

IAMO

Leibniz Institute of Agricultural Development
in Transition Economies



SUSADICA
Doctoral Programme on Sustainable
Agricultural Development in Central Asia



Does adoption of zero tillage save or intensify production costs? Evidence from Kyrgyzstan

Abdusame Tadjiev

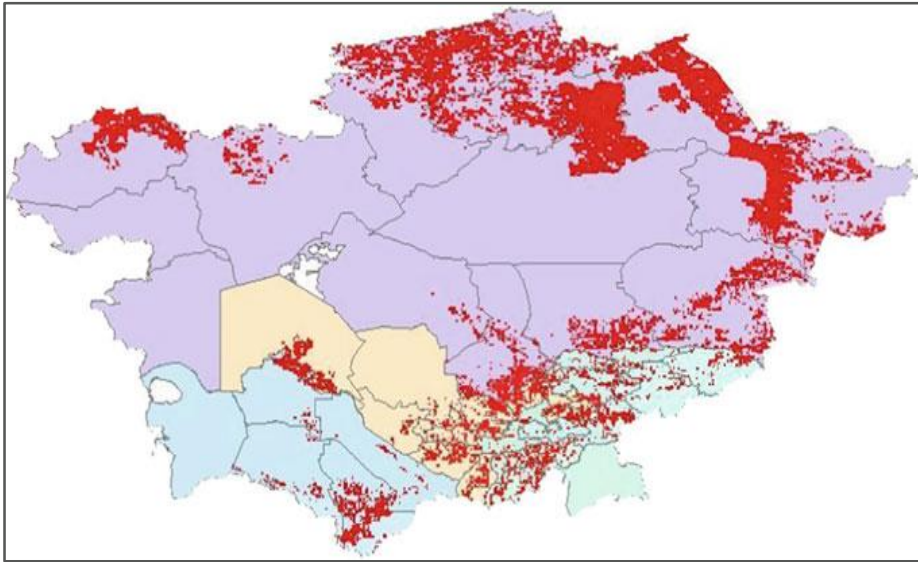
*Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Germany
Samarqand Branch of Tashkent State Agrarian University (SB TSAU), Uzbekistan
"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National
Research University (TIAME NRU), Uzbekistan*

The 8th Annual Life in Kyrgyzstan Conference 2022 | 10-12 October 2022



- Introduction
- Conceptual framework
- Data description
- Estimation procedure
- Results
- Conclusions

Land degradation in Central Asia



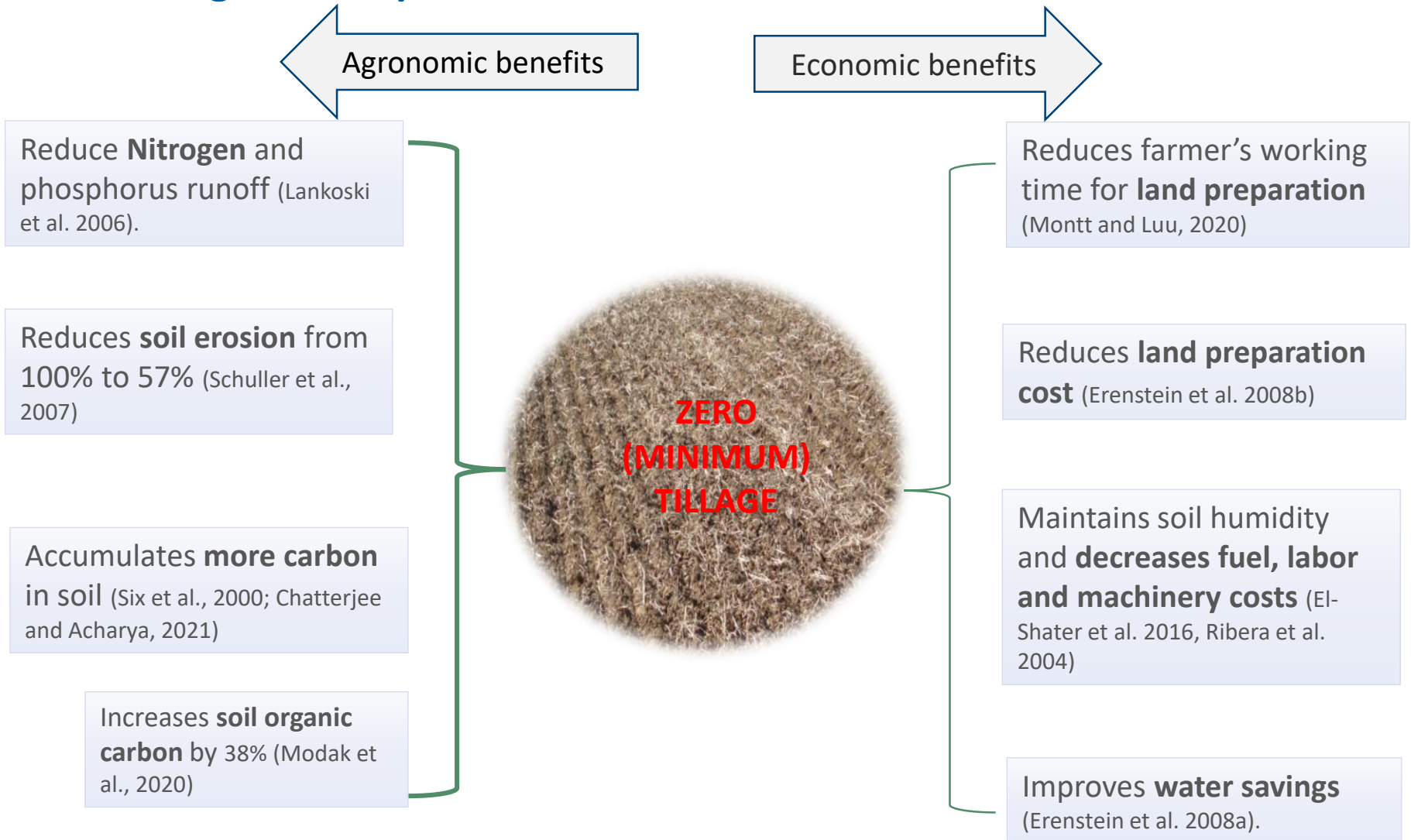
“Land degradation hotspots in Central Asia (in red)”.
Source: Mirzabaev et al. (2016)

Expansive and intensive land use (1924-1990), lack of land management system (after 1991) deteriorated **land degradation** in Central Asia (Nurbekov et al. 2016)

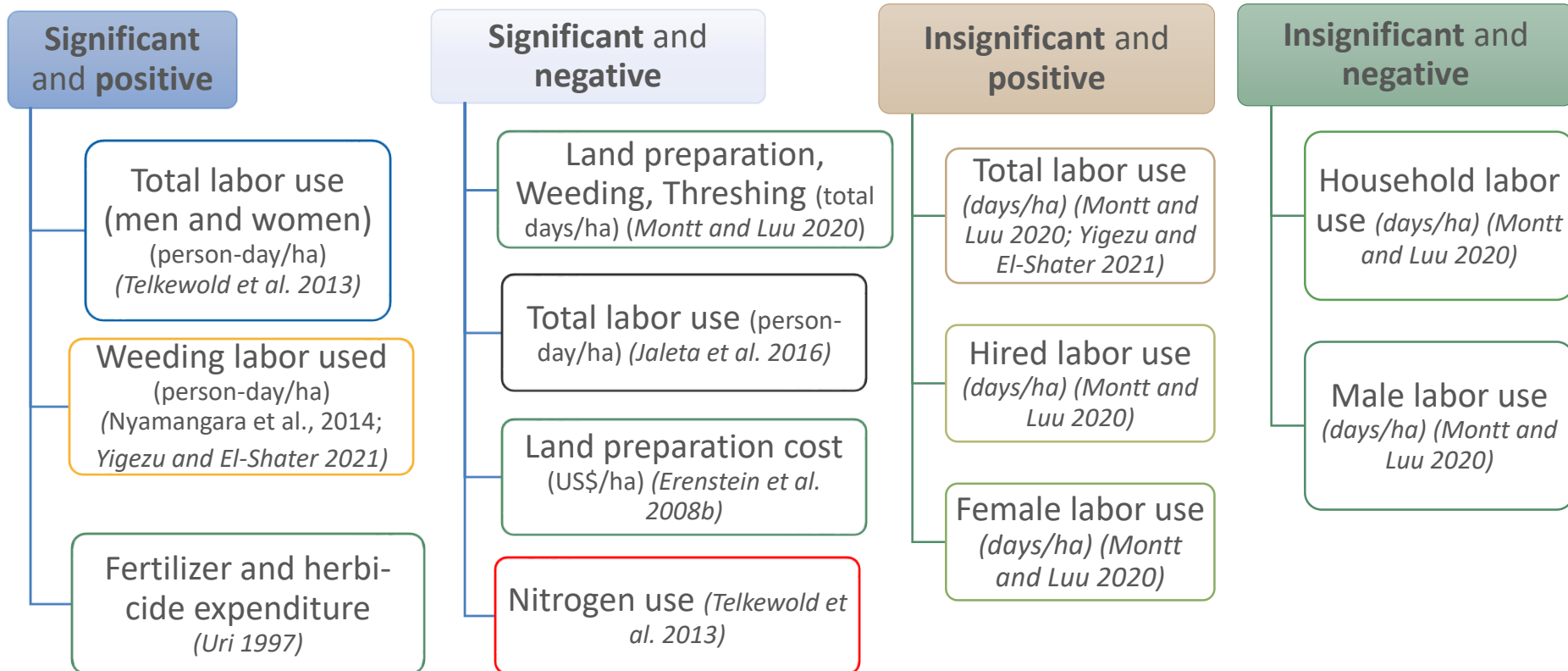
Rural households have limited **physical, financial and human** resources (Wolfgramm et al. 2010)

Soil erosion is a much greater problem in the mountainous places of Kyrgyzstan (Pender and Mirzabaev 2008)

Zero tillage as an option

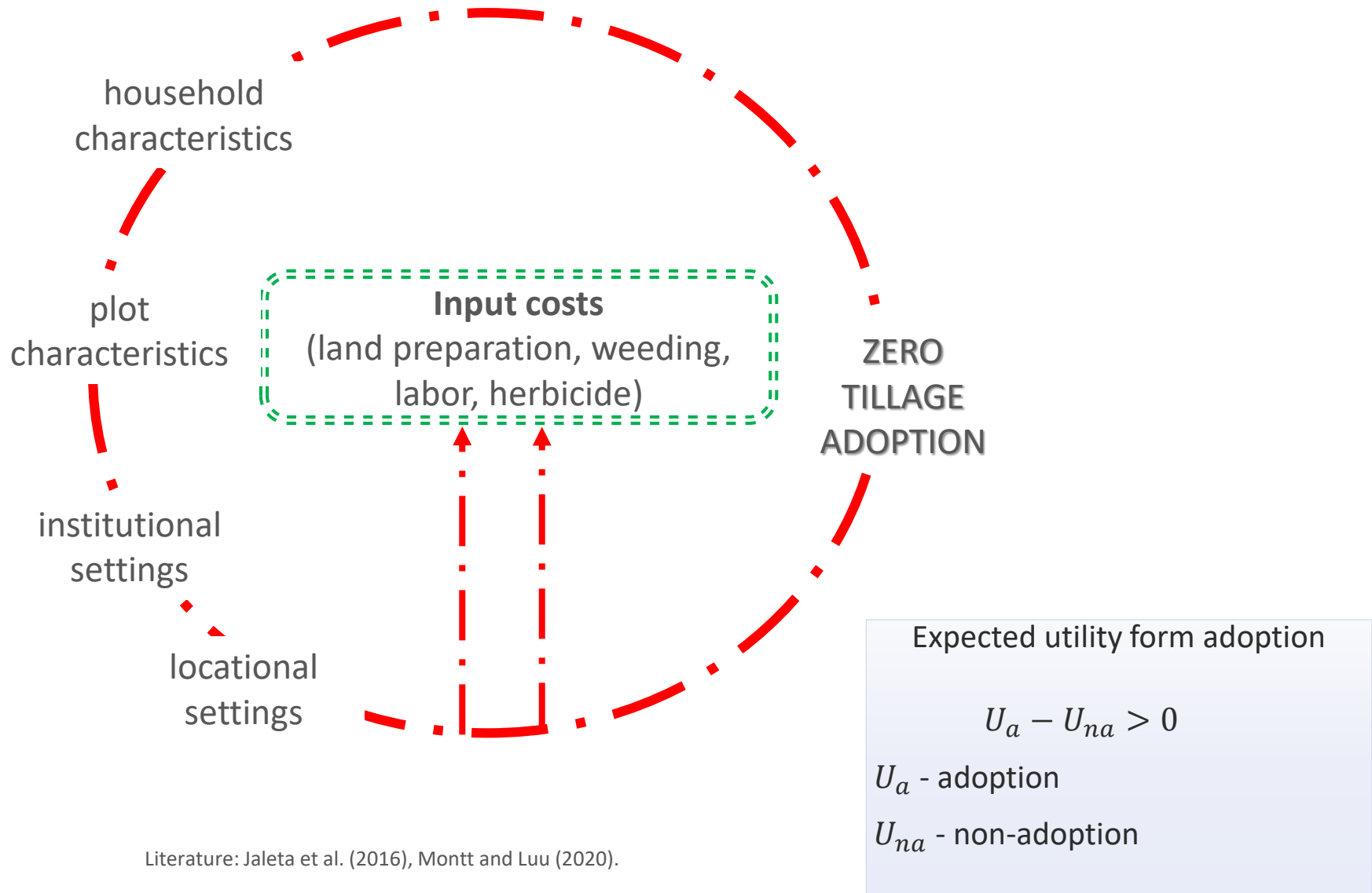


Empirics-based discussions: Zero (minimum) tillage adoption & input use



No agecon study on impact of ZT in Central Asia, e.g. based on “panel data” approach;

The **main goal** of the study is to answer a question “if ZT adoption saves or intensifies production costs in rural households”



- Life in Kyrgyzstan (LiK) dataset, 2016 and 2019 waves, plot level data
- Rural households in 7 provinces and 2 cities

| Number of plots | 2016 | 2019 |
|-----------------|-------------|-------------|
| 1 | 243 | 307 |
| 2 | 963 | 882 |
| 3 | 128 | 203 |
| 4 | 19 | 28 |
| 5 | 10 | 0 |
| 6 | 0 | 5 |
| Total | 1363 | 1425 |

Dropped from dataset:

- if HHs were surveyed only one year
- outliers (especially variables about “costs” of HH)
- plot size > 21 ha (strange difference comparing previous year)
- two cities (Bishkek and Osh)

Source: Life in Kyrgyzstan 2016 and 2019 HH survey data

Zero tillage adoption level

| Field Code | “What types of tillage methods were used in this field?” <i>List up to TWO, starting with the most important method first, then the second most important (see codes below) 98. Not applicable</i> | |
|---------------------------|---|------|
| | A304 | A305 |
| 1 (1 st field) | <u>2</u> or <u>7</u> | 4 |
| 2 (2 nd field) | 3 | 6 |
| ..6 | | |

Main Tillage (A304, A305)

- 1 = Hand tillage
- 2 = Zero tillage
- 3 = Ploughing with tractor
- 4 = Ploughing with horses
- 5 = Ridging (before planting)
- 6 = Mounding
- 7 = Did not till – broadcast seed
- 8 = Other tillage method

Zero tillage (ZT) plots = 1; non zero tillage (nZT) plots=0

| Provinces | 2016 | | 2019 | |
|--------------|-----------|--------------|------------|-------------|
| | ZT plots | nZT plots | ZT plots | nZT plots |
| Issik-Kul | 39 | 179 | 70 | 185 |
| Jalal-Abad | 11 | 279 | 45 | 241 |
| Narin | 15 | 84 | 12 | 56 |
| Batkent | 16 | 154 | 63 | 111 |
| Osh | 7 | 348 | 44 | 373 |
| Talas | 1 | 107 | 5 | 95 |
| Chuy | 4 | 119 | 51 | 74 |
| Total | 93 | 1,270 | 290 | 1135 |

Source: Life in Kyrgyzstan 2016 and 2019 HH survey data

Explanatory variables (selected)

| stylized facts: | Pooled 2016 and 2019 (N=2788) | | |
|--|-------------------------------|-----------------|-------------|
| | ZT (N=383) | nZT (N=2405) | mean differ |
| | Mean | Mean | |
| 1-human capital (education) | | | |
| 2-financial capital (assets) | | | |
| 3-physical capital (farm size) | | | |
| Age of HH (year) | 56.342 | 55.941 | 0.401 |
| Education level of HH (categorical, 1=illiterate...7=university) | 4.350 | 4.262 | 0.088 |
| Female HH (dummy, 1=female) | 0.209 | 0.229 | -0.02 |
| Employment in agricultural sector (dummy, 1 = occupation as agriculture, fishing) | 0.462 | 0.319 | 0.143*** |
| Number of household members, (above 10 and under 65) | 4.587 | 4.475 | 0.113 |
| Ethnicity of the household (dummy, 1 = Kyrgyz) | 0.815 | 0.771 | 0.044* |
| Remittance (during the last year did household receive money, dummy, yes=1) | 0.180 | 0.188 | -0.007 |
| Number of assets (number) | 10.402 | 10.610 | -0.208 |
| Tractor (number of owned tractors) | 0.047 | 0.042 | 0.005 |
| Amount of credit (US\$) | 579.826 | 227.735 | 352.091*** |
| Distance to main road (km) | 0.808 | 0.627 | 0.181*** |
| Plot size (ha) | 1.027 | 0.700 | 0.327*** |
| Distance from dwelling to field (km) | 1.565 | 1.280 | 0.285* |

Source: Life in Kyrgyzstan 2016 and 2019 HH survey data

Outcome variables

| | Pooled 2016 and 2019 (N=2788) | | |
|---|-------------------------------|-----------------------|-------------|
| | ZT plots (N=383) | nZT plots (N=2405) | mean differ |
| | Mean | Mean | |
| Total payment for hired labor on a plot (US\$/ha) (How much did you pay for hired labor to work on this plot?) | 7.994 | 8.514 | -0.052 |
| Machinery cost for land preparation and seeding on a plot (US\$/ha) (How much did the HH spend on machinery for this crop during this season on this plot?) | 25.674 | 37.242 | -11.568*** |
| Machinery cost for weeding (US\$/ha) (How much did the HH spend on machinery for this crop during this season on this plot?) | 10.830 | 8.294 | 2.536 |
| Total herbicide cost on a plot (US\$/ha) (How much did it cost to spray with herbicides ?) | 25.750 | 12.956 | 12.794*** |
| Total machinery, labor and herbicide costs on a plot (US\$/ha) | 68.845 | 67.106 | 1.739 |

Source: Life in Kyrgyzstan 2016 and 2019 HH survey data

Endogeneity switching regression (ESR) model

- Logit model (1st stage)

$$Pr(zt_{itj}) = \frac{\exp(\alpha_i + \beta'x_{itj} + \delta'x_{it} + \gamma'\bar{x}_i + R_p + Y_t)}{1 + \exp(\alpha_i + \beta'x_{itj} + \delta'x_{it} + \gamma'\bar{x}_i + R_p + Y_t)}$$

where;

- i 's household; j 's plot; at t time
- x_{itj} – observables at plot level
- x_{it} – observables at household level
- \bar{x}_i – mean of time – varying variables
- R_p – province dummy (Issyk – Kol is reference province)
- Y_t – time dummy (2016 is the reference year)

$$\lambda_{0itj} = \frac{\varphi(\delta Z_{itj})}{\Phi(\delta x_i)}$$

$$\lambda_{1itj} = \frac{-\varphi(\delta x_i)}{1 - \Phi(\delta x_i)}$$

- OLS model (2nd stage)

$$y_{1itj} = X_{itj1}\beta_1 + \bar{x}_{it1}v_1 + R_p + Y_t + \lambda_{1itj}\sigma_1 + Y_t * \lambda_{1itj}\tau_1 + \eta_{1itj}, \text{ if } ZT = 1$$

$$y_{0itj} = X_{itj0}\beta_0 + \bar{x}_{it0}v_0 + R_p + Y_t + \lambda_{0itj}\sigma_0 + Y_t * \lambda_{0itj}\tau_0 + \eta_{0itj}, \text{ if } ZT = 0$$

ATT – average treatment effect

Distance to main road (km)

Determinants of zero tillage adoption decision (selected)

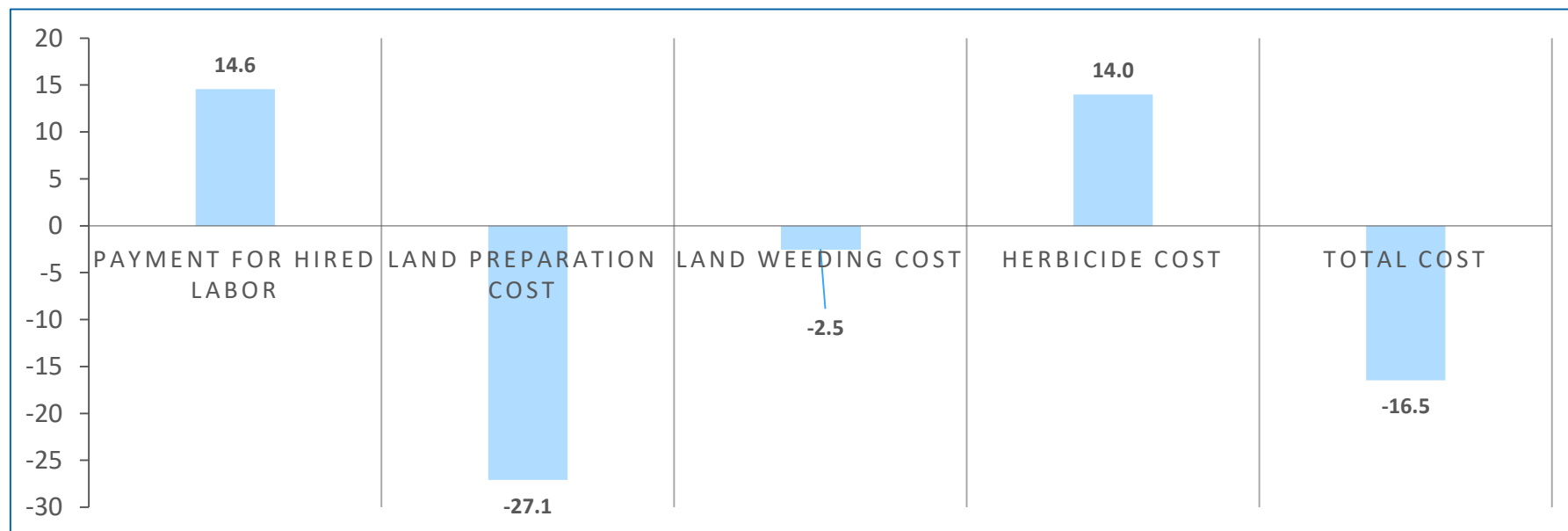
Logit model

| | Marginal effect | St.err |
|--|-----------------|--------|
| Employment in agricultural sector | 0.052** | 0.026 |
| Number of owned assets | -0.010*** | 0.003 |
| Distance to plot | 0.006*** | 0.003 |
| Number of plots of land owned by household | -0.019* | 0.011 |
| Using fertilizer on a plot (dummy, 1=used) | -0.047** | 0.020 |
| Jalal-Abad | -0.090**** | 0.021 |
| Osh | -0.136*** | 0.024 |
| Talas | -0.252*** | 0.047 |
| Year | 0.141*** | 0.015 |
| Distance to main road | 0.020*** | 0.006 |

- ZT adoption is positively related with:
 - ✓ employment in agriculture
 - ✓ distance to the field
 - ✓ distance to main road
- HHs from Jalal-Abad, Osh and Talas provinces are less likely to adopt ZT compared to HHs of Issyk-Kol provinces
- HHs using fertilizers on plots and with own assets are less likely to adopt ZT

*significant at 10% level, **significant at 5% level, ***significant at 1% level

| Outcome variable (USD \$/ha) (ln) | ZT plots (actual) | nZT plots (counterfactual) | Average treatment effect |
|--|----------------------|-------------------------------|-----------------------------|
| Payment for hired labor | 1.240 | 1.556 | -0.316*** |
| Machinery cost for land preparation | 0.380 | 0.244 | 0.136*** |
| Machinery cost for land weeding | 0.527 | 0.552 | -0.025 |
| Herbicide cost | 0.898 | 0.767 | 0.131** |
| Total machinery, labor and herbicide costs | 2.044 | 2.224 | -0.180** |



Note: Values calculated as $100 * (\exp(ATT) - 1)$ as in Asfaw et al. (2012)

Source: Calculation based on LiK 2016 and 2019 HH survey data




- A negative effect of “number of owned assets” on ZT adoption
 - Wealthy HHs use mechanized services (tractor) instead of applying ZT
- The probability of adoption increases with more number of plots and if plots are located further away from household dwellings
- ZT adoption decreases land preparation (27%) and weeding costs (3%) associated with machinery services, but increases hired labor costs (15%) and herbicide cost (14%)
 - ZT is an attractive option for reducing machinery costs and improving the employment of hired agri workers



- Policymakers should promote ZT adoption among rural households as a way to reduce machinery costs:
 - particularly among poor households and those with multiple plots and located at a distance from roads:
 - Promoting ZT adoption as a labor-saving or herbicide-reducing practice will create false expectations among smallholders

Thank you for your attention!

Tadjiev@iamo.de

Leibniz Institute of Agricultural
Development in Transition Economies
(IAMO)
Theodor-Lieser-Str 2
06120 Halle (Saale), Germany

 +49 345 2928-0
 iamo@iamo.de
 www.iamo.de/en

 [iamoLeibniz](https://www.facebook.com/iamoLeibniz)
 [iamoLeibniz](https://twitter.com/iamoLeibniz)



- Chatterjee, R., & Acharya, S. K. (2021). Dynamics of Conservation Agriculture: a societal perspective. *Biodiversity and Conservation*, 1-21.
- El-Shater, T., Yigezu, Y. A., Mugeru, A., Piggan, C., Haddad, A., Khalil, Y., ... & Aw-Hassan, A. (2016). Does zero tillage improve the livelihoods of smallholder cropping farmers?. *Journal of Agricultural Economics*, 67(1), 154-172.
- Erenstein, O., & Laxmi, V. (2008a). Zero tillage impacts in India's rice-wheat systems: a review. *Soil and Tillage Research*, 100(1-2), 1-14.
- Erenstein, O., Farooq, U., Malik, R. K., & Sharif, M. (2008b). On-farm impacts of zero tillage wheat in South Asia's rice-wheat systems. *Field Crops Research*, 105(3), 240-
- Jaleta, M., Kassie, M., Tesfaye, K., Teklewold, T., Jena, P. R., Marenya, P., & Erenstein, O. (2016). Resource saving and productivity enhancing impacts of crop management innovation packages in Ethiopia. *Agricultural Economics*, 47(5), 513-522.
- Khonje, M. G., Manda, J., Mkandawire, P., Tufa, A. H., & Alene, A. D. (2018). Adoption and welfare impacts of multiple agricultural technologies: evidence from eastern Zambia. *Agricultural Economics*, 49(5), 599-609.
- Lankoski, J., Ollikainen, M., & Uusitalo, P. (2006). No-till technology: benefits to farmers and the environment? Theoretical analysis and application to Finnish agriculture. *European Review of Agricultural Economics*, 33(2), 193-221.
- Mirzabaev, A., Goedecke, J., Dubovyk, O., Djanibekov, U., Le, Q. B., & Aw-Hassan, A. (2016). Economics of land degradation in Central Asia. In *Economics of land degradation and improvement—A global assessment for sustainable development* (pp. 261-290). Springer, Cham
- Modak, K., Biswas, D. R., Ghosh, A., Pramanik, P., Das, T. K., Das, S., ... & Bhattacharyya, R. (2020). Zero tillage and residue retention impact on soil aggregation and carbon stabilization within aggregates in subtropical India. *Soil and Tillage Research*, 202, 104649.
- Montt, G., & Luu, T. (2020). Does Conservation Agriculture Change Labour Requirements? Evidence of Sustainable Intensification in Sub-Saharan Africa. *Journal of Agricultural Economics*, 71(2), 556-580.
- Nurbekov, A., Akramkhanov, A., Kassam, A., Sydyk, D., Ziyadaullaev, Z., & Lamers, J. P. A. (2016). Conservation Agriculture for combating land degradation in Central Asia: a synthesis. *AIMS Agriculture and Food*, 1(2), 144-156.
- Nyamangara, J., Mashingaidze, N., Masvaya, E. N., Nyengerai, K., Kunzekweguta, M., Tirivavi, R., & Mazvimavi, K. (2014). Weed growth and labor demand under hand-hoe based reduced tillage in smallholder farmers' fields in Zimbabwe. *Agriculture, ecosystems & environment*, 187, 146-154.
- Pender J, Mirzabaev A. 2008. Economic analysis of sustainable land management options in central Asia, [progress report] (ADB).
- Ribera, L. A., Hons, F. M., & Richardson, J. W. (2004). An economic comparison between conventional and no-tillage farming systems in Burleson County, Texas. *Agronomy Journal*, 96(2), 415-424.
- Schuller, P., Walling, D. E., Sepúlveda, A., Castillo, A., & Pino, I. (2007). Changes in soil erosion associated with the shift from conventional tillage to a no-tillage system, documented using 137Cs measurements. *Soil and Tillage Research*, 94(1), 183-192.
- Six, J. A. E. T., Elliott, E. T., & Paustian, K. (2000). Soil macroaggregate turnover and microaggregate formation: a mechanism for C sequestration under no-tillage agriculture. *Soil Biology and Biochemistry*, 32(14), 2099-2103.
- Teklewold, H., Kassie, M., Shiferaw, B., & Köhlin, G. (2013). Cropping system diversification, conservation tillage and modern seed adoption in Ethiopia: Impacts on household income, agrochemical use and demand for labor. *Ecological Economics*, 93, 85-93.
- Uri, N. D. (1997). Conservation tillage and input use. *Environmental Geology*, 29(3), 188-201.
- Wolfram, B., Shigaeva, J., Nekushoeva, G., Bonfoh, B., Brey, T. M., Liniger, H., & Maselli, D. (2010). Kyrgyz and Tajik land use in transition: Challenges, responses and opportunities.
- Yigezu, Y. A., & El-Shater, T. (2021). Socio-economic impacts of zero and reduced tillage in wheat fields of the Moroccan drylands. *Agricultural Economics*, 52(4), 645-663.

Outcome determinants (selected)

| | Labor payment (ln) | | Land preparation cost (ln) | | Land weeding cost (ln) | | herbicide cost (ln) | | Total cost (US\$) | |
|--|--------------------|-----------|----------------------------|-----------|------------------------|-----------|---------------------|-----------|-------------------|-----------|
| | ZT plots | nZT plots | ZT plots | nZT plots | ZT plots | nZT plots | ZT plots | nZT plots | ZT plots | nZT plots |
| Education level of HH (categorical, 1=illiterate...7=university) | 0.047 | -0.061* | 0.057 | 0.028 | 0.083* | -0.005 | -0.019 | 0.018 | 0.015 | -0.052 |
| Employment in agricultural sector (dummy, 1 = Occupation as agriculture, fishing and private Households with employed persons) | 1.079** | 0.325* | 0.395 | 0.066 | 0.092 | 0.221* | 0.245 | 0.077 | 1.328** | 0.255 |
| Number of household members, (above 10 and under 65) | 0.185 | 0.057 | 0.054 | -0.006 | -0.108 | 0.039 | -0.329** | 0.057* | -0.027 | 0.057 |
| Ethnicity of the household (dummy, 1 = Kyrgyz) | 0.604** | 0.417*** | -0.138 | -0.216*** | 0.172 | -0.066 | -0.375 | -0.148* | 0.259 | 0.294*** |
| Number of assets (number) | -0.053 | 0.041** | -0.025 | -0.015 | -0.022 | 0.032** | 0.000 | 0.043*** | -0.031 | 0.066*** |
| Tractor owned (number of tractors that hh owned) | -0.325 | 0.223 | -0.039 | -0.160 | -0.541 | -0.070 | 1.168* | 0.063 | 0.841 | 0.169 |
| Plot size, (ha) | 0.070** | 0.023 | 0.065* | 0.065*** | 0.030 | 0.078*** | -0.047 | -0.023 | 0.035 | 0.033 |
| weather shock (dummy, 1=yes) | 0.730** | 0.319** | -0.017 | 0.033 | -0.095 | -0.035 | 0.298 | 0.138 | 0.801* | 0.362** |
| agricultural shock (dummy, 1=yes) | 0.332 | 0.054 | 0.059 | -0.168** | 0.356 | 0.251*** | -0.665* | -0.017 | 0.107 | 0.050 |
| average distance form dwelling to field (km) | 0.162*** | 0.145*** | 0.076** | 0.084*** | 0.075* | 0.067*** | -0.012 | 0.022** | 0.122*** | 0.155*** |
| Using fertilizer (dummy, 1=used) | 0.263 | 1.141*** | 0.377 | 0.409*** | 0.784** | 0.413*** | 0.563 | 0.864*** | 1.007* | 1.559*** |
| Number of plots of land owned by household | -0.337* | 0.174*** | -0.028 | -0.017 | -0.101 | 0.136*** | -0.123 | -0.009 | -0.406** | 0.113 |
| Total livestock units owned by households | -0.024 | -0.020 | -0.018 | 0.004 | -0.062** | -0.010 | 0.071* | 0.027** | -0.028 | -0.006 |
| Amount of credit (US\$) | 0.068 | -0.004 | 0.020 | 0.018 | 0.022 | -0.010 | 0.041 | -0.040** | 0.109 | -0.021 |
| Jalal-Abad | -2.110*** | -0.354** | -0.274 | -0.053 | -0.467 | -0.595*** | -0.299 | -1.268*** | -2.030*** | -0.998*** |
| Narin | -1.393** | -0.141 | -0.130 | 0.174 | -0.5740* | -0.513*** | -0.288 | -0.991*** | -1.229** | -0.573*** |
| Batkent | -0.193 | -0.820*** | 0.136 | -0.027 | 0.154 | -0.427*** | 0.364 | -0.701*** | 0.335 | -1.158*** |
| Osh | -0.943 | 0.562*** | 0.515 | -0.027 | -0.068 | -0.624*** | 1.066 | -0.977*** | -0.118 | -0.077 |
| Talas | -3.186* | 0.395** | -0.196 | 0.754*** | -1.113 | 0.012 | -0.245 | -0.802*** | -2.891 | -0.047 |
| Chuy | -0.217 | -0.310* | 0.299 | 0.307*** | -0.025 | -0.260** | 0.440 | -0.866*** | 0.235 | -0.745*** |
| year_2 | 1.826* | -0.396*** | 0.115 | -0.151** | 0.822 | 0.149** | -0.187 | 0.358*** | 1.407 | -0.062 |