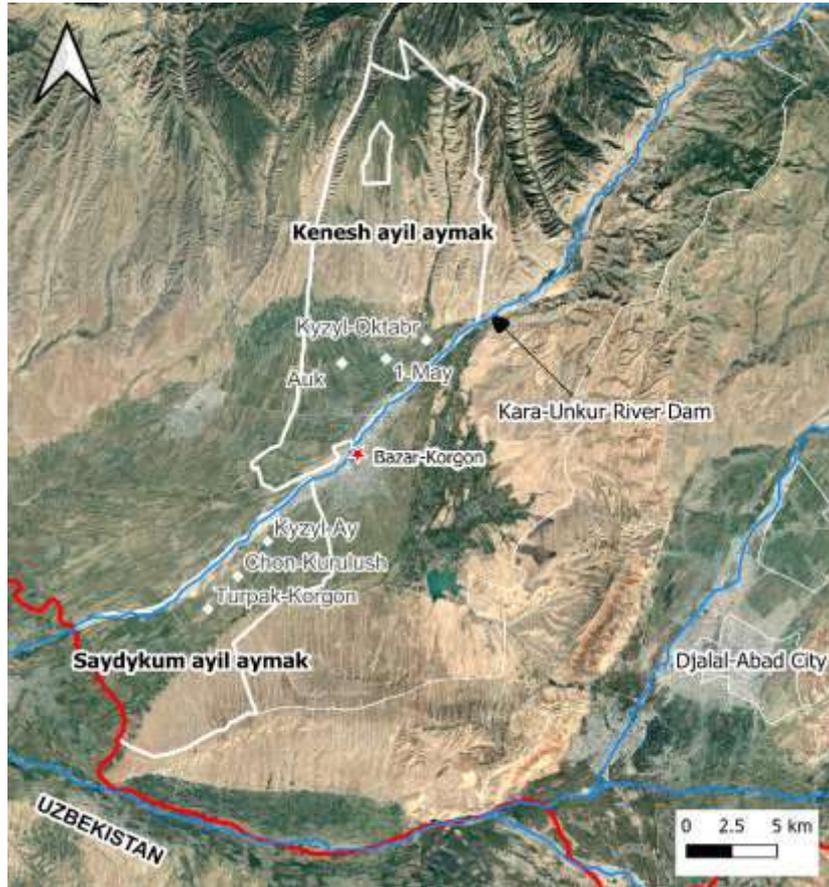
- **Water scarcity**, as a major environmental issue, undermines agricultural sustainability through climate change and resource overuse (Zobeidi et al., 2021).
- **Water scarcity** poses one of the most prominent threats to the well-being of **smallholder farmers** around the world (Aguilar et al., 2022).
- **Water scarcity** is one of the main long-term challenges to economic and social development in **Central Asia** (Eurasian Development Bank (2023)).
- **Smallholder farmers**, cultivating plots under **two hectares**, produce about 80% of the world's crops (FAO et al., 2018).

Are farmers' **risk** and **time preferences** associated with the exposure to regular irrigation water scarcity and extreme weather events?



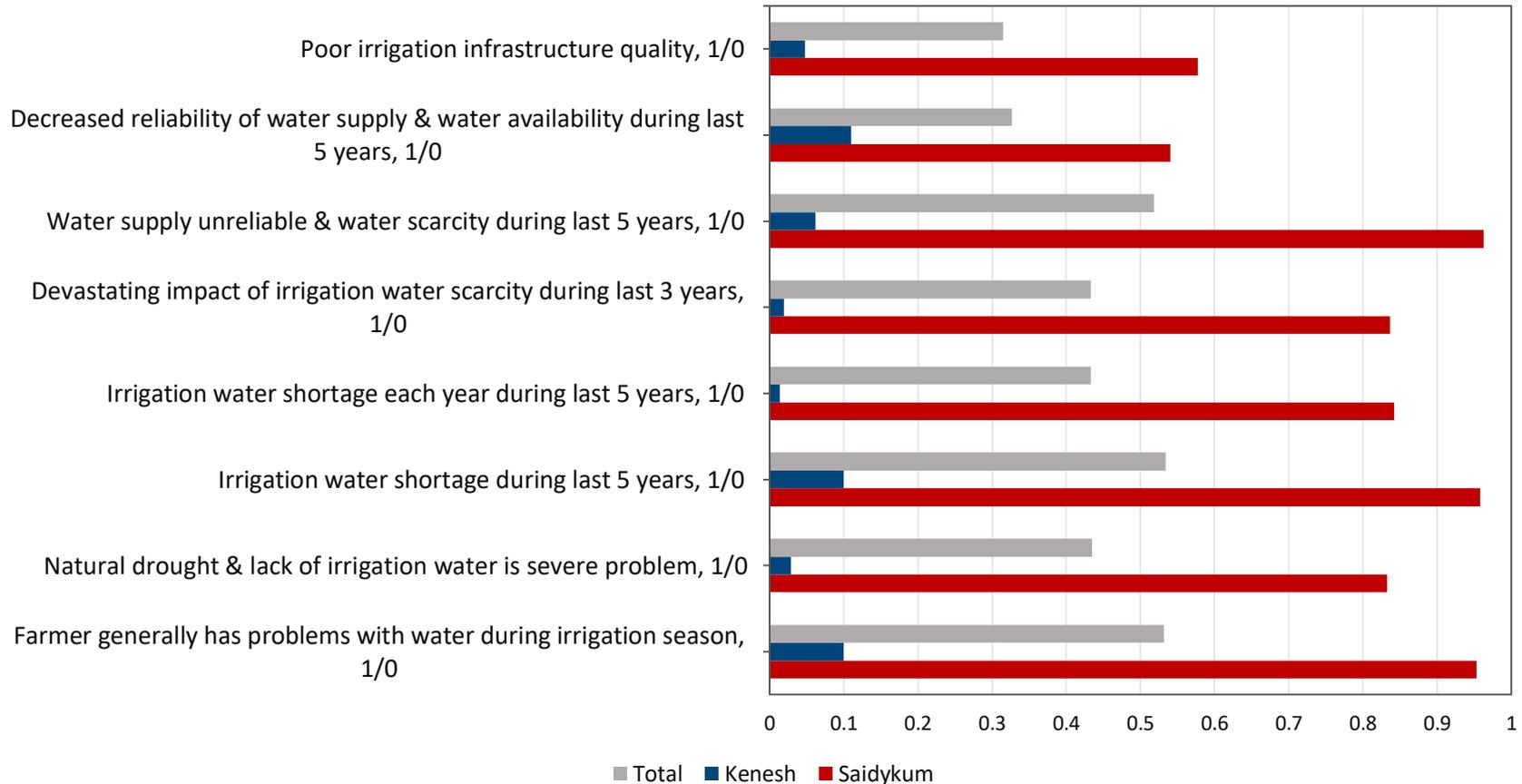
*More specifically,* to assess whether water-scarce farmers show **higher risk aversion, loss aversion, probability distortions, impatience,** and **present bias** compared to those in water-abundant areas.

# Study area and data collection



- Jalal-Abad Province, Kyrgyzstan
- 425 smallholder farmers including:
- 215 smallholder farmers from Saidykum ayil aymak (water-scarce zone)
- 210 smallholder farmers from Kenesh ayil aymak (water-abundant zone)
- Lottery game/post-experimental survey

# Irrigation water issues in two study zones and sample



## Prospect theory (PT) – risk preference

*(Value function)*

$$v(x) = \begin{cases} x^\sigma; & x \geq 0 \\ -\lambda(-x)^\sigma; & x < 0 \end{cases}$$

for gains → for losses

where  
 $\sigma$  = concavity (a proxy for risk aversion)  
 $\lambda$  = loss aversion (sensitivity to losses)

*(Probability weighting function)*

$$w(p) = \frac{1}{[exp(\ln(1/p))]^\alpha}$$

where  
 $\alpha$  = probability weighting

## Quasi-hyperbolic discounting (QHD) – time preference

$$D(\beta, r, t) = \begin{cases} 1; & \text{if } t = 0 \\ \beta exp(-rt); & \text{if } t > 0 \end{cases}$$

where  
 $r$  = parameter for time preference  
 $\beta$  = parameter for present bias

## Risk preference parameters for water scarce and water-abundant farmers

Prospect theory parameters	Water scarce farmers (N=215)	Water-abundant farmers (N=210)	All (N=425)
Risk aversion ( $\sigma$ )	0.651	0.682	0.666
Loss aversion ( $\lambda$ )	3.080	2.823	2.953
Probability weighting ( $\alpha$ )	0.682	0.756	0.719

## Summary of behavioral parameters according to Prospect theory

Parameter	Main properties
Risk aversion $\sigma$	Risk-neutral: $\sigma=1$ Risk-averse: $\sigma<1$ Risk-seeking: $\sigma>1$
Loss aversion $\lambda$	No loss aversion: $\lambda=1$ Loss aversion: $\lambda>1$ Loss seeking: $\lambda<1$
Probability weighting $\alpha$	Linear weighting: $\alpha=1$ Distorted weighting: $\alpha<1$ (more weights on small chance events) $\alpha>1$ (more weights on high chance events)

Water scarce farmers are **more risk and loss averse** and **overestimate small-probability events more**

## Time preference parameters for water scarce and water-abundant farmers (quasi hyperbolic)

	Water-scarce farmers	Water-abundant farmers	All
Discount rate ( $\delta$ ) (impatience)	0.012	0.010	0.011
Present bias ( $\beta$ ) (time-inconsistent)	0.619	0.725	0.678
N	5520	7230	12750
R2	0.522	0.519	0.520

## Summary of behavioral parameters Quasi-hyperbolic time discounting

Parameter		Main properties
Impatience (Discount rate)	$r$	No discounting: $r=0$ Discounting of present gains (saving now) $r<0$ Discounting of future gains (spending now): $r>0$
Present bias	$\beta$	No present bias: $\beta=1$ Extra discounting of future gains: $\beta<1$ (more present bias) Extra discounting of present gains: $\beta>1$

Water scarce farmers are **less patient** and show **stronger present bias** for soon options

# Model estimates of risk preference parameters (multiple linear regression (OLS))

Variables	Risk aversion ( $\sigma$ )		Loss aversion ( $\lambda$ )		Probability weighting ( $\alpha$ )	
	(1)	(2)	(1)	(2)	(1)	(2)
Age	-0.001 (0.002)	-0.002 (0.002)	0.033* (0.018)	0.031* (0.018)	0.001 (0.001)	0.001 (0.001)
Gender	-0.083* (0.045)	-0.086* (0.045)	0.367 (0.393)	0.325 (0.390)	-0.007 (0.031)	-0.009 (0.031)
Ethnicity	0.045 (0.057)	0.044 (0.057)	-1.195** (0.562)	-1.137** (0.558)	-0.008 (0.041)	-0.002 (0.041)
Education	-0.04 (0.050)	-0.023 (0.053)	-0.041 (0.428)	0.014 (0.435)	-0.001 (0.034)	-0.006 (0.035)
Experience	0.031 (0.200)	0.036 (0.199)	-1.729 (1.791)	-1.524 (1.766)	-0.224* (0.135)	-0.209 (0.133)
Dependency ratio	-0.026 (0.096)	-0.02 (0.096)	1.177 (0.717)	1.174 (0.720)	-0.109* (0.059)	-0.112* (0.059)
Income		-0.035 (0.032)		-0.04 (0.262)		0.017 (0.022)
Distance	-0.004 (0.007)	-0.004 (0.007)	-0.032 (0.062)	-0.028 (0.061)	0.010** (0.004)	0.010** (0.004)
Soil quality	-0.009 (0.058)	-0.008 (0.058)	0.299 (0.460)	0.303 (0.462)	-0.075** (0.037)	-0.074** (0.037)
Irrigation quality	-0.038 (0.058)	-0.031 (0.059)	0.687 (0.485)	0.743 (0.485)	-0.092*** (0.032)	-0.092*** (0.032)
<b>Yearly water shortage</b>	<b>-0.206***</b> (0.068)	<b>-0.205***</b> (0.068)	0.962* (0.581)	1.055* (0.570)	-0.023 (0.042)	-0.015 (0.042)
<b>5-year water scarcity and drought</b>	<b>0.172**</b> (0.068)	<b>0.158**</b> (0.064)	-0.131 (0.547)	0.029 (0.508)	-0.049 (0.046)	-0.026 (0.044)
<b>3-year water scarcity and drought</b>	0.018 (0.014)	0.015 (0.014)	<b>-0.289**</b> (0.125)	<b>-0.258**</b> (0.118)	-0.009 (0.009)	-0.005 (0.009)
5-year extreme weather event	-0.005 (0.019)		0.172 (0.174)		0.018 (0.011)	
_cons	0.757*** (0.151)	0.799*** (0.162)	2.264* (1.270)	2.551* (1.339)	0.777*** (0.112)	0.777*** (0.111)
F-test	1.719	1.789	2.039	1.966	2.014	2.06
Prob>F	0.055	0.043	0.017	0.022	0.019	0.016
R-squared	0.051	0.054	0.059	0.057	0.063	0.06

Main explanatory variables	Risk aversion ( $\sigma$ )	Loss aversion ( $\lambda$ )	Aligning (yes) or contrasting (no) with existing literature
Experience of irrigation water shortages each year	↑ Higher	↑ Higher	1. Begho & Anik (2022) – yes (RA)
Experience of irrigation water scarcity & drought past 5 years	↓ Lower	-	1. Bchir et al. (2024) – yes (RA) 2. Joshi et al. (2021) – yes (RA) 3. Mulungu et al. (2023) – no (RA)
Experience of more severe water scarcity & drought past 3 years	-	↓ Lower	1. Holden & Tilahun (2024) – yes (RA) 2. Page et al. (2014) – yes (RA)

# Model estimates of time preferences (nonlinear least-squares regression)

Variables	Discount rate (r)		Present bias ( $\beta$ )	
	(1)	(2)	(1)	(2)
$\mu$			0.000***	0.000***
			0.000	0.000
Constant ( $\beta_0, r_0$ )	0.010** (0.004)	0.005 (0.004)	1.021*** (0.117)	0.899*** (0.126)
Age	-0.002 (0.005)	0.001 (0.006)	-0.001 (0.002)	0.000 (0.002)
Gender	0.465*** (0.138)	0.565*** (0.141)	-0.006 (0.035)	0.007 (0.035)
Ethnicity	0.139 (0.164)	0.065 (0.170)	0.026 (0.050)	0.013 (0.051)
Education	-0.239* (0.134)	-0.361** (0.146)	0.017 (0.041)	-0.019 (0.042)
Experience	0.376 (0.500)	0.094 (0.544)	0.008 (0.154)	-0.026 (0.153)
Dependency ratio	0.071 (0.243)	0.090 (0.267)	-0.043 (0.071)	-0.043 (0.070)
Income		0.205** (0.082)		0.060** (0.024)
Distance	0.005 (0.018)	-0.006 (0.020)	-0.014** (0.006)	-0.015*** (0.005)
Soil quality	0.041 (0.148)	-0.019 (0.149)	-0.015 (0.039)	-0.011 (0.039)
Irrigation quality	-0.174 (0.192)	-0.275 (0.201)	0.062 (0.044)	0.040 (0.044)
Yearly water shortage	0.132 (0.212)	-0.057 (0.222)	0.062 (0.056)	0.050 (0.057)
5-year water scarcity & drought	<b>0.565***</b> (0.181)	<b>0.352**</b> (0.175)	<b>-0.213***</b> (0.052)	<b>-0.233***</b> (0.051)
3-year water scarcity & drought	<b>0.099**</b> (0.044)	0.065 (0.043)	-0.006 (0.011)	-0.010 (0.011)
5-year extreme weather event	<b>-0.229***</b> (0.052)		0.022 (0.016)	0.006 (0.016)

Notes: Standard errors are in parentheses. Standard errors are adjusted for within-subject correlations. The estimated coefficients of explanatory variables for r (discount rates) are multiplied by 100.  
N=12750 (Number of clusters=425).

Main explanatory variables	Discount rate ( $\delta$ )	Present bias ( $\beta$ )	Aligning (yes) or contrasting (no) with existing literature
Experience of irrigation water shortages each year	-	-	
Experience of irrigation water scarcity & drought in past 5 years	 <b>Higher</b> (more impatient)	 <b>Higher</b> (more time-inconsistent)	1. Cassar et al. (2017) – yes (PB) 2. Akesaka (2019) – yes (DR, PB)
Experience of severe irrigation water scarcity & drought in the past 3 years	 <b>Higher</b> (more impatient)	-	
Experience of a higher diversity of extreme weather events during past 5 years	 <b>Lower</b> (more patient)	-	

This study provides new evidence on how chronic and acute water stress are associated with the economic preferences of smallholder farmers.

## Risk preference:

As experience with irrigation water scarcity & drought is associated with **lower risk** and **loss aversion**

- *Post-shock periods can provide potential windows to introduce and promote riskier but potentially more profitable agricultural innovations*

## Time preference:

As experience with irrigation water scarcity & drought is associated with **higher discount rate** and **present bias**

- *Commitment devices to help farmers stick to beneficial long-term decisions*

- **Plan ahead** at least 8-9 months before
- Follow as much as possible the **original design of experiment**
- **Piloting experiments** & post-experimental questionnaire really matters
- Adapt the translated questionnaire to local language
- Difficulties with arranging **5-participant sessions**
- Farmers may associate lottery tasks with gambling games
- **Carefully explain the experiments** & check the understanding
- **Make adjustments** in the experiment design **before the start**

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