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Climate change and health in Central Asia: a literature review

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ABSTRACT

Countries in Central Asia, which are highly vulnerable to climate change, experience a variety of health-related impacts to which they must adapt. At the same time, climate mitigation interventions in the health sector in the form of reduced greenhouse gas (GHG) emissions may also generate co-benefits. This article briefly outlines current understanding of the relationship between climate change impacts and human health in Central Asia and establishes a scope of inquiry based on climate and health linkages as identified by the Intergovernmental Panel on Climate Change (IPCC). It then identifies and summarizes existing research and reporting on this topic in the region as presented in published literature, country reporting to the United Nations Framework Convention on Climate Change (UNFCCC), and gray literature, including policy literature and documentation of donor-funded development interventions in the region. This review, which attempts to summarize and appraise those efforts, has found that both peer-reviewed and grey literature on this topic must be used with caution. The most frequent problems with peer-reviewed and grey literature resources involved confounding bias, and—to a lesser extent—self-reporting bias. The use of an appraisal framework for grey literature sources can frame these diverse resources in the proper context, identify potential shortcomings, and gain insights into current priorities and future direction for research on climate change and health in the region.

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1. Introduction

A “Health Day” at 28th Conference of the Parties (COP28) of the United Nations Framework Convention on Climate Change (UNFCCC), the first of its kind, called attention to the multivarious linkages between climate change impacts and health. While this event was the first of its kind at a COP, it was informed by many prior years of research into the relationship between climate change and health. Adverse health impacts due to climate change were originally noted in Article 1 of the UNFCCC (UNFCCC, 1992: Art. 1.1). At the meeting of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA) held at COP28, the CMA adopted the UAE Framework for Global Climate Resilience, which establishes a target of “Attaining resilience against climate change related health impacts, promoting climate-resilient health services, and significantly reducing significantly reducing climate-related morbidity and mortality, particularly in the most vulnerable communities…” by 2030 and beyond (CMA, 2023: Art. 8 (c)).

Momentum to action in the area of climate change and health has also come from the global health policy sector. A December 2023 World Health Organization (WHO) report by the Director General to the organization’s Executive Board on climate change and health, noting that “This fundamental threat to human health requires a strong response from the global health community to protect health from increasing climate hazards, ensure access to high quality, climate resilient, environmentally sustainable health services, and improve health, while limiting global warming to the agreed 1.5˚C limit. This will require action on both adaptation (protecting health from the impacts of climate change) and mitigation (limiting emissions of greenhouse gases and other climate pollutants into the atmosphere)” (WHO, 2023). Specifically, the report notes that “There is a need for national health and environment agencies to systematically assess climate-related risks to health systems and health outcomes, and to develop national health adaptation plans to ensure that the health of the population is resilient to climate shocks and stresses” (WHO, 2023).

2. Climate change and health

In discussing the relationship between human health and adaptation to climate change, defining a scope for inquiry can be challenging due to conceptual complexity. Talkuder et al., (2023) present climate change and health as a complex adaptive system, where sub-systems of extreme weather, ecological services, food security, disaster risk reduction (DRR) and clinical public health interact in simple and complex ways. Interaction occurs within these five sub-systems, with adjacent variables, and with all of the five sub-systems interacting with one another.

Current understanding of general conceptual relationships of climate change adaptation and human health is elaborated in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) Working Group II and the IPCC Synthesis Report (IPCC, 2022, 2023a). Specifically, the AR6 notes that hazards and associated risks expected in the near term include an increase in heat-related human mortality and morbidity (high confidence), food-borne, water-borne, and vector-borne diseases (high confidence), and mental health challenges (very high confidence)…Cryosphere-related changes in floods, landslides, and water availability have the potential to lead to severe consequences for people, infrastructure and the economy in most mountain regions (high confidence)" (IPCC, 2023: 15). The report also notes that adaptation actions could generate health benefits. As the report concludes, "Deep, rapid, and sustained mitigation and accelerated implementation of adaptation actions in this decade would reduce projected losses and damages for humans and ecosystems (very high confidence), and deliver many co-benefits, especially for air quality and health (high confidence)" (IPCC, 2023: 15). Specific adaptation options to help protect human health identified with high confidence or very high confidence by the report include Heat Health Action Plans, surveillance and prevention of vector-borne and water-born illnesses, early warning systems, and universal access to healthcare. (IPCC, 2023: 107).

The AR6 report also covers the relationship between climate change mitigation and health, noting that "Implementing both mitigation and adaptation actions together and taking trade-offs into account supports co-benefits and synergies for human health and well-being. For example, improved access to clean energy sources and technologies generates health benefits especially for women and children; electrification combined with low-GHG energy, and shifts to active mobility and public transport can enhance air quality, health, employment, and can elicit energy security and deliver equity. (high confidence)" (IPCC, 2023: 31).

3. Climate-Health Relationships and the Central Asian Context

From the perspective of threats to human health as noted by the IPCC, all Central Asian countries experience extreme all Central Asian countries experience extreme heat to varying degrees along with other extreme weather events. Mean temperatures in the region are projected to increase by as much as 6.5 degrees Celsius by 2100, exposing the population of the region to heat waves that are more frequent and longer (Reyer et al., 2017). Infectious diseases with vector-borne and water borne pathogens are also found in the region. The presence of the high-mountain cryosphere in four of the five countries also presents threats in the form of mudslides, avalanches, and glacial lake outburst floods, or GLOFs (Hock et al., 2019).

Secondary effects such as drought have a variety of indirect effects on human health in the region, such as decreased water quality and reduced agricultural yields, which in turn can affect food security and livelihoods.

Vulnerability, as a function of exposure to climate threats and adaptive capacity, varies both across countries in the region and within individual countries (Novikov and Kelly, 2017, Droogers and Lal, 2018). Vulnerability also differs between men and women, as they experience different levels of exposure to climate threats and different levels of adaptive capacity. Other vulnerable groups in the region include infants and children, pregnant women, the elderly, people with pre-existing health conditions, and people residing in areas at risk for climate-related hazards such as floods or mudslides.

Variability across countries should also be seen as influenced by differing conditions in demography, population health, and health services. These factors may influence exposure to climate threats and adaptive capacity. Table I provides an overview of summary indicators by country.

Table I. Summary Health Indicators by Country

	Female/ Male Life Expectancy at Birth (2022 est.)	Total Fertility Rate (Live Births per Woman, 2022 est.)	Infant Mortality per 1,000 Live Births (2022 est.)	Current Health Expenditure as a % of GDP (2020)
Kazakhstan	73.0 (F) 65.8 (M)	3.0	8.5	3.8
Kyrgyzstan	74.9 (F) 66.2 (M)	2.9	13.1	5.3*
Tajikistan	71.3 (F) 69.2 (M)	3.1	23.4	8.2
Turkmenistan	72.9 (F) 65.9 (M)	2.6	32.9	5.7
Uzbekistan	74.3 (F) 69.0 (M)	2.8	12.4	6.7

*Estimate

Source: UNSD, 2023: 26-54 (demographic data); 177-186 (expenditure data).

Beyond descriptive literature covering general conceptual linkages, information on health and climate change research in Central Asia can be elusive. A 2022

article entitled "A void in Central Asia research: Climate change," which reviewed the academic research in English-language databases, found that "Anthropology, international relations, and public health are the least active disciplines in the study of climate-related issues in Central Asia." (Vakulchuk et al., 2022: 5). The authors also state that the lack of literature on climate change and health in the region "is one of the major gaps in the literature that needs to be addressed" and "We found only one peer-reviewed publication and one grey literature publication on climate change and health, although the health impacts of climate change are likely to have social, economic, and potentially even political ramifications." (Vakulchuk et al ., 2022: 8, 12). This study represents an important assessment of research as identified in English-language, peer-reviewed sources (although it also cites some studies that are not published in academic journals). It also identifies a gap in the literature and rightly notes its potential implications. However, as the authors note, it does not survey Russian-language publications, which limits its scope in a region where Russian-language journals have been a traditional path for academic publication and where many researchers received their doctoral degrees from Russian-language institutions. As a result, the review excludes a stream of research that has emerged in the previous two decades on climate change, and as a sub-sector, climate change and health.

In a study that builds on this work, Mirzabaev notes that "The scientific literature on climate change in Central Asia has also been growing rapidly, but remains very small." (Mirzabaev, 2022: 23). His bibliometric analysis does not mention health directly, but rather addresses climate change as a whole. The analysis also identifies Russian-language literature, which provides additional information on addresses a – another important step – identifying additional resources. His English-language search identifies 325 publications relevant to the region as a whole, and country-specific publications for Kazakhstan (104), followed by Uzbekistan (69), Tajikistan (65), Kyrgyzstan (35) and Turkmenistan (5). For Russian-language sources, he identifies "indexes 32 publications for Central Asia as a whole. By country, the figures were 51 publications for Kazakhstan, followed by Tajikistan (26), Kyrgyzstan (19), Uzbekistan (14) and Turkmenistan (1) (Mirzabaev, 2022: 27).

He notes that "These results show that publications on climate change in Central Asia have been primarily dedicated to the biophysical impacts of climate change. There have been relatively few studies investigating the socioeconomic impacts of climate change, issues related to people's vulnerability to climate change and the social and economic dimensions of climate change adaptation." (Mirzabaev, 2022: 27). This study broadens current understanding of climate change research related to Central Asia in peer-reviewed publications.

4. Methodological approach

This article aims to cast a broad net across peer-review, grey literature, and video resources for climate change and health in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan in order to provide additional information on the state of research, policy, and understanding in that area. In addition to assessing peer-reviewed articles on climate change and health, it supplants these sources with additional research and reporting through key word searches, referrals from experts in the field, and the author's personal collection, drawing upon the following types of non-peer-review sources in English and Russian:

1) National communications to the UNFCCC;
2) Analytical reports by UN agencies and multilateral organizations
3) Donor-funded project reports and evaluations
4) Press releases and articles in the popular press
5) National policies and strategies
6) Non-print sources (video and film)

For all sources, the author limited review to sources of information that were publicly available in digital format in English and/or Russian.

For the identification of peer-reviewed articles, the author ran a Web of Science Core Collection search using the search terms ["climate change" AND "human health" AND "Central Asia"] and five country-specific searches (e.g. ["climate change" AND "human health" AND "Kazakhstan"]). For Russian-language publications, the author conducted a search on Google Scholar using the query ["изменение климата" "здоровье" "в Центральной Азии"] and five country-specific queries (e.g. ["изменение климата" "здоровье" "в Казахстане"]). Criteria for inclusion were a focus on a specific climate threat or threats and linkages to human morbidity and/or mortality in the five countries under study. For this reason, general review articles with statements on climate change potentially affecting human health were not included, nor were articles that looked broadly at environmental health without focusing on climate variability. The author supplanted this list with three previously-identified sources that met inclusion criteria.

For National Communications to the UNFCCC, the author searched the UNFCCC on-line database of non-Annex I NCs submitted as of February 28, 2024 for each of the five countries (18 results). All 18 reports were deemed to be official NCs and were included in consideration. The topics identified in these reports were then classified by the major health and well-being areas identified by the IPCC Sixth assessment report as having medium, high, or very high confidence regarding adverse impacts: infectious diseases; heat, malnutrition, and harm from wildfire; mental health; and displacement (IPCC, 2023: 7).

Analytical reports by UN agencies and multilateral organizations were compiled by searching the available UNECE Environmental Performance Reports and OSCE Environmental Security Initiative reports for the region. An additional report from the IMF was also included.

For donor-funded project reports and evaluations, the author consulted donor document databases (UNDP, GCF, WHO). Information on other sources of print information consists of selected examples and is not meant to be indicative. For non-print sources, (video and film), YouTube and Vimeo searches conducted for English-language video material [“climate change” “health” “Central Asia”] and for Russian-language video material ["изменение климата" "здоровье" "в Центральной Азии"] were supplanted with two videos available on Vimeo known to the author that did not appear in the search results and with country-specific Russian-language searches on YouTube.

Findings from these sources were compiled and then summarized and appraised critically. The appraisal is modeled on the AACODS framework for assessing grey literature (Tyndall, 2010), which considers authority, accuracy, coverage of content, objectivity, date, and significance. This scope of inquiry is not intended to be exhaustive, but rather to expand the current documentation of literature, describe key types of grey literature, identify diverse sources of information on climate change and health in Central Asia, assess their utility in the current discussion, and identify trends and gaps that should be addressed by future research.

5. Findings

5.1. Published literature

Peer-reviewed articles and books with a discussion of climate change and health are rare. Under English-language resources, the Web of Science Core Collection search ["climate change" AND "human health" AND "Central Asia"] produced 33 results, but all were excluded according to the methodology provided in the previous section. Country searches yielded one journal article:

- ["climate change" AND "human health" AND "Kazakhstan"] (R=8), all excluded.
- ["climate change" AND "human health" AND "Kyrgyzstan"] (R=5), all excluded
- ["climate change" AND "human health" AND "Tajikistan"] (R=4), all excluded
- ["climate change" AND "human health" AND"Turkmenistan"] (R=5), all excluded
- ["climate change" AND "human health" AND "Uzbekistan"] (R=13), all excluded

That said, foundational work, in which relationships between climate and health, particularly as health is impacted by climate change, is common. One recent example is that of a book chapter by Daloz (2023) entitled “Climate Change: A Growing Threat for Central (Asia)". The chapter includes a general description of the

nature of climate change impacts on health in Central Asia, including heat stress and secondary effects, such as threats to livelihoods and potential malnutrition (Daloz, 2023:18).

A number of articles searched that included climate change and health in their titles and/or abstracts did not present health data. For example, Kaimuldinova and Abdimanapov (2013) stated that their study examined "dangerous meteorological phenomena" and their "influence on human health" (p. 390). This study focused on the Jambyl and Almaty provinces and presented the frequency of various extreme weather events. However, no health data were included in the article, making it impossible to see an association between changes in frequency and changes in morbidity and mortality. Isaev et al. (2022), in their article "Impact of Climate Change and Air Pollution...," studied a phenomenon that had an indirect effect on human health: air quality. As the authors stated, "Climate change in Bishkek and the impact on air pollution was assessed via the frequency of days characterized by daytime temperature inversions and air stagnation," and the article also stated that "Atmospheric stability increased from 2015 to 2020 with ongoing climate change leading to more temperature inversions." (Isaev, 2022: 1). While both of these articles were not able to establish a relationship between climate change and health outcomes, they present information that could serve as the foundation for climate-health research in the region if health data and statistics were introduced.

The Russian language search also identified articles that primarily addressed climate-health relationships in a broad conceptual manner. For example, Yunusova (2023) discusses the characteristics of heat islands in Kazakhstan and states that "on average, 1000 people die of extreme heat" but does not cite data sources or the area of coverage of that figure p. 352 in (Russian). A contribution to conference proceedings by Tuktibaeva and Bekturganov (2019), "The Impact of Climate Change, Seasonal Change on the Dynamics of Morbidity of Preschool-Aged children" [in Russian] provides only general climate information and assesses morbidity by using statistics on school absence. While this study comes the closest of those identified to intentionally study an association between climatic phenomena and health outcomes, its use of a proxy for illness (school absence) and assertion that weather is the primary determinant in morbidity leads it open to substantial confounding bias. The study does not discuss limitations of its approach.

In addition to these results, two peer-reviewed articles on climate change and health in Central Asia that were identified as secondary sources from a broader literature review overstated the scope of research in their titles. One "regional" article titled "Failed development and vulnerability to climate change in Central Asia: implications for food security and health" (Janes, 2010), which was identified by Vakulchuk et al., does not study any of the five Central Asian republics in this

review, but rather limits its research to Mongolia. Another, Bhuiyan and Khan (2011), titled "Climate change and its impacts on older adults' health in Kazakhstan," relied on self-reported data from 60 adults in Almaty, 40% of whom were under the age of 50. The authors did acknowledge these limitations in the discussion section of their article, writing "First, the field study of this research was conducted only in five micro-districts in the Almaty region among 16 oblasts (regions) in Kazakhstan; therefore, the empirical results presented here are not representative but indicative in nature. Second, the respondents were asked subjective questions to understand their awareness of the effects of climate change and its impact on health without knowing whether or not the respondents had been suffering from the climatic diseases; more accurate and objective answers would have been recorded if the survey was conducted only among those people who had been affected by climatic health trauma. (Bhuiyan and Khan, 2011: 113).

In another case, a study summarized was not possible to analyze, as only the conference summary proceedings were published. Belov and Filipchenko (2013) described a study they had developed in conjunction with a joint WHO-Ministry of Health project supported by the German Ministry of Environment, Nature Protection, and Nuclear Safety. The summary describes the study as covering climate factors in morbidity and mortality of residents in Bishkek and the Chuy Valley. The study found "Significant associations between incidence and mortality of residents of Bishkek for different classes of diseases in relation to weather conditions, at a more significant level for advanced and senile age were revealed. An increase in the incidence of cardiac and cerebro-vascular diseases is predicted." However, the original study data are not provided, and it is not clear how the study controlled for other factors.

5.2. Country Reporting to the UNFCCC

Country reporting to the UNFCCC in the form of National Communications (NCs) has provided analysis of health and climate change for countries in Central Asia, but these documents are often overlooked. Health and climate change information tends to be included in discrete sections under the prescribed chapter on impacts, vulnerability, and adaptation; however, additional information relevant to human health, such as data on wildfires, floods, mudslides, and glacial lake outburst floods may appear elsewhere. Occasionally health- and healthcare-related information is provided with information on mitigation; education, training, and public awareness; and research.

Kazakhstan has produced five NCs. Its initial NC mentioned the relationship between climate change and health in its description of national circumstances, although specific health data were not provided. Heat stress, infectious disease, and sub-national differences were already identified: "Possible influence of climate

change on human health can be negative because of strengthening heat stress, especially in southern areas, and distribution of many kinds of diseases as well." (RK, 1998: 31). The initial NC also noted that education and public awareness programs could decrease negative health impacts of climate change (RK, 1998: 69). The second NC expanded health coverage in its vulnerability assessment, it and covered a broad variety of health impacts. It also identified vulnerable groups and regions. The 3rd-6th NC (submitted as a single report as Kazakhstan shifted its reporting status under the UNFCCC), summarized a vulnerability assessment that had been carried out for the public health system as part of the compilation of the NC, which identified groups vulnerable to health impacts (MEP, 2013: 23).

The 8th NC reports on health impacts of floods and notes the health impacts of displacement. (MEGNR, 2022: 296). The 8th NC also provides findings from studies cited in the vulnerability assessment. For example, a study for Astana in 2012 an increase in death by suicide and drowning associated with a temperature increase (incidence not known). (MEGNR, 2022: 296). Other studies related to ambulance calls in Nur Sultan, self-reported changes in blood pressure.: and average temperature and coronary heart disease and an inverse relationship between temperature and acute bronchial asthma. (MEGNR, 2022: 300-301; 304; 306). Kazakhstan is the only country in this sample to mention mental illness, stating that "People with mental illnesses and those taking medications to treat various mental disorders, such as depression, anxiety, and other mood disorders, are particularly vulnerable to extreme weather events. Severe heat, as a rule, aggravates existing mental illnesses (impaired mood, increased anxiety, emerging aggression, more intense hallucinations in patients with schizophrenia, dementia, organic brain lesions). As a result, suicides tend to rise during periods of intense heat (MEGNR, 2022: 312).

Finally, the 8th NC notes limitations in research, such as the fact that moribidity and mortality data from institutions are only submitted annually. (MEGNR, 2022: 315). They suggest prospective data collection in cooperation with provincial governments, citing an older study on temperature and strokes (Erkebaevna et al., 2011). They also acknowledge issues with confounding bias, stating "At the moment, it is possible to observe higher incidence of diseases, the occurrence and exacerbation of which may be associated with climate change, but it is difficult to confirm such relationship because the development of diseases can also be influenced by living in an ecologically unfavorable area, harmful habits, heredity, non-participation in existing screening medical programs, remoteness from healthcare institutions, or vice versa, improved quality and accessibility of medical care enable better diagnostics, and, accordingly, increase the number of cases of newly detected diseases." (MEGNR, 2022: 315).

Kyrgyzstan has produced three NCs and submitted its first NC in 2003, which contained a discussion of health in the vulnerability assessment (MEE, 2003: 16).

The communication contains information on emergency room admissions in summer months and a discussion of temperature increase and its impacts. It also recommends measures to adapt to climate change.

In the second NC, health is identified as a priority sector for adaptation. Discussion of health focuses largely on modeling impacts and vulnerability for population health, including chronic disease incidence. The report models climate-related hazards for the Central, South and North regions of the country. The second NC also provides recommendations on adaptation to climate change in the health sector, including expanding research on adverse health impacts, developing a climate and health research plan, increasing public awareness, and providing training for health professionals. (KR, 2009: 24-5). The second NC developed its vulnerability assessment from statistic from sources including the Republican Medical-Information Centre (RMIC); the Department of State Sanitary and Epidemiologic Control, the Ministry of Health (DSSEC); the Center of State Sanitary and Epidemiologic Control (c. Bishkek, Ton and Jety-Oguz rayons of Issyk-Kul oblast (CSSEC); the National Center of Oncology, Kyrgyz Republic Ministry of Health (NCO), the Research and Production Association 'Preventive Medicine,' the Ministry of Health (RPAPM); and the Republic National Statistical Committee (NSC). The second NC mentions lack of data as a problem for the vulnerability assessment, and the discussion of health statistics notes that "Analysis of the data on acute intestinal infections and blood circulation system diseases did not consider the gender aspect" (KR, 2009: 142). The third NC presents climate-sensitive health information, including climate hazards in mountain regions, vector-borne illness (malaria and tic-borne encephalitis) (KR, 2016: 22-3).

Tajikstan has submitted four NCs, with its first in 2002. Its first NC addressed threats to human health and noted that "Alterations in the hydrological cycle will lead to water shortage and an increase of water temperature in the rivers. This fact will favor to the formation of potential choleric and malaria water reservoirs, especially in lower reaches of Syrdarya, Vakhsh, Kafirnigan and Pyanj rivers." (RT, 2002: 16). It also identifies the Kurgan-Tube district of the Khatlon province as particularly vulnerable to heat stress with its effects on health and labor productivity (RT, 2002: 76). It also identifies key themes, such as increased vulnerability to climate experienced by low-income people, the need for improved public health surveillance, the need for further study on climate and health, the need for awareness raising and capacity building in the health sector, and the potential for adaptation measures to "decrease or prevent severe effects of climate change and provide common preparedness" (RT, 2002: 18; 21). The initial NC also provides historical analysis of temperature and malaria incidence in Tajikistan from 1935 to 1995 (RT, 2002: 76). The third NC assesses temperature and reproductive health and reported health risks to pregnant women and infants when the temperature exceeded +37°C, which

is a frequent occurrence in parts of the country (GRT, 2014: 12). The third NC also identified health co-benefits of mitigation in the waste sector.

The fourth NC confirms previous topics and reiterates that the most powerful determinant of vulnerability to health risks associated with climate change appears to be poverty (GRT, 2022: 93). It also puts forward long-term adaptation priorities determined on basis of policy docs, expert review, and consultations, and it reports on education activities, such as a series of lectures for students on human adaptation to climate change and health aspects of climate change, which were delivered in 2000-2012 at the Public Health Faculty of Tajik State Medical University. (GRT, 2022: 134.). Furthermore, the fourth NC identifies co-benefits of mitigation projects that it presents, such as the activities of two NGOs, noting, "The use of energy-efficient stoves and improved insulation of houses enabled a 30% reduction in the consumption of firewood and coal, which, in addition to benefits for the climate system, also lowers the impact of emissions from burning fuel and biomass in or near the premises on the health of the local communities. (GRT, 2022: 137). The fourth NC also describes a microcredit program to improve the efficiency of heating and cooking systems designed to reduce risks to households. (GRT, 2022: 138.)

Turkmenistan has produced three NCs, beginning with its initial NC in 2000. Treatment of health and climate change is brief, although heat stress and water availability are identified as serious issues for the country (MNP, 2000: 37, 38). The second NC mentions the mentions the adverse health impacts of the oil and gas industry (MNP 2010: 18). Some published literature is cited, although very little is related to climate change and health in a way that is specific to Turkmenistan. However, literature cited does reflect a long-standing tradition of research of heat and arid climate on human health, including occupation health, with a number of publications from the 1980s and 1990s cited in the bibliography. The second NC outlines challenges for specialists in the field of medical climatology in Turkmenistan, including the assessment of health impacts of high temperatures in different regions of the country, the identification of populations at high risk of climate-related health problems, the development of prevention programs, the development of climate-sensitive working conditions in the arid region of the country, and the creation of a database on climate change impacts on human health and subsequent preventive measures. (MNP, 2010: 60).

In the third NC, health is identified as a priority sector for adaptation, but the discussion of health and the healthcare sector is very general and not linked to climate, although there is some information on climate-related elements of national health policy. The bibliography repeats some of the same sources from the 1980s and 1990s on heat and health that were cited in the third NC.

Uzbekistan has submitted three NCs and submitted its first report to the UNFCCC in 1999. The Ministry of Public Health was a member of the national climate change commission that oversaw the first NC. Modeling in the second NC up to 2050 examined thermal discomfort and stress, cerebrovascular diseases, acute intestinal infection, the incidence of leishmaniasis and melanoma incidence, and the frequency and severity of climate hazards. (Uzhydromet, 2008: 108-9). Modeling runs indicated an unfavorable heat wave index for entire territory but with uneven increases depending on region (Uzhydromet, 2008: 110). That report also included an overview with key climate-related threats (heat related diseases, cardiovascular diseases, infectious diseases, malaria, and leishmaniasis) and corresponding recommendations for adaptive measures (Uzhydromet, 2008: 112). The findings and approach of the third NC are very similar to those of the second. Mudflows and GLOFs are mentioned, but not in the health section of the reporting. The report includes a survey of 4,000 people in two provinces on self-reported symptoms related to climate or meteorological conditions, including aggravation of chronic cardiovascular conditions, reduced ability to work, with 50% reporting overheating or sunstroke. (Uzhydromet 2016: 139). It includes a brief collection of secondary sources on climate-related health research, including several articles on cerebrovascular disease, and it reports on training for medical practitioners (Uzhydromet, 2016: 139; 142). Recommended adaptation actions are divided into those that prevent health risks (e.g. EWS, supply of clean drinking water), health monitoring, and studies of climate change risks such as heat for different segments of the population (Uzhydromet, 2016: 158). Finally, the third NC reports on a mitigation/adaptation demonstration project for health care facilities in the Aral Sea region (Uzhydromet, 2016: 139).

Table II provides an overview of topics that have appeared in national communications by country and communication. Numbering in the table refers to the number of the country's national communication in which the topic is mentioned.

Table II. Overview of health topics reported in National Communications in Central Asia, by country (n=5) and report (n=18)

Country	Infectious Disease	Chronic Disease, Heat Stress, Malnutrition, Wildfire	Mental Health	Other Climate-related hazards (mudslides, avalanches, GLOFs)	Other (Mitigation, Public Awareness, CCA and CCM measures)	Vulnerable Groups	Vulnerable Regions
Kazakhstan	General diseases (NC1) Vector-borne illnesses (NC2, NC3-6, NC8) Water-borne illness, water quality (NC2, NC3-6, NC8)	Heat stress (All NCs) heat stroke, burns, (NC2) Water accidents (drowning) (NC2, NC8) Cardiovascular disease (NC2, NC3-6, NC8) Allergies (NC3-6), asthma (NC8) Forest and steppe fires (NC2, NC8)	Death by suicide increase associated with temperature increase (NC8) Impact of extreme heat on chronic mental health conditions (NC8)	Floods, mudflows, landslides (NC2, NC 3-6, NC7, NC8) Icy road conditions due to warm days in winter (NC8) Extreme storms, blizzards, snowdrifts in ski areas (NC8) Unintended injuries (NC8)	Recommends improved public health monitoring, disease control (NC2) Healthcare waste incineration (NC3)	Children (NC2, NC 8) Older people (NC2, NC8) People with pre-existing health conditions (NC2) Rural residents (NC3-6) Urban residents (NC8) Outdoor workers (NC8)	Southern Kazakhstan (NC1, NC2) Aral Sea (NC2) Cities with high levels of air pollution (NC2) Kyzlordinsk Region (NC2) piedmont regions (NC2) Mountain regions (NC8)

Table II. cont.

Krygyzstan	Vector-borne illness (All NCs) Waterborne illness (NC1, NC3)	Heat stress (NC1) Cardiovascular disease (NC1, NC3) Kidney stones (NC1) Malignant neoplasms (NC2) Respiratory disease (NC3)		Mudflows, GLOFs, avalanches (NC2, NC3) Severe wind (NC3)	Reported teaching materials on climate and health (NC1) Health is a priority sector for CCA (NC1) Recommended adaptive measures (research on health impacts, public awareness, education and training) (NC2)	Pregnant women (NC1)	Regional differences in project cardio-vascular impacts (NC2) People living near waterways (NC2) Mountainous areas (NC3) Malaria outbreak risk regions (NC3)
Tajikistan	Vector-borne illness (NC1, NC2) Water-borne illness (NC1, NC2, NC3)	Heat stress (NC1, NC2) Cardiovascular disease (NC1) Respiratory disease (NC1) Low birthweight (NC1) Malnutrition (NC4)		Flooding, droughts as a source of water-borne illness (NC2)	Recommended adaptive measures: research on health impacts (NC1) research on malnutrition (NC2) Public awareness, education and training (NC1, NC4) Calls for improvements in maternal and child health care (NC2) Co-benefits from mitigation measures (NC4)	Low-income population (NC1, NC4) Children and older people (NC2) Pregnant women (NC2, NC3)	Lower reaches of Syrdarya, Vakhsh, Kafirnigan and Pyanj rivers (NC1) Mountain population (NC1) Urban population—Dushanbe, Kurgan-Tube (NC1) Rural population (NC1)

Table II. cont.

Turkmenistan	Diseases (not specified) (NC1) Water-borne illnesses (NC2) Vector-borne illnesses (NC2)	Heat stress (NC1, NC2) Nutritional disorders (NC2)	Neuropsychic conditions, unspecified (NC2)	Drought (NC1)	Mentions that CCA and CCM measures will generate health benefits (NC1) Mentions adverse health impacts of the oil and gas industry (NC2) Mentions climate/health needs, including a health impacts database (NC2) Notes mainstreaming of climate into health policy. (NC3) Calls for research on CC and health (NC3)	People with neurocirculatory dystonia (NC2)	Aral Sea region (NC1)
Uzbekistan	Vector-borne illness (NC1, NC2) Water-borne illness (NC1, NC2)	Heat stress (NC1, NC2) Melanoma (NC1)		Mudflows, floods, avalanches (NC1, NC3)	Climate-health project with training for doctors reported (NC3) Calls for medical early warning systems, territorial action plans, training, public awareness and studies (NC3)		Central desert territories, Aral Sea basin, and Kashkadarya and Surkhandarya provinces (NC1) Older people (NC3) People with chronic cardiovascular conditions (NC3)

5.3. Analytical reports by UN agencies and other multilateral organizations

While reports on environment in Central Asia have been produced since multilateral donors became active in the region in the early 1990s, a rise in donor interest in climate change adaptation that emerged with the 2007/8 Human Development Report, Fighting Climate Change: Human Solidarity in a Divided World (UNDP, 2008) and the World Bank report Adapting to Climate Change in Europe and Central Asia (World Bank, 2009) led to the beginning of "mainstreaming" climate into development work and environmental reporting in the region.

The Environment and Security initiative (ENVSEC) of OSCE, which produces climate change and security regional assessments. The 2017 report considers vulnerability and "security implications and risks related to climate change." They note that four sub-regions: high mountain areas, remote areas on the Afghan border, the Syr Darya River basin, and the Aral Sea and coastline were areas of human health insecurity, which could exacerbate climate risks. (Novikov and Kelly, 2017: 46, 47, 49).

The 2023 ENVSEC report notes that earlier that year, "adverse winter conditions across Central Asia, including the coldest temperatures ever recorded in the region, had severe impacts on the countries' infrastructure and economy (with gas, electricity, and water supply outages, and major roads blocked by snow), as well as on people's livelihoods and health (as some households resorted to burning waste to fuel their stoves, a practice that causes severe air pollution)" (Imanaliyeva, 2023 in Mosello 2023: 14). The report also notes the "severe environmental and health impacts" of the continued use of coal in the region (OSCE, 2022 in Mosello, 2023: 15).

A recent report that addresses Central Asia as a region, albeit as of two regions, is an 2023 IMF assessment, Feeling the heat: adapting to climate change in the Middle East and Central Asia (Duenwald et al., 2023). The report describes dual factors of high exposure, such as in land-degraded areas or close to rivers and snowmelt flows, aggravated by dependence on rain-fed agriculture; and high vulnerability, marked by "inadequate infrastructure and investment," including in the healthcare sector (Duenwald et al., 2023: 12). The report also notes that employment levels of women and youth in the regions are low and could be disproportionally affected by climate change. Duenwald et al., 2003: 29-30).

For specific countries, UNECE environmental performance reviews provide reporting with information compiled by multidisciplinary teams. The 3rd Environmental performance review for Kazakhstan, which was conducted in 2019, did not mention health information related to climate change adaptation, but it found that an increase in moribity from non-communicable disease in children may be linked to environmental quality. (UNECE, 2019: xli). It also provided information on mitigation in the healthcare sector, noting that "Medical institutions are a

significant consumer of energy, and the reduction of their energy consumption is a policy priority. However, actions to improve the energy efficiency of the health sector are not funded through the national programmes. In the majority of cases, the replacement of equipment is done through international projects or using hospitals' own budgets." (UNECE, 2019: xli).

The 3rd Environmental Performance Review of Uzbekistan specifically mentions the health hazards related to climate change, noting that "Owing to intense precipitation and increase in temperature in the mountainous areas in March-April, snow avalanche hazards occur, threatening the lives and livelihoods of the population…. The high-risk areas are located in Tashkent, Namangan, Kashkadarya and Sukhandarya Oblasts" (UNECE, 2020: 355). The review also provides health statistics and data for the Aral Sea region.

As good practice, these reports may mention data-related challenges, as the authors of the Third Environmental Performance Report for Uzbekistan did. When reporting on a variety of chronic diseases in the Aral Sea regional, and they also noted, "Even if the routinely reported morbidity data have limitations for assessment of the population's health status in the Aral Sea Region, very limited statistics were published but they are rather difficult to access, especially at the subnational level" (UNECE, 2020: 369).

6. Other Sources of Information

In addition to country reporting and international environmental reviews, there are several other types of information in Central Asia on climate change: donor-funded project reports and evaluations; press releases and articles in the popular press; national policies and strategies; and non-print sources (video and film).

6.1. Donor-funded project reports and evaluations

While project reports and evaluations may also be drafted or published by international organizations, they differ from analytical reports described in the previous section of this article. The purpose of reporting is generally not related to research to advance the general state of knowledge, and but rather research in support of a technical assistance project or an evaluation of its performance and/or impact. For example, a project evaluation of the WHO-UNDP project "Piloting Climate Change Adaptation to Protect Human Health" in Uzbekistan, a program that was unique in the region, was thoroughly summarized in a terminal evaluation that is available through UNDP's Evaluation Resource Center (Ebi, 2015).

Many climate change projects and many health projects have associated project documentation. Two reports, which are not necessarily typical, are good

examples of relevant contributions. One is a brochure describing a climate change mitigation and adaptation project in the health care sector of Uzbekistan (UNDP). That project piloted energy efficiency and renewable energy measures in four rural health clinics in the Republic of Karakalpakstan. Project documentation also provides insight into policies and programs that are under development, such as the proposal for support from the Green Climate Fund for the National Adaptation Plan for Kyrgyzstan; a readiness proposal to the GCF provides an overview of the scope of the plan and its intended content (GCF, 2020).

6.2.Press releases and blogs and articles on websites and in the popular press

Popular coverage of climate change and health in the region, while plentiful, is difficult to characterize. It varies widely across the region, ranging from NGO websites to press releases from international organizations and articles in national and regional news outlets. The following examples, which are not necessarily typical, are good examples of relevant contributions. One press release that touches on both climate change adaptation and health is an article covering UNICEF's children's climate risk index, entitled "Children in Kyrgyzstan at 'high risk' of the impacts of the climate crisis." (UNICEF, 2021). Press releases also cover mitigation-related health issues, such as "Changing the primary energy use for 26% of the urban population will help Bishkek to combat air pollution," a UNICEF press release (UNICEF, 2022).

In the case of web portals, information may be curated, such as the Central Asia Climate Portal, which has a health topic section (CAREC, 2024). Finally, these sources of information can give an indication of draft policies or strategies that may be under development but are not available publicly. One example of this is the draft Heat Health Strategy for Turkmenistan (Altyn Asyr, 2021).

6.3.National policies and strategies

Countries in Central Asia have enacted a variety of policies and programs that directly and indirectly address climate change and health. These include national development strategies, climate change strategies, adaptation strategies, and health strategies. These include the Concept of Kazakhstan on Transition to a Green Economy (2013), the National Strategy of Adaptation to Climate Change of the Republic of Tajikistan for the period till 2030 (2019), the National Strategy on Climate Change 2030 of Turkmenistan (2019), and the Strategy for the transition of the republic to a "green" economy for the period 2019-2030 for Uzbekistan (2019).

There are also a few selected examples of policies and programs that explicitly address both climate and health.

• The Government of Kyrgyzstan introduced a national program for climate change adaptation in the health sector for 2011-2015 (Belov and Filipchenko, 2013).

The program was developed under a joint project with the European Office of the WHO and a working group at the Ministry of Health. It was designed to protect human health against extreme weather events, including temperature extremes, reduce the threat of food-borne and water-borne illness, to reduce the impacts of climate-related natural disasters, to improve the public health system, to strengthen the capacity of healthcare providers, to increase public awareness, and to strengthen the role of local communities to address climate threats. The policy also included mitigation targets, such as adopting alternative energy technologies and resources in the healthcare sector.

• Tajikistan also adopted (as of 2017) a national climate change and health strategy (Novikov and Kelly, 2017: 23). In addition, the Medium-term Development Program of the Republic of Tajikistan for 2021-2025 includes specific tasks and indicators related to the gender aspects of climate change (Section 5.8.), and the program includes gender-sensitive indicators for health and will establish them for disaster risk management (GRT, 2022).

• The state program “Health” in Turkmenistan for 2015-2025 includes measures to prevent and reduce climate impacts on human health, such as raising awareness of the public, health professionals, and policy makers on climate impacts; strengthening the health system, and research related to health and climate change. (TUK NC3: 69). Turkmenistan also has a National Action Plan for the Adaptation of the Health of Turkmenistan’s Population to Climate Change and its Negative Impact for 2020-2025, and a donor-funded project is supporting the development of a Heat Health Strategy for Turkmenistan (Altyn Asyr, 2021).

6.4. Non-print sources

While the review of non-print sources is not neither systematic nor comprehensive, a YouTube search was conducted for English-language video material [“climate change” “health” “Central Asia”], which yielded 6 results, and for Russian-language video material, a similar query ["изменение климата" "здоровье" "в Центральной Азии"] yielded 6 results, which were distinct from the English-language results. Similar searches on Vimeo yielded no results. A YouTube search for country-specific material yielded thousands of videos that ranged from news programs to awareness-raising videos related to climate change and its impacts; a complete examination was beyond the scope of this report.

The 2009 film Pamiri women and the melting glaciers of Tajikistan (Goluvnev 2009) featured several women discussing the effects of climate variability and climate change on their daily lives. Health is mentioned in relation to reported effects of temperature extremes. Another film from the same series shows mountain community members collecting scrub bushes due to reduced water level and

subsequent hydropower shortages and burning that biomass in cookstoves (Patrón, 2009), which is identified in the literature as a source of poor air quality.

Videos may also provide an opportunity to present information collection and analysis in donor-funded climate policy projects. For example, a webinar was organized to discuss the methodology behind the health research that informed the country's updated Nationally Determined Contribution (NDC) under the Paris Agreement (Climate Learning Portal, 2022).

More recently, a video virtual panel on climate and women's well-being in Tajikistan described the stress that compounds health issues for women in Tajikistan who are overseeing farms and households due to men's labor migration (Pulatova , 2023). The discussion notes additional burden of climate change on collecting cooking fuel and water, particularly for women, which is mentioned in only one other source covered in this article, and remarks also discuss breastfeeding and temperature extremes and identify women as agents of climate change adaptation. (Abt Global , 2023). These are views are not included in the printed literature surveyed.

7. Discussion

Peer-reviewed literature. Peer-reviewed research on climate change and health in Central Asia is rare, and the existing literature has serious limitations that do not merit the development of an evidence table. These limitations include confounding bias and limited sample size. The literature search did not identify research findings relevant to advancing the understanding of relationships between climate change and health, although there were sources (Kaimuldinova and Abdimanapov, 2013; Isaev et al., 2022) that provided data that could be used in observational studies moving forward.

Country reporting to the UNFCCC. The NCs reviewed reflected the output of multiple researchers and were validated by working groups and subsequently by their respective country governments. When compared to the major topics presented for health and human well-being by the IPCC's 6th Assessment Report, information in the region from NCs focused primarily on infectious diseases and heat. Other topics identified in the IPCC reports (malnutrition, harm from wildfire, mental health, and displacement) were mentioned on infrequently. That said, a variety of resources consulted emphasized climate-related hazards significant to the region such as floods, mudslides, and GLOFs. Table II provides an overview of the incidence of climate and health topics that appeared. As the table indicates, health was mentioned predominantly in the context of adaptation, although there were instances where mitigation was mentioned in individual NCs.

Analytical reports by UN agencies and other multilateral donors. These reports by nature were focused on the synthesis of existing data, but they represented positive contributions to regional understanding of health and climate by using a systematic approach to documenting different levels of exposure to health/climate threats, be it by vulnerable group or sub-region. Certain reports (UNECE, 2020) also documented data limitations, an acknowledgement that was unusual for both peer-reviewed and non-peer-reviewed sources.

Donor-funded reports and evaluations. This large source of potential information is not often used by the research community. There were examples of project activities supported research on health and climate change, such as in Uzbekistan, where preparatory studies indicated “strong evidence that climate-sensitive diseases exert a large health toll” and project studies addressed cardiovascular disease, diarrheal disease, respiratory illness, and health effects from dust storms, each of which “showed high sensitivity to climate variability.” (Ebi, 2015: 19). This type of source also addressed mitigation-related health topics, which are less common generally (UNDP undated).

National policies and strategies: "Climate may or may not be mainstreamed into health strategies and vice versa. Many strategies are accompanied by a governmental action plan that assigns a budget and responsibilities for the various activities proposed. These policies do not cite supporting research directly, but they are at times accompanied action plans, which mention specific steps, and they identify priority areas for government activity. Certain policies account for gender differences in vulnerability" (Belov and Filipchenko, 2013).

Non print sources (video): "Non-print sources have been able to provide first-hand documentation of the experience of climate change in the region for some time, and they include instances of documentation of health effects by those directly affected" (Goluvnev, 2009; Abt Global, 2023). Videos also provide an opportunity to present information collection and analysis in donor-funded climate policy projects, such as in the presentation on the climate and health research that contributed to the updated NDC of Kazakhstan, which reiterated and expanded on climate threats to human health reported in the country’s NCs (Climate Learning Portal, 2022).

To summarize non-peer-review sources of information, Table III presents an overview of their advantages and disadvantages as sources of information on climate change and health in Central Asia.

Table III. Advantages and Disadvantages of Sources of Climate and Health Information for Central Asia

Type of Source	Advantages	Disadvantages
National communications to the UNFCCC	Overview of in-country thinking related to climate change and health over time (the first NC in the region was submitted in 1998, and the most recent was in 2022). Useful point of departure for additional research. Sections on impacts and adaptation are often compiled by senior researchers in their fields. They include citations and/or bibliographies. They are significant, as country reporting is often used as a reference point by multilateral climate funds when determining whether proposals for projects reflect national priorities.	Lack of access to supporting research. The limited research commissioned for the NCs on climate change and health is not generally published in full, and it may not reach a peer-review or grey literature audience. This practice represents a lost opportunity. Incomplete source citations. NCs may not distinguish between published research and expert judgment, and statements in them may not be clearly labeled as one or the other. Research may be relatively old (the oldest citation noted was from the 1970s), and published resources cited may not have been digitized. Confounding bias. NCs show repeated instances of presenting negative health data against the backdrop of climate change without controlling for other socio-economic factors in the region. While approach is understandable given the lack of targeted studies, the limitations are not always clearly stated, and they do not support conclusions on these relationships.
Analytical reports by UN agencies and multilateral organizations	Frequently edited and reviewed by the agencies that fund them. May contain helpful information on topics that are directly or indirectly related to climate change and health impacts, and they provide some discussion on mitigation. May draw attention to policies, measures, and statistics and analysis that might be otherwise overlooked. May note challenges in data collection and analysis.	Information may be incidental, as the focus of broader environmental reports is not necessarily on climate change. May lack empirical data for climate and health, may lack supporting research, may be subject to confounding bias.

Table III. Cont.

Donor-funded project reports and evaluations	May provide information on good practice that is not available elsewhere. May provide insight into policies and programs that are under development. , such as the proposal for support from the Green Climate Fund for the National Adaptation Plan for Kyrgyzstan; the readiness proposal to the GCF provides an overview of the scope of the plan and its intended content (GCF 2020). In addition, project evaluations can be detailed and may include community information and interviews with community members, which are not common in country reporting.	Reporting may be old when there are few documented interventions, and publication dates may not be provided on project literature. Scope issues: Evaluations and reports for projects in the region seldom have the scope and budget to determine a significant correlation between climate change and changes in health. Limitations are not necessarily mentioned. Objectivity issues: For materials that are written in-house, review procedures vary widely. Evaluations may or may not involve an external, independent evaluator. For reports other than evaluations, lists of sources and references may not be provided.
Press releases and articles in the popular press	May catalogue demonstrated adaptation and mitigation measures and provide learning. May give an indication of potential research directions and some indication of public interest in topics related to health and climate change that have not yet been addressed formally. In the case of web portals, may provide a curated source of information. May give an indication of draft policies or strategies that may be under development but are not available publicly.	These sources of information do not provide research findings.
National policies and strategies	The underlying analysis that has informed policy development is not generally available publicly. Furthermore, performance monitoring of the action plans that often accompany policies and strategies in the region is not available publicly. This can make it difficult to track implementation / enforcement, and therefore difficult to ascertain relationships between policy implementation and health outcomes, even when the relevant morbidity and mortality data are available. Researchers have also drawn attention to the limited ability of governments in the Central Asian republics to monitor and assess the effectiveness of adaptation measures in laws and regulations (Liu et al., 2020: 1449). Furthermore, national climate change policies and strategies may not explicitly mention health measures.	Reviews of policies and strategies may provide an indication of national priorities, and there may be some available underlying data and analysis that could also guide further research. The few policies that relate directly to climate and health may also serve inspiration as other country policies and strategies are updated and introduced.

Table III. cont.

Non-print sources (video and film)	The visual element of these resources conveys messaging in a different way and can provide visual documentation of certain phenonomena, complementing printed or electronic literature. May identify issues that could benefit from further study. May introduce voices that are not directly represented in other literature, such as women in rural areas.	Funded content or institutional affiliations may raise issues with objectivity May be limited in scope or overly general if directed towards a public audience. Livestreamed discussions at regional conferences and meetings are not necessarily archived.

7.1. Strengths and limitations of the approach taken

Expanding to Russian-language sources increased the available citations, and moving to grey literature and non-print resources has expanded previous estimates of climate-health literature (Vakulchuk, 2023) significantly.

The approach was limited by the availability of source material. It is difficult to draw conclusions or establish association between climate and other factors given the primary research available, which often consists of conceptual statements or observational study designs with serious challenges to validity. In addition, this review did not consider publications or video in languages other than English and Russian, which is a limitation in the five countries studied. The exclusion of non-digitized print literature may have also limited the yield of sources, as some materials, particularly older work and academic publications such as theses may not be available in digital format in the region.

The following recommendations are provided for future study:

• Promote regional scholarship drawing on donor-funded projects and reports with a view to publishing findings related to development interventions. These interventions provide an opportunity to assess the health benefits of climate change mitigation and adaptation measures. Government initiatives, such as reporting under the UNFCCC and Paris Agreement and health and climate policy action planning, also provide opportunities to evaluate the efficacy of climate/health policies and measures

• Consider some of the traditional areas of regional literature as a starting point for future research. These disciplines include climate medicine, mountain health and communities, and occupational health research in hot climates. In addition, ongoing research on climate change mitigation may also serve as a foundation for the analysis of health-related benefits of mitigation measures. Countries should also consider pooling research efforts across countries; current cooperation on the high-mountain cryosphere and regional studies on air pollution are two examples of ongoing efforts.

• For study design in areas of high interest for countries (heat-related morbidity and mortality, infectious disease, and cardiovascular disease), control for factors other than climatic conditions to the extent possible and state study limitations clearly.

• Consider the heterogeneity of vulnerable populations when designing research studies. Groups that have been identified in previous research include children, older people, women, pregnant women, people with existing chronic health conditions, rural residents, urban residents, low-income groups, high-mountain communities, areas with severe ecological problems (the Aral Sea region), and areas with low health security or other factors contributing to low adaptive capacity.

8. Conclusions

While peer-reviewed literature on climate change and health in Central Asia is sparse, there are also a variety of additional sources of information that reflect more than two decades of data collection, analysis, and scholarly effort on the part of many individuals to move the state of knowledge forward in this area. Grey literature is broader and richer than previously depicted in reviews of climate change literature in the region, and this review attempts to summarize and appraise those efforts.

This review finds that both peer-reviewed and grey literature on this topic must be used with caution. That said, grey literature has a variety of contributions to make to the evolving understanding of climate change and health in Central Asia. Topics also varied in different types of grey literature, with media resources providing unique perspectives on the intersection between health, climate, and gender.

Research and understanding of climate change and health in Central Asia is at a well-developed state conceptually, with supporting work on vulnerability, but there is a lack of evidence-based analysis. The next step in a causal inquiry is more rigorous study that goes beyond anecdotal or general associative relationships between climate variability and chronic and acute morbidity and mortality. In short, there is an urgent need for observational studies that will confirm and increase understanding of climate-health interactions in the region. Governments should also support this research in support of the policies they are currently developing and the reports they submit as parties to the UNFCCC and Paris Agreement, and they should draw on existing research to identify vulnerable sub-regions and groups that may face disproportionate climate-related health risks.

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Determinants of household energy use in the Fergana Valley

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ABSTRACT

In July-August, 2023, CAREC Institute, Public Opinion Research Institute, and Asian Development Bank Institute conducted a sociological survey on household energy use in the Fergana Valley spanning over the Kyrgyz Republic, Tajikistan, and Uzbekistan. The following article uses the data from that survey for investigating what determines the choice of different energy types for heating. The article concludes that high household expenditures for coal and high awareness of the harm fossil fuels can inflict on the environment and family health are insufficient to trigger a large-scale shift towards cleaner energy. To motivate households for such a shift a substantial increase in fossil fuel prices compared to electricity and other clean energy is required. This might call for a sales tax on coal. However, energy expenditure already accounts for up to one-third of household income. Low- and middle-income households would need to be compensated for increased energy spending to avoid social hardship and a backlash against such a tax.

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1. Introduction[1]

The following article examines one of the aspects of energy transition – households' access to energy and energy use habits. To know these habits is crucial for designing policies and incentives promoting the adoption of sustainable heating technologies, as well as for accelerating the transition to a low-carbon heating, cooling, and cooking environment.

The project region was the Fergana Valley, which spans over parts of the Kyrgyz Republic, Tajikistan and Uzbekistan. Geographically, it is a relatively compact area shared by three different countries. It thus provides a good opportunity to study the differences and similarities of energy use by households living under three different legislations and three different power supply systems.

The main survey topics were related to the ones generally mentioned in the literature, i.e. energy poverty, affordability and reliability of energy supply, etc. The impacts of various energy sources on health were likewise investigated during the research. Numerous studies have documented the health risks associated with traditional cooking fuels such as biomass and coal, including respiratory illnesses, cardiovascular diseases, and indoor air pollution related deaths.

Household energy access is not least determined by socio-economic characteristics such as income level, education, gender, and employment. In turn, improved energy access can enhance productivity, enable income-generating activities, and alleviate poverty. At the same time, demographic characteristics influence the readiness to transit to new ways of energy use.

A considerable body of literature focuses on technological interventions to improve household energy access. This includes better access to electricity distributed via the grid, off-grid electrification solutions such as solar home systems, microgrids etc., and the adoption of cleaner cooking technologies, including improved cook stoves, biogas digesters, solar cookers and the like. A range of studies evaluates the effectiveness, scalability, and sustainability of these technologies in different contexts. To an extent, the survey also intended to cover these aspects.

Due to the growing concern about climate change and the need to reduce greenhouse gas (GHG) emissions, environmentally friendly heating solutions have become a subject of height-ened interest. Electrifying heating systems and powering them with renewable energy (RE) like wind or solar can drastically reduce GHG emissions associated with heating. However, this approach relies on

[1] This article is based on the data from a project initiated by the Central Asia Regional Economic Cooperation (CAREC) Institute in partnership with the Asian Development Bank Institute (ADBI). The CAREC Institute is an intergovernmental organization of 11 countries, namely Afghanistan, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Mongolia, Pakistan, the People's Republic of China, Tajikistan, Turkmenistan, and Uzbekistan. The survey was organized by the Public Opinion Research Institute, Republic of Kazakhstan (PORI). The project was funded by the Asian Development Bank. The general project report is published at the CAREC Institute's website (https://www.carecinstitute.org/publications/new-research-report-reveals-insights-on-household-access-to-energy-in-the-fergana-valley/).

the decarbonization of the electricity supply to ensure electric heating remains environmentally friendly. The literature now often mentions heat pumps which are still costly but can be highly efficient, particularly in moderate climates, and can utilize RE such as geothermal or air-source heat.

The literature also emphasizes the importance of energy-efficient building design to reduce heating demand. Strategies such as proper insulation, air sealing, and passive solar design can significantly lower heating requirements and improve the total energy performance.

Overall, the literature suggests that a combination of environmentally friendly solutions tailored to local conditions and resources is necessary to achieve significant reductions in GHG emissions while ensuring energy security and affordability.

Another topic in the literature is rural vs. urban dynamics. While rural areas typically face challenges related to infrastructure and poverty, urban ones may struggle with energy affordability, reliability, and pollution.

Examination of the effectiveness of various policy instruments, regulatory frameworks, incentives, etc. in promoting energy access represents a highly important research track. The questionnaire for the Fergana Valley study was developed considering most of the above-mentioned topics discussed in the literature.

1.1. Other recent studies

The findings of the survey on household energy use in the Fergana Valley are very much in line with the results of other recent reported studies.

The factors influencing heating choices include income level, education, and awareness of environmental issues (Bai et al., 2023). Factors influencing energy-related decision-making also include financial considerations, and access to information (Brown et al., 2023). House-hold carbon footprints are influenced by a combination of socio-economic, demographic, and environmental factors (Gao et al., 2024). Demographic characteristics such as household size, type (urban or rural), etc. play a role as well. Cultural norms cannot be neglected either (Mbaka et al., 2019). Consumer attitudes and behavior towards energy consumption play a crucial role in shaping energy demand (Brown et al., 2023). Consumption patterns significantly influence household carbon footprints (Huang et al., 2024).

Another major issue is the availability of energy-efficient technologies (Guo et al., 2023). Access to reliable and affordable energy services is essential for enhancing households' resilience to climate-related challenges (Deng et al., 2023). Energy affordability plays a critical role in households' decision-making regarding clean energy adoption, according to some research results (Li et al., 2023). Rural households are particularly vulnerable to energy price increases due to lower income levels and limited access to alternative energy sources (Nie et al., 2024).

At the same time, environmental awareness and climate change policies matter and have led to changes in energy consumption patterns and reduced CO2 emissions

in Lithuanian house-holds (Jakučionytė-Skodienė et al., 2023). Rural households in China showed willingness to pay more for clean heating options (Bai et al., 2023).

Most of the literature is quite optimistic about the potential of policy interventions to change households' energy behavior, at least in the longer term, and if properly designed. Many articles indicate that policy interventions targeting clean heating adoption in rural areas could be effective in reducing pollution and improving public health (Bai et al., 2023). They also express the opinion that policy measures promoting energy efficiency and RE adoption can contribute to mitigating climate change at the household level (Jakučionytė-Skodienė et al., 2023). Integrated policies that target both energy access and environmental sustainability goals are seen to be able to maximize societal benefits and foster sustainable development (Xin et al., 2024).

Recommendations put forward that policy interventions should aim to influence consumer behavior by providing incentives and promoting awareness of sustainable energy practices (Brown et al., 2023). They should focus on incentivizing low-carbon behaviors and transitioning to renewable energy sources to achieve sustainability goals (Huang et al., 2024). Policies should leverage behavioral insights to design effective incentives and nudges that motivate households to adopt sustainable practices (Caballero et al., 2024).

A substantial role is given to financial incentives to change consumer behavior. Incentives are seen to play a crucial role in motivating household action towards energy efficiency and sustainability (Caballero et al., 2024). Policy interventions should focus on improving energy affordability through targeted subsidies, financing mechanisms, and income generation opportunities (Li et al., 2023).

Tailoring interventions to address the diverse needs and preferences of households according to different demographic and other characteristics is essential for promoting clean energy and sustainability (Mbaka et al., 2019).

Other approaches more strongly emphasize technological preconditions. Policies should focus on promoting energy efficiency and technological solutions (Lingyan Li et al., 2023), address disparities in carbon footprints between urban and rural areas by promoting equitable access to clean energy technologies (Gao et al., 2024). Localized approaches that account for the specific needs are necessary for effective energy planning and resource allocation (Guozhu Li et al., 2016).

1.2. Research question

Based on the survey on household energy access and use in the Fergana Valley, the article strives to answer the question of what determines the choice of energy source in the target region, and what policy recommendations can be derived from this research.

2. Methods and data

The following paragraphs describe the sampling, interviewing methods, and respondent profile.

2.1. Sample

The survey was conducted among the settlement residents in the Kyrgyz Republic (Jalal-Abad, Osh and Batken Regions, and the city of Osh), Tajikistan (Sughd Region) and Uzbekistan (Fergana, Namangan, Andijan Regions) located in or near the Fergana Valley. The respondents were citizens of the countries sharing the Fergana Valley, over 18 years old, heads of households or family members making decisions on financial and household matters. The total of 1,522 interviewees from three countries partook in the survey, among them 763 male and 759 female household heads. In the Kyrgyz Republic, 262 male and 260 female heads of house-holds; in Tajikistan – 245 male and 255 female heads of households; in Uzbekistan – 256 male and 244 female heads of households participated in the survey.

The survey used a special quota of 50:50 for male and female household heads to understand the difference in answers in the gender context. The household members themselves determined the status of the "head" or "member" of the household responsible for making decision on financial and other household issues (buying food, paying for utilities, buying fuel, etc.). Previous studies of households conducted by national and international organizations pointed to a difference in the behavior of men and women in matters regarding financial costs, fuel costs, etc. This study has also revealed gender differences.

Table I. shows the basic survey parameters for the three countries.

Table I. Basic sociological research parameters

Country/ Parameters	Kyrgyz Republic	Tajikistan	Uzbekistan
Survey geography	3 regions and 1 city - Jalal-Abad, Osh, Batke, City of Osh	1 region – Sughd	3 regions - Fergana, Namangan Andijan
Number of respondents	522	500	500
Age of respondents	18 and older	18 and older	18 and older

Table I. Cont.

Number of questions in the questionnaire	62	62	62
Number of socio-demographic parameters	12	12	12
Survey method	face-to-face CAPI	face-to-face CAPI	face-to-face PAPI
Survey language	Kyrgyz, Russian	Tajik, Russian	Uzbek, Russian
Sampling error	+/-4.38 at 95% confidence interval	+/-4.38 at 95% confidence interval	+/-4.38 at 95% confidence interval
Refusal rate	561	44	607

2.2. Interview method

The interviews in all three countries were executed using a single method – face-to-face. In the Kyrgyz Republic and Tajikistan, the interviews were conducted with the help of tablets (Computer-assisted personal interviews, CAPI), and in Uzbekistan a paper questionnaire (Pen and paper personal interviews, PAPI) was used.

2.3. Field work

The survey was held in July-August, 2023, using a single questionnaire that consisted of the main part and a socio-demographic (age, gender, level of education, social status, employment) block.

2.4. Respondent profile

The survey respondents were the heads of households or other family members that were the decision-makers related to energy supply, heating or cooling. The selection of the respondents was carried out according to quotas that made it possible obtaining opinions of men and women in equal proportion, and of respondents of different ages, ethnicity, education, and forms of employment. The questionnaire was answered by 130 urban and 392 rural residents in the Kyrgyz Republic, 137 urban and 363 rural residents in Tajikistan, 290 urban and 210 rural residents in Uzbekistan. Approximately an equal proportion of male and female household heads participated in the survey.

The survey was conducted using interviews with respondents – heads of households or family members who decide on matters related to energy supply, heating or cooling of the house. A total of 1,522 respondents were interviewed:

522 in the Kyrgyz Republic (262 men, 260 women), 500 in Tajikistan (245 men, 255 women), and 500 in Uzbekistan (256 men, 244 women). The survey was conducted in July-August 2023.

Table II. Respondent gender

Answer options	Kyrgyz Republic		Tajikistan		Uzbekistan	
	Q-ty	%	Q-ty	%	Q-ty	%
Men	262	50.2	245	49.0	256	51.2
Women	260	49.8	255	51.0	244	48.8
Total	522	100.0	500	100.0	500	100.0

2.5. Family

The majority of the survey participants had family experience, only 5% of Uzbekistan is, 11.6% of Tajikistanis, and 13.4% residents of the Kyrgyz Republic indicated that they had never been married. 81% of respondents from Uzbekistan, 78.7% of respondents from the Kyrgyz Republic and 72% of respondents from Tajikistan are married. The majority of respondents from the Kyrgyz Republic and Uzbekistan lived in families of 4 to 7 people, including themselves. The majority of respondents from Tajikistan lived in families of 3 to 7 people. On average, the families that took part in the survey in the Kyrgyz Republic had 6 members, in Tajikistan and Uzbekistan – 5 members.

2.6. Employment

The largest share of respondents were housewives (and some housemen) – 149 women and 6 men, i.e. 155 respondents (29.7%) in the Kyrgyz Republic, 109 women (21.8%) in Uzbekistan, and 66 women and 18 men, i.e. 84 respondents (16.8%) in Tajikistan (Table III.). Other relatively large groups that participated in the survey were pensioners (retired), farmers, civil servants, individual entrepreneurs, and private and public sector employees.

Table III. Responses to the question "What is your current employment?"

Answer options	Kyrgyz Republic		Tajikistan		Uzbekistan	
	Q-ty	%	Q-ty	%	Q-ty	%
I work for myself - individual activity (sole proprietorship without hired employees)	32	6.1	61	12.2	23	4.6
I work for myself - an entrepreneur (with hired employees)	9	1.7	40	8.0	21	4.2
Self-employed/do not have an official/ permanent place of work	33	6.3	48	9.6	40	8.0
Private sector employee	47	9.0	53	10.6	18	3.6
Public sector employee	9	1.7	39	7.8	49	9.8
Civil servant	56	10.7	53	10.6	64	12.8
Student	22	4.2	28	5.6	6	1.2
Pensioner (retired)	74	14.2	46	9.2	126	25.2
Housewife/householder	155	29.7	84	16.8	109	21.8
Unemployed	18	3.5	29	5.8	42	8.4
Farmer	67	12.9	10	2.0	2	0.4
Refuse to answer	-	-	9	1.8	-	-
Total	522	100.0	500	100.0	500	100.0

3. Results

3.1. Energy use for heating by type of energy

The main source of energy used by households for heating in the Fergana Valley strongly differed between the target countries. Whereas over 70% of the surveyed households with off-grid heating systems in Tajikistan used electricity, only 13% of households in Uzbekistan and only 6.7% in the Kyrgyz Republic did so (Table IV.).

Table IV. Responses to the question "If you have an off-grid heating system, what energy source do you use to heat your house during the winter season?"

Response options	Kyrgyz Republic		Tajikistan		Uzbekistan	
	N=466		N=500		N=500	
	Q-ty	%	Q-ty	%	Q-ty	%
Hard coal	413	**88.6**	68	13.6	273	**54.6**
Fuel oil/diesel	-	-	2	0.4	3	0.6
Natural gas from underground pipes	2	0.4	-	-	76	15.2
Propane (bottled gas)	-	-	03	0.6	43	8.6
Electricity	31	6.7	351	**70.2**	65	13.0
Biofuel (pressed dung)	5	1.1	10	2.0	1	0.2
Kerosene	-	-	-	-	-	-
Firewood	15	3.2	64	12.8	39	7.8
Solar panels	-	-	-	-	-	-
Waste and garbage (rubber, plastic, paper, etc.)	-	-	2	0.4	-	-
Total	466	100.0	500	100.0	500	100.0

Note: Only respondents with off-grid or mixed heating answered this question.

At the same time almost 55% of households in Uzbekistan and almost 89% of households in the Kyrgyz Republic used coal for heating. In Uzbekistan, gas also played a significant role; and firewood to some extent in all three countries.

An obvious candidate for the explanation of what determines such a choice of energy sources is the relative price of different sources of energy and the resulting household spending for them. Preferences related to different demographic characteristics or different degrees of awareness of the harm fossil fuels can inflict on the environment or family health could also explain the choice of energy type.

When asked directly about their motives for choosing a specific energy source, about one-third of respondents across the three countries of the Fergana Valley indicated the "least financial burden" (Table V.). In the Kyrgyz Republic and Uzbekistan, the reliability of supply and the presence of the existing heating systems were frequent responses as well. In Tajikistan, environmental and health consideration played a larger role than in the other two countries – an explanation could be that "greener" statements are easier to make when already more heating by electricity is in place.

The following parts of the article trace down to what extent the answers to the direct question are in line with the data generated by the survey on current energy use and on plans for change.

Table V. Responses to the question "What guides you in choosing your main heating source?"

Response options	Kyrgyz Republic		Tajikistan		Uzbekistan	
	N=466		N=500		N=500	
	Q-ty	%	Q-ty	%	Q-ty	%
I choose based on the least harm to the environment	2	0.4	158	**31.6**	80	16.0
I choose based on the least harm to the health of my family	51	10.9	130	**26.0**	5	1.0
I choose based on the least financial burden	144	**30.9**	143	**28.6**	175	**35.0**
I choose based on the considerations of uninterruptedness/reliability of energy supply	192	**41.2**	33	6.6	140	**28.0**
Due to the presence of an existing heating system	77	**16.6**	-	-	100	**20.0**
Difficult to answer	-	-	34	6.8	2	0.4
Responses recorded based on respondent statements						
I'm trying to prepare for winter	-	-	1	0.2	-	-
Every year there are electricity issues	-	-	1	0.2	-	-
Total	466	100.0	500	100.0	500	100.0

Note: Only respondents with off-grid or mixed heating answered this question.

3.2. Spending on energy by income

To get a first impression of spending patterns, Fig. 1. gives an overview of the distribution of spending by income brackets. The vertical lines in the histograms represent the mean for the total sample population of each country. A normal-density plot is added for reference. As to be expected, poorer households generally spend less on energy than the more affluent ones; the bulk of the distributions of the lower-income brackets lie left of the mean in all three countries.

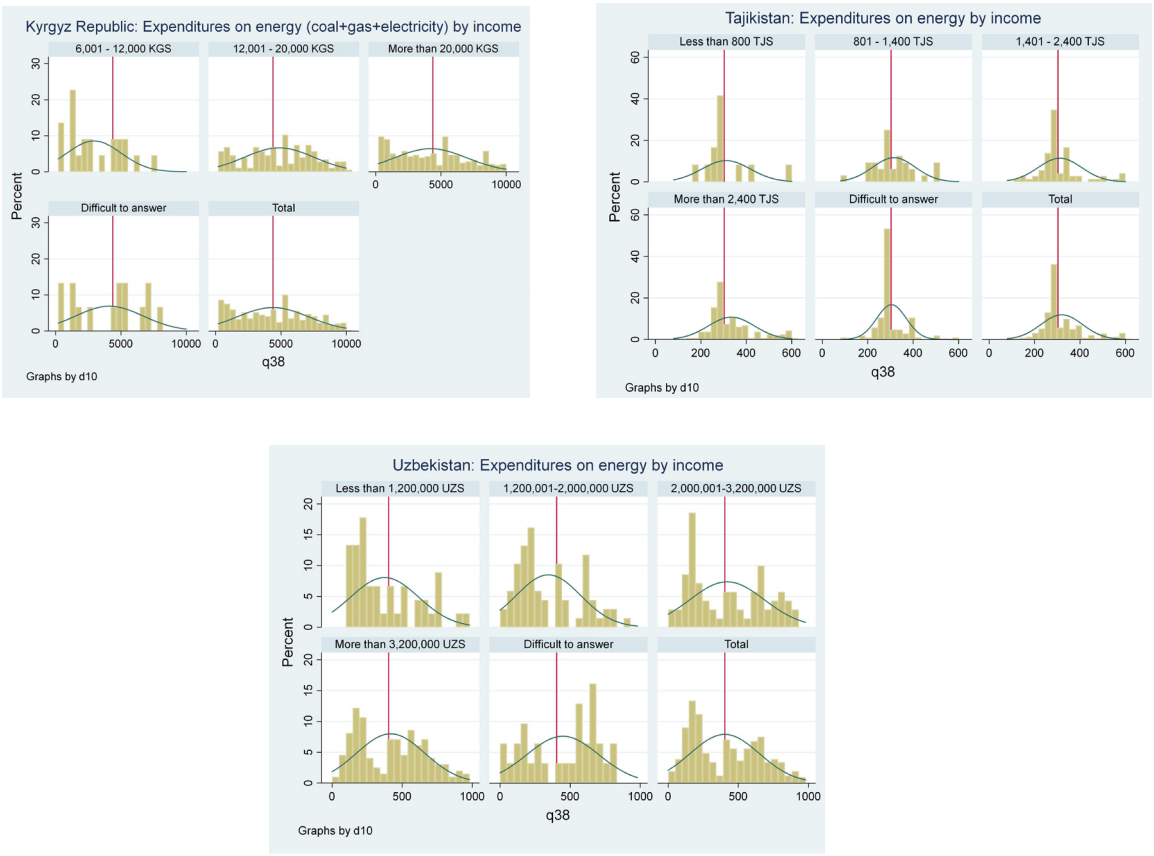


Figure 1. Expenditure on energy by income brackets.

Table VI. shows that a common feature for all three countries of the Fergana Valley is that households spend a substantial part of their income on energy. Looking at the two income brackets in the middle – where midpoints can be assumed to roughly represent the average income in these brackets – delivers the following results: in the Kyrgyz Republic, the median expenditure amounts to KGS 2,325 for the lower of the middle income-brackets. This is as much as 26% of the income bracket's mid-point. The respondents of the next higher income bracket indicated that they spent even 33% (median) of the income bracket's mid-point on energy. In Tajikistan, the respective numbers are 27% and 15.5%, respectively, and in Uzbekistan it is 17% in both income brackets.

Table VI. also confirms that in general more affluent households tend to spend more on energy than poorer ones. In the Kyrgyz Republic and Tajikistan there is a significant difference by household income of how much households spend on energy – with an 0.48% and 5.36% error probability, respectively. However, in the former the "more than 20,000 KGS" bracket spends less than the "12,001 - 20,000 KGS" bracket. The result for Uzbekistan is that more affluent households spend more – but the result is significant only at the error probability of 17%.

Table VI. Expenditure on energy per month - by income brackets.

Household income per month		Spending per month on coal, gas, and electricity				
	Frequency	Median	Mean	Std. Err.	[95% Conf. Interval]	
Kyrgyz Republic (Analysis of Variance: Adj R-squared = 0.0203; **Pr > F = 0.0048**)						
Less than 6,000 KGS	0 (0.0%)	-	-	-	-	-
6,001 - 12,000 KGS	22 (4.5%)	**2,325**	**2,938**	442	2,069	3,808
12,001 - 20,000 KGS	175 (35.9%)	**5,150**	**4,863**	202	4,466	5,260
More than 20,000 KGS	276 (56.6%)	**4,100**	**4,208**	167	3,880	4,536
Difficult to answer	15 (3.1%)	**4,900**	**4,114**	668	2,802	5,426
Total	488 (100.0%)	**4,450**	**4,382**	124	4,139	4,626
Tajikistan (Analysis of Variance: Adj R-squared = 0.0119; **Pr > F = 0.0536**)						
Less than 800 TJS	15 (3.3%)	**295**	**307**	24	259	355
801 - 1,400 TJS	38 (8.5%)	**297**	**311**	15	282	340
1,401 - 2,400 TJS	90 (20.0%)	**294**	**308**	10	289	328
More than 2,400 TJS	186 (41.4%)	**297**	**333**	7	319	347
Difficult to answer	120 (26.7%)	**296**	**304**	6	292	317
Total	449 (100.0%)	**296**	**318**	4	309	326
Uzbekistan* (Analysis of Variance: Adj R-squared = 0.0059; Pr > F = 0.1708)						
Less than 1,200 thUZS	45 (10.9%)	**250**	**375**	36	303	446
1,200-2,000 th UZS	68 (16.5%)	**265**	**345**	28	290	399
2,000-3,200 th UZS	70 (17.0%)	**413**	**420**	32	358	483
More than 3,200 th UZS	197 (47.9%)	**430**	**418**	17	383	452
Difficult to answer	31 (7.5%)	**550**	**447**	46	356	538
Total	411 (100.0%)	**400**	**404**	12	380	428

KG: Expenditure limited to below or equal to 10,000 KGS per month to cut off outliers;

TJ: Expenditure limited to below or equal to 600 TJS per month to cut off outliers;

*UZ: *Expenditure in thousand UZS; expenditure limited to between 100th and 1,000th UZS per month to cut off outliers.*

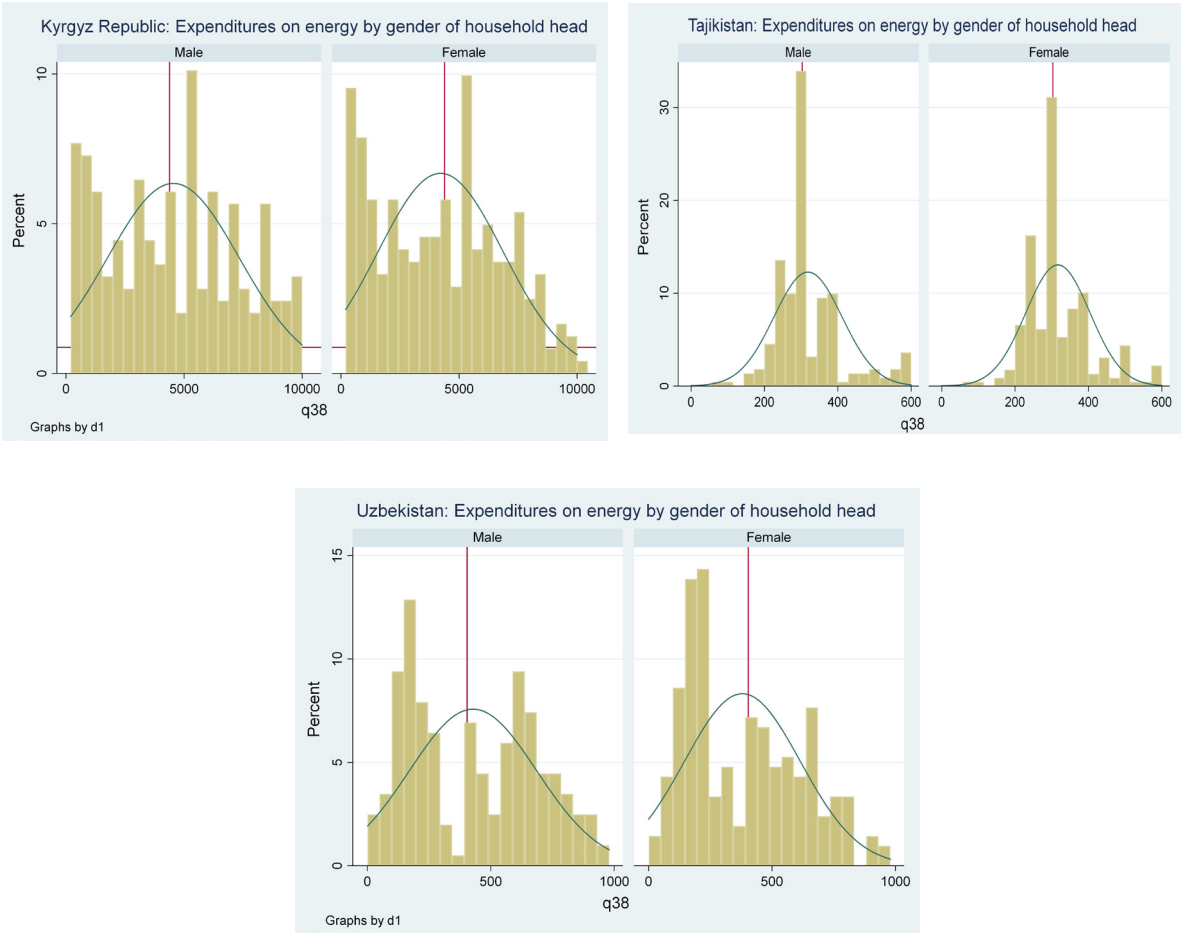


Figure 2. Expenditure on energy by gender.

Fig. 2. and Table VII. indicate that in the Kyrgyz Republic and Uzbekistan households with female heads spend somewhat less on energy than households with male heads. This is in line with the survey finding that significantly fewer households of female respondents are in the higher income brackets than households with male heads (10% error probability). For Tajikistan, the picture is less clear both regarding the energy spending and the household head income by gender.

Table VII. Expenditure on energy by gender.

	Kyrgyz Republic			Tajikistan			Uzbekistan		
	Frequency	Median	Mean	Frequency	Median	Mean	Frequency	Median	Mean
Male	247 (50.6%)	4,500	4,545	221 (49.2%)	295	319	202 (49.1%)	430	428
Female	241 (49.4%)	4,250	4,216	228 (50.8%)	296	317	209 (50.9%)	330	380
Total	488 (100.0%)	4,450	4,382	449 (100.0%)	296	318	411 (100.0%)	400	404

Households with more members spend generally more than smaller households (Fig. 3 and Table VIII.). In all three countries households with more than 6 members spend the most, households with 1-3 people – the least.

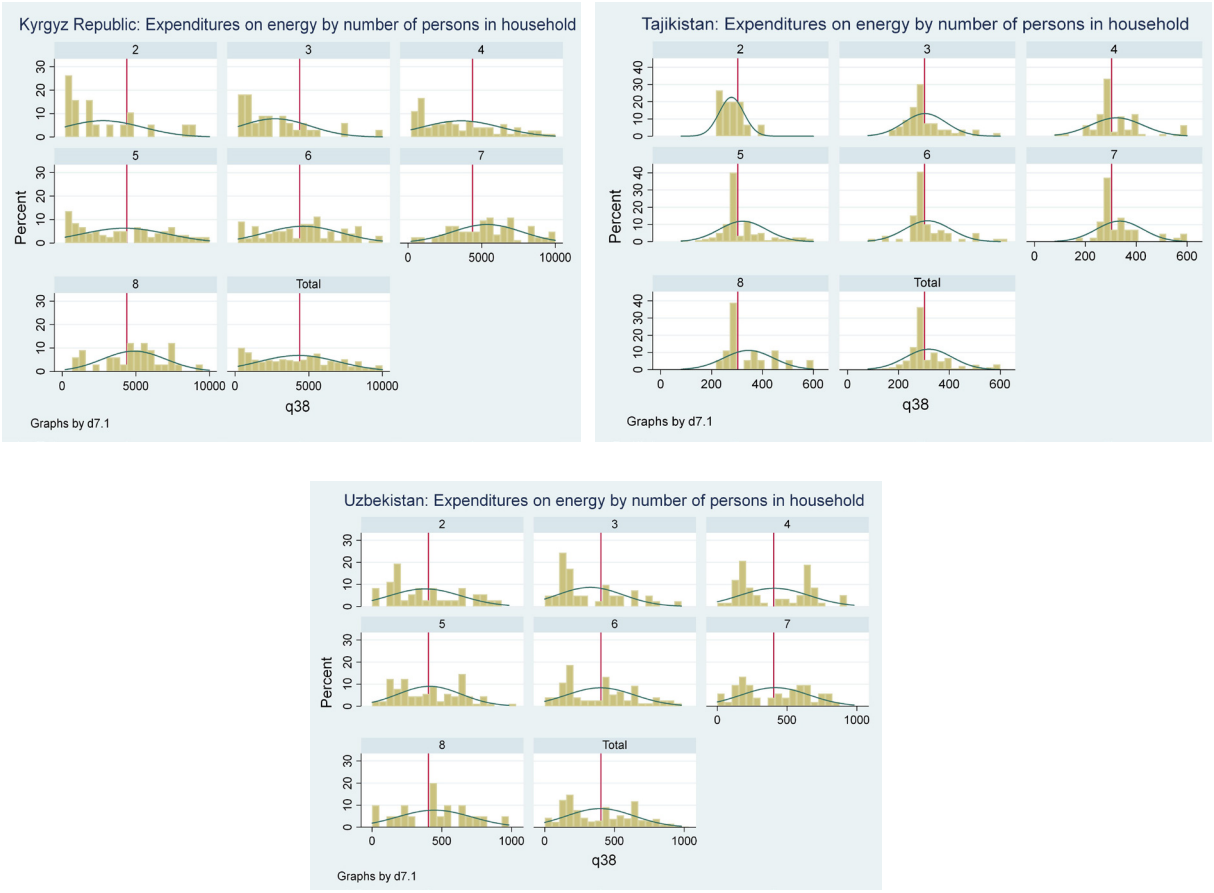


Figure 3. Expenditure on energy by the number of persons in household.

Table VIII. Expenditure on energy by the number of persons in household.

	Kyrgyz Republic			Tajikistan			Uzbekistan		
	Frequency	Median	Mean	Frequency	Median	Mean	Frequency	Median	Mean
1	1*	8,250	8,250	41 (9.1%)	293	302	6 (1.5%)	225	292
2	19 (3.9%)	1,700	2,775	15 (3.3%)	274	278	36 (8.8%)	318	380
3	33 (6.8%)	1,750	2,711	53 (11.8%)	295	304	41 (10.0%)	200	326
4	72 (14.8%)	2,950	3,604	78 (17.4%)	296	323	58 (14.1%)	326	408
5	118 (24.2%)	4,075	4,231	117 (26.1%)	296	322	89 (21.7%)	400	412
6	98 (20.1%)	4,750	4,615	59 (13.1%)	294	315	75 (18.2%)	425	399
7	83 (17.0%)	5,500	5,370	43 (9.6%)	298	335	52 (12.7%)	438	415
8	33 (6.8%)	5,280	4,879	18 (4.0%)	297	345	20 (4.9%)	450	447
>8	31 (6.4%)	5,500	5,502	25 (5.6%)	294	316	34 (8.3%)	582	481
Total	488 (100%)	4,450	4,382	449 (100%)	296	318	411 (100%)	400	404

* Seems to be an outlier.

While the survey reveals differences in energy spending by income brackets, gender, and household size, only a small portion of the variance is explained by these factors; in Table VI., less than 2% of the expenditure variance is explained by income brackets for all three countries. This leads to the conclusion that the amount the households in the Fergana Valley spend on energy is not hugely influenced by the amount of money they can dispose of, even though spending on energy eats up a substantial part of household income, and some differences exist.

3.3. Spending on energy by the main source of energy used for heating

All three countries of the Fergana Valley demonstrate statistically significant differences of household energy spending depending on the main source of energy for heating, as the analysis of variance shows (Table IX.). However, the somewhat surprising result of comparing the expenditures on different energy sources is that the average (mean) spending of households that use electricity as their main energy source is lower than the spending by households that use coal – in all three countries, notwithstanding that in the Kyrgyz Republic and Uzbekistan coal is the dominant source for heating. Except for the Kyrgyz Republic this is also the case for the median.

Table IX. Expenditure on energy per month - by main energy source for heating

Main energy source for heating		Spending per month on coal, gas, and electricity				
	Frequency	Median	Mean	Std. Err.	[95% Conf. Interval]	
Kyrgyz Republic (Analysis of Variance: Adj R-squared = 0.0895; **Pr > F = 0.0000***)						
Coal	382 (88.4%)	**4,581**	**5,137**	120	4,901	5,373
Natural gas from underground pipes	2 (0.5%)	3,988	5,200	4,400	-3,448	13,848
Electricity	29 (6.7%)	**5,720**	**2,324**	460	1,420	3,229
Biofuels (pressed dung)	5 (1.2%)	4,236	2,766	1,066	671	4,861
Firewood	14 (3.2%)	**4,955**	**3,318**	957	1,437	5,198
Tajikistan (Analysis of Variance: Adj R-squared = 0.0161; **Pr > F = 0.0110***)						
Coal	54 (12.0%)	**302**	**340**	13	314	367
Fuel oil/diesel	2 (0.4%)	336	336	43	251	421
Propane (gas in cylinders)	2 (0.4%)	331	331	246	-152	814
Electricity	319 (71.0%)	**295**	**318**	5	308	328
Biofuels (pressed dung)	8 (1.8%)	398	364	28	309	419
Firewood	62 (13.8%)	**297**	**291**	9	274	309
Waste and garbage	2 (0.4%)	280	280	71	141	418

Table IX. Cont.

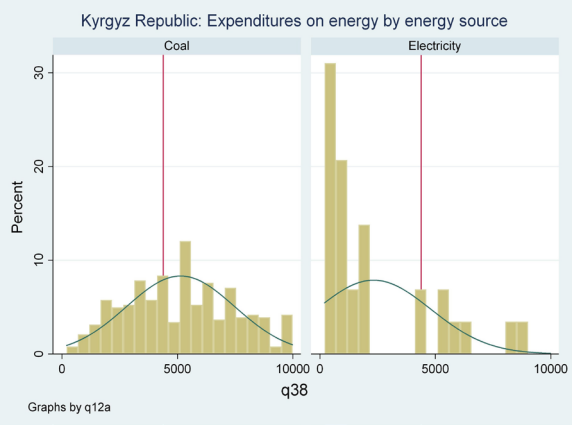
Uzbekistan* (Analysis of Variance: Adj R-squared = 0.2160; **Pr = 0.0000****)						
Coal	203 (49.4%)	**575**	**531**	17	498	563
Fuel oil/diesel	3 (0.7%)	195	275	88	103	447
Natural gas from underground pipes	69 (16.8%)	**200**	**283**	23	239	327
Propane (gas in cylinders)	40 (9.7%)	**188**	**224**	20	184	264
Electricity	58 (14.1%)	**210**	**313**	27	259	367
Biofuels (pressed dung)	1 (0.2%)	250	250	-	-	-
Firewood	37 (9.0%)	**190**	**280**	34	213	348

KG: Natural gas and biofuels omitted from Anova due to low count; expenditure limited to below or equal to 10,000 KGS per month to cut off outliers;

*TJ: *Oil/diesel, propane, biofuels, and waste omitted from Anova due to low count; expenditure limited to below or equal to 600 TJS per month to cut off outliers;*

*UZ: *Thousand UZS; **Oil/diesel and biofuel omitted from Anova due to low count; expenditure limited to between 100 and 1,000 UZS per month to cut off outliers.*

Fig. 4. depicts energy spending by households that use coal as their main source of energy for heating versus the spending by households that use electricity as their main source. The t-test for these two energy sources shows that for the Kyrgyz Republic the zero-hypothesis that there is no difference can be rejected with an error probability of 0.00% – with a mean spending of KGS 5,137 on coal and KGS 2,324 on electricity.



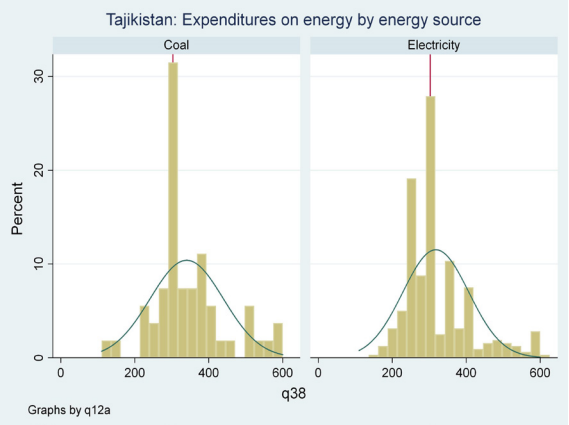


Figure 4. Cont.

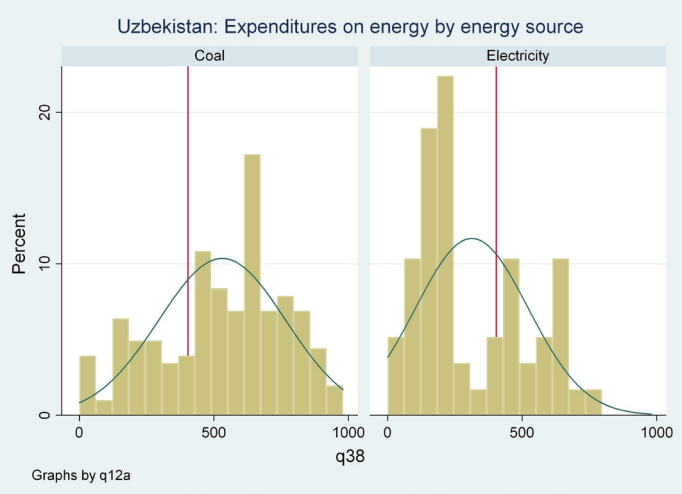


Figure 4. Expenditure on energy by main energy source for heating

In Tajikistan the mean spending is TJS 340 on coal and TJS 318 on electricity, respectively, the error probability that there is a difference is 4.7%, and in Uzbekistan the mean spending is UZS 531,000 on coal and UZS 313,000 on electricity, and the error probability is 0.00%. Thus, households that use coal clearly tend to spend more in the Kyrgyz Republic and Uzbekistan. This leads to the conclusion that notwithstanding the rather high emphasis of financial issues in the direct responses on the motives of energy choice, the relative spending is currently not the decisive determinant for households' choice of energy.

3.4. Plans and motives for changing households' heating systems

Another way of looking at the determinants for the choice of energy is to investigate plans and motives for changing heating systems. While one could assume that wealthier house-holds are more likely to change their energy systems than the lower-income ones because of more financial opportunities, there is no clear evidence for that. The chi-quadrat test shows little significance for any of the three countries, and both in Tajikistan and in Uzbekistan even a lower percentage in higher income brackets have plans to change their heating systems than in lower income brackets (Table X.).

Table X. Planning to change the autonomous heating system in the next 5 years - by income brackets

Frequency	Plan to change	Don't plan to change	Total	Plan to change, % of total
Kyrgyz Republic (Pearson chi2(4) = 1.3009; Pr = 0.729)				
Less than 6,000 KGS	-	-	-	-
6,001 - 12,000 KGS	**5**	15	**20**	25.0
12,001 - 20,000 KGS	**53**	115	**168**	31.5
More than 20,000 KGS	**73**	191	**264**	27.7
Difficult to answer	**3**	11	**14**	21.4
Total	**134**	332	**466**	28.8
Tajikistan (Pearson chi2(4) = 3.4099; Pr = 0.492)				
Less than 800 TJS	**4**	14	*18*	22.2
801 - 1,400 TJS	**4**	36	*40*	10.0
1,401 - 2,400 TJS	**13**	84	*97*	13.4
More than 2,400 TJS	**21**	201	*222*	9.5
Difficult to answer	**14**	109	*123*	11.4
Total	**56**	*444*	*500*	11.2
Uzbekistan (Pearson chi2(4) = 0.3039; Pr = 0.990)				
Less than 1,200,000 UZS	**8**	39	**47**	17.0
1,200,001 - 2,000,000 UZS	**12**	62	**74**	16.2
2,000,001 - 3,200,000 UZS	**14**	70	**84**	16.7
More than 3,200,000 UZS	**41**	213	**254**	16.1
Difficult to answer	**8**	33	**41**	19.5
Total	**83**	417	**500**	16.6

While the large majority of respondents in all three countries were aware of the harm that fossil fuels can inflict on the environment and on family health, there is little evidence that this awareness leads them to plan a change in their heating systems. The same 28.7% aware and not-aware plan a change in their heating systems in the Kyrgyz Republic; and in Uzbekistan the percentage is also almost the same – at 20% in both groups (Table XI.). In Tajikistan, where most of heating is already based on electricity, 11.5% of the ones aware plan to change versus 8.6% of the non-aware; however, also in Tajikistan the difference is not significant.

Table XI. Planning to change the autonomous heating system in the next 5 years - by awareness of potential harm to environment and health

Frequency	Plan to change	Don't plan to change	Total	Plan to change, % of total
Kyrgyz Republic (Pearson chi2(1) = 0.0623; Pr = 0.969)				
Aware	107	266	373	28.7
Not aware	25	62	87	28.7
Difficult to answer	2	4	6	33.3
Total	134	332	466	28.8
Tajikistan (Pearson chi2(1) = 0.4451; Pr = 0.800)				
Aware	46	354	400	11.5
Not aware	5	53	58	8.6
Difficult to answer	5	37	42	11.9
Total	56	444	500	11.2
Uzbekistan (Pearson chi2(1) = 0.0277; Pr = 0.986)				
Aware	54	271	325	19.9
Not aware	28	140	168	20.0
Difficult to answer	1	6	7	16.7
Total	83	417	500	19.9

Among the households that are inclined to change their heating systems, it is not coal from which households intend to move away most frequently. In the Kyrgyz Republic this is electricity, and in Tajikistan and Uzbekistan – firewood (Table XII.).

Table XII. Planning to change the autonomous heating system in the next 5 years - by main energy source for heating

Frequency	Plan to change	Don't plan to change	Total	Plan to change, % of total
Kyrgyz Republic (Pearson chi2(1) = 5.5383; Pr = **0.063***)				
Coal	**112**	**301**	**413**	**27.1**
Natural gas from underground pipes	0	2	2	0.0
Electricity	**14**	**17**	**31**	**45.2**
Biofuels (pressed dung)	2	3	5	40.0
Firewood	**6**	**9**	**15**	**40.0**

Table XII. Cont.

Tajikistan (Pearson chi2(2) = 9.4894; Pr = **0.009***)				
Coal	**10**	**50**	**60**	**16.7**
Fuel oil/diesel	1	1	2	50.0
Propane (gas in cylinders)	0	3	3	0.0
Electricity	**27**	**313**	**340**	**7.9**
Biofuels (pressed dung)	1	9	10	10.0
Firewood	**11**	**46**	**57**	**19.3**
Waste and garbage	0	1	1	0.0
Total	50	423	473	10.6
Uzbekistan (Pearson chi2(4) = 20.1766; Pr = **0.000***)				
Coal	**45**	**228**	**273**	**16.5**
Fuel oil/diesel	1	2	3	33.3
Natural gas from underground pipes	**11**	**65**	**76**	**14.5**
Propane (gas in cylinders)	1	42	43	2.3
Electricity	**10**	**55**	**65**	**15.4**
Biofuels (pressed dung)	0	1	1	0.0
Firewood	**15**	**24**	**39**	**38.5**
Total	83	417	500	16.6

*KG: *Natural gas and biofuel omitted due to low count;*
*TJ: *Oil/diesel, propane, and biofuel omitted due to low count;*
*UZ: *Oil/diesel and biofuel omitted due to low count.*

There is some difference in the readiness to change heating systems by the level of education. In the Kyrgyz Republic and Tajikistan, higher education households show the highest propensity for change (Table XIII.). However, this is not the case for Uzbekistan, and for all three countries the outcome is not significant.

Table XIII. Planning to change the autonomous heating system in the next 5 years - by the level of education

Frequency	Plan to change	Don't plan to change	Total	Plan to change, % of total
Kyrgyz Republic (Pearson chi2(1) = 2.6644; Pr = 0.446)				
Incomplete secondary (9 classes)	**11**	27	**38**	**28.9**
Secondary (11 classes)	**69**	180	**249**	**27.7**
Secondary specialized and vocational education (college, technical school)	**21**	64	**85**	**24.7**
Higher education (specialist, bachelor, master, candidate of science, doctor of science, PhD)	**33**	61	**94**	**35.1**
Total	134	332	466	28.8

Table XIII. Cont.

Tajikistan (Pearson chi2(2) = 1.3226; Pr = 0.516*)				
Incomplete secondary (9 classes)	4	47	51	7.8
Secondary (11 classes)	**17**	120	**137**	**12.4**
Secondary specialized and vocational education (college, technical school)	**11**	114	**125**	**8.8**
Higher education (specialist, bachelor, master, candidate of science, doctor of science, PhD)	**24**	163	**187**	**12.8**
Total	56	444	500	11.2
Uzbekistan (Pearson chi2(2) = 0.7969; Pr = 0.671*)				
Incomplete secondary (9 classes)	2	12	14	14.3
Secondary (11 classes)	**35**	158	**193**	**18.1**
Secondary specialized and vocational education (college, technical school)	**28**	161	**189**	**14.8**
Higher education (specialist, bachelor, master, candidate of science, doctor of science, PhD)	**18**	86	**104**	**17.3**
Total	83	417	500	16.6

*TJ: *Incomplete secondary omitted due to low count;*
*UZ: *Incomplete secondary omitted due to low count.*

The readiness to change heating systems is almost the same in all three countries between urban and rural areas: about 26-29% in the Kyrgyz Republic both in urban and rural areas, 16-17% in Uzbekistan, and 11-12% in Tajikistan. The Chi-square tests are highly insignificant (Table XIV.).

Table XIV. Planning to change the autonomous heating system in the next 5 years - by urban/rural households.

Frequency	Plan to change	Don't plan to change	Total	Plan to change, % of total
Kyrgyz Republic (Pearson chi2(1) = 0.4073; Pr = 0.523)				
Urban	**19**	55	**74**	25.7
Rural	**115**	277	**392**	29.3
Total	**134**	332	**466**	28.8
Tajikistan (Pearson chi2(1) = 0.0435; Pr = 0.835)				
Urban	**16**	121	**137**	11.7
Rural	**40**	323	**363**	11.0
Total	**56**	444	**500**	11.2
Uzbekistan (Pearson chi2(1) = 0.0439; Pr = 0.834)				
Urban	**49**	241	**290**	16.9
Rural	**34**	176	**210**	16.2
Total	**83**	417	**500**	16.6

The results about the plans for changing the heating system are somewhat more significant for gender than for income, harm awareness or level of education, and the urban-rural divide – however, with a lower than 10% error probability only for the Kyrgyz Republic (Table XV.). Male household heads are slightly more likely to have plans for changing the heating system than female ones: the percentage of male respondents indicating such plans were between 2.9 percentage points in Tajikistan and 7.4 percentage points in the Kyrgyz Republic higher than for their female counterparts. Given that this result is not well explained by any of the other demographic indicators, it should probably be attributed to some upbringing-based higher male propensity to "technical plans".

Table XV. Planning to change the autonomous heating system in the next 5 years - by gender

Frequency	Plan to change	Don't plan to change	Total	Plan to change, % of total
Kyrgyz Republic (Pearson chi2(1) = 3.0731; Pr = **0.080**)				
Male	**77**	161	**238**	**32.4**
Female	**57**	171	**228**	**25.0**
Total	**134**	332	**466**	28.8
Tajikistan (Pearson chi2(1) = 1.0198; Pr = 0.313)				
Male	**31**	214	**245**	**12.7**
Female	**25**	230	**255**	**9.8**
Total	**56**	444	**500**	11.2
Uzbekistan (Pearson chi2(1) = 2.4458; Pr = 0.118)				
Male	**49**	207	**256**	**19.1**
Female	**34**	210	**244**	**13.9**
Total	**83**	417	**500**	16.6

There is also some higher tendency among the young population to change heating systems than among the older one, significant at roughly 10% error probability only in the Kyrgyz Republic though (Table XVI.).

Table XVI. Planning to change the autonomous heating system in the next 5 years - by age

Frequency	Plan to change	Don't plan to change	Total	Plan to change, % of total
Kyrgyz Republic (Pearson chi2(1) = 2.5640; Pr = 0.109)				
Age 19-45	**99**	220	**319**	**31.0**
Age 45+	**35**	112	**147**	**23.8**
Total	**134**	332	**466**	28.8
Tajikistan (Pearson chi2(1) = 0.0323; Pr = 0.857)				
Age 19-45	**41**	320	**361**	**11.4**
Age 45+	**15**	124	**139**	**10.8**
Total	**56**	444	**500**	11.2
Uzbekistan (Pearson chi2(1) = 0.7786; Pr = 0.378)				
Age 19-45	**46**	209	**255**	**18.0**
Age 45+	**37**	208	**245**	**15.1**
Total	**83**	417	**500**	16.6

When asking household heads directly about the reasons households plan to change the heating system, the most frequent answer was “problems with the existing system”, followed by “con-venience”, colder winters, and financial issues (Fig. 5.). New technical possibilities also played a role. The environment and health got a count of only 11% in Tajikistan, 7.5% in the Kyrgyz Republic, and mere 2.1% in Uzbekistan.

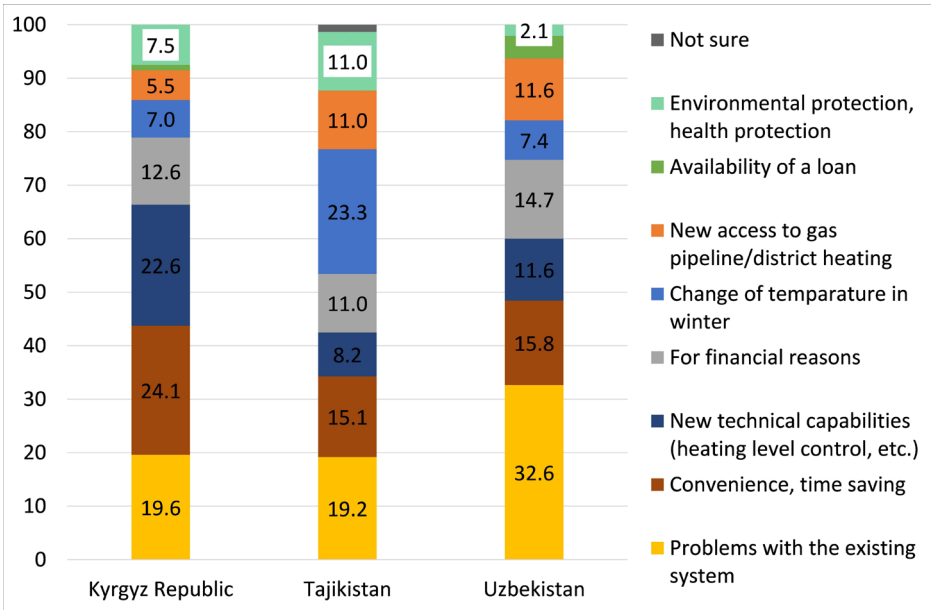


Figure 5. Answers to the question “What is the reason you are planning to change your heating system?” (%)

This outcome is roughly in line with the answers to the question "What guides you in choosing your main heating source?" shown in Table 5. However, when asked about future plans, even encountered issues with energy supply in the past seem not sufficient to induce households to change their heating systems. In the Kyrgyz Republic, 33.5% of those with problems in the past stated their readiness for change, significantly more than the 21.6% for the ones not affected (Table XVII.). For Tajikistan the respective figures are 12.5% and 8.6%, respectively, which is significant only on the 20% level, however. In Uzbekistan, of the 90% of the respondents who mentioned encountering challenges with energy in winter only 15.6% intend to change versus 25% of the households without issues (though the number of 13 of households without problems is small, which might have affected the outcome).

Table XVII. Planning to change the autonomous heating system in the next 5 years - by past problems

Frequency	Plan to change	Don't plan to change	Total	Plan to change, % of total
Kyrgyz Republic (Pearson chi2(1) = 7.6211; Pr = **0.006**)				
Problems in winter	**94**	187	**281**	**33.5**
No problems in winter	**40**	145	**185**	**21.6**
Total	**134**	332	**466**	28.8
Tajikistan (Pearson chi2(1) = 1.6578; Pr = 0.198)				
Problems in winter	**42**	295	**337**	**12.5**
No problems in winter	**14**	149	**163**	**8.6**
Total	**56**	444	**500**	11.2
Uzbekistan (Pearson chi2(1) = 2.9579; Pr = **0.085**)				
Problems in winter	**70**	378	**448**	**15.6**
No problems in winter	**13**	39	**52**	**25.0**
Total	**83**	417	**500**	16.6

4. Conclusions and policy recommendations

As many as 80.5% respondents in the Kyrgyz Republic, 80.0% in Tajikistan, and 65.0% in Uzbekistan indicated their awareness of the potential harm fossil fuels can inflict on the environment and on health. Yet, the dominant type of energy for heating in the Kyrgyz Republic and Uzbekistan is coal, notwithstanding higher energy expenses by households that use coal as the main source of energy for heating than by households that use electricity.

A large-scale move towards clean energy use by households will thus require profound policy interventions.

The relative price between clean energy such as electricity and coal should be sharply adjusted in favor of clean energy. This calls for taxes on coal, for example a sales tax and removal of subsidies for coal and/or administrative setting of price limits. At the same time, households in the Fergana Valley already spent up to one-third of their income on energy. In order not to further increase their financial burden, to cause social hardship, and to trigger a backlash against reforms such as taxes on coal, households need to be compensated for their higher energy bills by money transfers to them.

An increasing part of literature – for example Feng et al. (2018) for Latin America – shows that recycling a relatively small part of fiscal revenues from removing energy subsidies or from energy taxation could be sufficient to shield vulnerable households from the effects of energy price hikes. At the same time, the literature on the impact of energy taxes on residential final energy consumption (RFEC) in the context of developing countries and "within the integrated framework which takes into account socio-economic and contextual factors" (Borozan, 2019) is still relatively limited. This is even more the case regarding sales taxes on coal. However, Parry et al. (2017) found that ramping up India's special additional tax (cess) on coal would "significantly reduce local outdoor air pollution deaths, raise revenue… and is about the most efficient policy for reducing CO2 emissions". And Sumarno and Laan (2021) recommended to the Government of Indonesia: "Simply increase taxes on coal as a de facto form of carbon taxation". Further studies on the potential impact of coal sales taxes in the Central Asian region would be helpful as guidance for the authorities on what measures should be taken.

Borozan (2019) concludes for the EU that in less energy-consuming countries, high energy taxes have a stronger impact on residential energy consumption than in more energy-consuming ones. To an extent, this might also be the case for "higher-coal-consuming" house-holds, simply because there are fewer actual choices available due to the lack of appropriate technical solutions, which are also affordable.

Therefore, a new wave of (green) electrification is required to be able to satisfy the potentially higher demand for electricity from households and other sectors of the economy such as e- ve-hicles and the production of hydrogen. In fact, it is already underway in the three countries of the Fergana Valley – in Uzbekistan with a focus on solar and wind, and on hydropower in Tajikistan and the Kyrgyz Republic on hydropower. Azhgaliyeva et al. (2021) also found for Kazakhstan and the Kyrgyz Republic that "access to cleaner and more modern energy infrastructure such as natural gas pipelines and district heating reduces solid fuel consumption, especially in rural areas".

For utilizing each country's comparative advantages in the generation of electricity and for facilitating the balancing of supply and demand during different

seasons and times of the day, closer cross-country cooperation, upgraded grid connectivity and intensified electricity trading are desirable.

"Gradual and well-publicized reforms are also recommended to give firms and house-holds time to adjust in anticipation of higher energy prices and to allow time for strengthening social safety nets" (Parry, 2017). Along with these reforms, timely information campaigns via the internet, social networks, and other communication channels about opportunities for using clean and renewable energy sources are necessary to trigger a broad-based movement towards cleaner household energy use.

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The challenge of doing good: promotion of recycling in Almaty through civic community initiatives

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ABSTRACT

Recycling is one of the key components in reduction of carbon emissions and improving environmental conditions, especially in the urban context. In Central Asia, the legislation and infrastructure necessary for waste management is still under development. Thus, the knowledge gap and public awareness campaigns are mostly done at the grassroots level. This paper looks at the case of recycling promotion through civic community initiatives that also have a charitable component in Almaty. It explores the ethical considerations that are being entangled with the introduction of recycling culture in the city and is grounded in the literature on civil society, environmental ethics and social entrepreneurship. The data was collected through semi-structured interviews with organizers of recycling fairs and NGOs working on recycling. The paper reveals that by appealing to the ethical considerations of people to "do good" and contribute to charitable cause, the organizers of the recycling fair also demonstrate the effects of over-consumerism, ways of doing waste management, and educate about reuse and upcycle culture. The single case of Darmarka in Almaty present a limitation of the study. Therefore, a more in-depth research on the organisation of Darmarka events in other cities in Kazakhstan and CIS, as well as on similar initiatives in other Central Asian countries would be beneficial in the future. This is an important contribution in understanding what challenges and opportunities exist in promotion of recycling in Central Asia, that can be useful to national governments, experts, and international organizations working in this area.

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1. Introduction

Hip-hop music is blasting from the speakers, and a DJ in the corner is preparing to play the next tune. The stalls with products can be seen at the back of the room. It is a Saturday afternoon and there are plenty of people going around the space of the event. This is not just a usual fair aimed at selling local products and crafts. The path towards the stalls is lined with people in green T-shirt uniforms…and huge collecting bins. The volunteers collect 16 different materials for further recycling and re-use. This is Darmarka (a combination of *darit* [gifting] and *yarmarka* [fair]) a civic community initiative that aims to popularise recycling and waste management culture across Kazakhstan. At its core Darmarka addresses a crucial aspect of environmental campaigning in Kazakhstan, i.e., that a conscious waste management is key to improving the ecology in the urban settings and a primary aspect to raise awareness of individual behaviours and their impact on environment.

Darmarka is among several environmental initiatives that have started in the past few years in Central Asia. The effects of climate change are more acutely felt in Central Asia every year and the public is increasingly conscious about environmental problems in the region and globally (Sabyrbekov, Overland, & Vakulchuk, 2023). However, instead of focusing on campaigning and raising public awareness like many past environmental initiatives in the region, the new wave of organisations is pivoting towards civic community initiatives and even eco-entrepreneurship. In that way, environmentalism becomes a catalyst of ethical community work and ethical business rendering a wider community impact.

This paper investigates these themes through the case-study of Darmarka and other eco-projects in Almaty bringing together literatures on environmentalism, civil society, and ethical business and social entrepreneurship. The goal of the paper is to demonstrate how the current eco-initiatives are propagating waste management and utilising the sense of ‘doing good’ to benefit larger community. Therefore, these initiatives also bridge the gap between the lack of legislation and governmental programmes in the areas of waste management and upcycling. The paper starts by giving an overview of existing literature and introduce key concepts that will be in use throughout. It will then progress to describe the methodological framework and the case study of *Darmarka*, concluding with reflections on how such initiative brings together socio-economic issues with environmentalism and promotion of circular economy and a sustainable lifestyle.

2. Literature review

Climate change is a major concern for national governments in Central Asia. Thus, the governments are part of international and regional initiatives to alleviate the effects of climate change and signatories to several global pledges, such as the Paris Agreement, to give an example (Costa Buranelli, 2023). At a national level, the revision of environmental codes and strategies for environmental protection are implemented, often with the support from international organisations (Peyrouse, 2022). Despite these efforts the lack of public awareness about environmental issues is a concern and a challenge for the alleviation of effects of climate change (Peyrouse, 2022, p. 27). Limited education on ecology at school or university levels also affects the ability to raise public consciousness of issues like pollution, recycling, and general climate change basics.

With respect to wate management, it is important to understand national policies for it and what the governments are doing to tackle this issue. Waste management in Central Asia is one of the significant issues in environmental policies and is a multifaceted topic. Industrial waste creates significant environmental concerns for the whole region, and result in soil and water contamination that further impacts agriculture, livestock, and local eco systems (Peyrouse, 2022). Similarly, the common practice of bringing household waste into landfills located outside the urban centres results in the contamination of land, water, and air due to occasional fires. Air pollution is already a major environmental problem in the main cities across Central Asia, where concentration of harmful particles are exceeding by many times any average normal levels (Peyrouse, 2022, p. 8). Furthermore, the increase in urbanisation and continuous exponential growth of the household waste poses a major issue to the environment and natural habitat, unless dealt with appropriately. This is a common problem in Central Asia and something that the governments are struggling with. Thus, for example, in Kyrgyzstan the World Bank is supporting a program to modernise the waste management and landfill management around Bishkek (Tskhay, 2023).

In Kazakhstan, the government first initiated programmes of waste sorting by providing separate bins for paper, plastics, and general waste on the streets and collecting plastic bottles in Almaty. One of the issues in the collection of sorted waste is in fact its proper sorting, so that it can be then reused and recycled. In the absence of such proper waste recycling culture, the existing infrastructure remains idle, and businesses are required to buy the materials from abroad. Thus, while landfills in urban centres get more packed, the waste recycling centres are not utilised to the full capacity.

Waste management often refers to the stages of 3Rs – reduce, recycle, re-use. It is crucial to pay attention to this, for as we progress in this paper all these stages will appear. Thus, recycling refers to the process of transforming the waste into something else or degradable material. Re-use refers to the ability to utilise whole or parts of the waste into something else, for example using spare parts of electrical appliances or converting glass bottles into art objects. Upcycling is another notion that can signify this process. Reduction of waste refers to the conscious behavioural change to limit consumption, for example using reusable cups for coffee instead of a single-use plastic/paper ones.

Civil society has long been involved in environmental campaigning and promotion of safer ecology in Central Asia. Such major environmental problems as the Aral Sea protection, water management of transboundary rivers, and protection of natural habitat, have dedicated NGOs and international networks (Farmer & Farmer, 2001). Several recent studies reflect on the development of environmental movements, eco-activism, and environmental behaviour in Kazakhstan. In their study Kuzembayeva et al. (2017) argue that before 1985 it was almost impossible to start any initiatives due to the Soviet political regime (Kuzembayeva et al., 2017, p. 95). Even though later there were some prominent movements that gained international attention and actually caused significant changes like the “Nevada-Semipalatinsk” movement against nuclear activity, authors suggest that because of the economic crisis, attention of the population and the government was given to the economy, not ecology (Kuzembayeva et al., 2017, pp. 95-96).

A growing literature on environmental movements also draws on the tensions between government and civil society and the challenges of environmental campaigning (O’Connor, 2022). This follows an established line of enquiry on the operation of civil society in authoritarian context in Central Asia (Adibayeva, Saari, & Utarbayeva, 2023; Buxton, 2009; Knox & Sharipova, 2024; Peyrouse, 2022). The political aspect of civil society activities in the region are given more attention by scholars. Thus, for example Adibayeva et al. (2023) studied environmental initiatives through the prism of political movements, and focused on conservation, protests, and sustainable development campaigns. Adibayeva et al. (2023) mention several campaigns that they consider as successful in raising environmental awareness in Kazakhstan such as “Green Activist”, “Green Academy”, “The Altyn Dala Conservation Initiative”, “Zhasyl Kazakhstan”, “Eco-Damu”, “Tazalyk”, The Green Economy Financing Facility for Kazakhstan (GEFF). Moreover, in their study on the Kok-Zhailau case (a part of a national park near Almaty that is facing extreme pollution and is argued to become a ski resort), the authors have demonstrated how through years of campaigning and negotiations with both private and public bodies, the eco-activists were successful to secure the preservation of Kok-Zhailau (Adibayeva et al., 2023,

p. 22). It is important to note that, as Kumar (2022) states, the participation in eco-movements is limited due to prevailing concern about economic issues that occupy more the general public in Kazakhstan.

The focus on waste management is not done by chance, as numerous studies have shown a grim situation with recycling. One study uses national statistics on waste management in Kazakhstan, where the authors found that only 2.6% of all waste in Kazakhstan is municipal waste (which is mostly household waste), whereas waste from mining industry and electricity and gas industries accounts to 68% and 15% correspondingly (Serikova, Baidakov, & Syrlybayeva, 2020, p. 2). According to them, in 2018 about 25% of the municipal waste was transferred to third-party organizations/waste recycling plants, and this number is increasing each year from 2015 to 2018 (Serikova et al., 2020, pp. 3–4). However, out of this 25% only 4.8% is reported to be recycled. The authors suggest three solutions for this problem: "control over the application of laws in the waste management field, change people's ecological behaviour, and the availability of a secondary resources market" (Serikova et al., 2020, p. 6).

Review of the current literature on the topic revealed that previous studies do not address ethical considerations of the population of Kazakhstan in the context of eco-activism. In other words, reasons for environmental movements and civil engagement are not being analysed from the perspective of ecological ethics (Elegbede, Sanni, Mekuleyi, & Afolabi, 2023; Palmer, McShane, & Sandler, 2014). Especially, as the later part of this article will present, the new wave of eco-initiatives is utilising the charitable aspect together with commercial activities in promoting a more sustainable lifestyle and instillation of eco-friendly behaviour.

It is helpful to look at literature and global examples of social entrepreneurship and civil society initiatives in the area of sustainability and environmentalism. Definition of social enterprises includes the alignment of commercial profit with social impact, where that impact can be described as "achieving its social mission that will help alleviate societal problems and produce environmental benefits" (Kamaludin, Xavier, Amin, & Xavier, 2024, p. 31; Santos, Pache, & Birkholz, 2015, p. 39). For Austin, Stevenson and Wei-Skillern (2006) social entrepreneurship is linked to use of business opportunities for the "creation of social value for meeting the basic and long-term needs of society" (Groma & Licite-Kurbe, 2021, p. 233). These two definitions represent a general pattern in the discussions about social entrepreneurship and point at the business activity and acumen directed at creating social value and long-term social impact. It is the social entrepreneurs that fill the market gap in addressing the social needs, and the ability of being closer to the community level allows them to make a greater impact. The flexibility, creativity,

and social awareness paired with business models are the qualities that position social entrepreneurs to achieving results (Kamaludin et al., 2024, p. 29).

Another important factor in the operation of social entrepreneurs is their mission (Austin et al., 2006). The guiding priciniples and mission help social entrepreneurs to focus on social impact and perform in a more targteted manner. Relying on extensive networks and by mobilising resources, social entrepreneurs can grow and learn, thus being more agile and proactive in their approach and activities than established corporations and/or governements (Kamaludin et al., 2024, p. 29). In fact, it is acknowledged in the literature that social entrepreneurs are filling that gap left by government institutions (Hill, Kothari, & Shea, 2010).

To summarise the above presented discussion indicates that climate change and environmental issues do have an impact and concern local pouplation in Kazakhstan. This is also shown in the operation of multitude of environmental campaigns and projects. Yet, the present paper aims to move beyond the study of environmental civil society and campaigns, and utilise the concept of social entreprenurs in application to the new wave of initiatives that promote circular economy and sustainable lifestyle. This further contributes to the study of the topic os enviornment and sustainability in the urabn context in Central Asia, as well as the impact and development of grassroot movements.

3. Methodology and data collection

The paper takes a case study as a research strategy to explore the connection between recycling promotion and social entrepreneurship on the example of *Darmarka* – a civic community initiative in Almaty. The case study methodology allows to present an in-depth analysis of a phenomena within its natural setting and to utilise multiple data collection methods (Priya, 2021). Therefore, the example of *Darmarka* was selected specifically to explore the way civic community initiative develops and how its organisers connect it to environmentalism and waste recycling culture. This exploratory case study of *Darmarka* project is designed to bring fresh view on the impact of civic community initiatives and social entrepreneurship in Central Asia and, thus, to foster new research studies in this area.

As the paper attempts to explore the notion of social entrepreneurship and sustainability promotion in the region, the methodological design was constructed to fit such purpose. The data collection for this article was done through a mix of participant observation, interview, and social media posts review methods conducted over the period of two months in 2023 and 2024. Participant observation happened on December 9, 2023 when the Darmarka event was organised in one of the exhibition halls in Almaty. The organisers of the event were notified in advance of

my observation, with minimum intervention on behalf of the author. The observation was necessary to take notes of performativity, and interactions between visitors, volunteers, entrepreneurs, and organisers. An in-person conversation with organisers of *Darmarka* was held during the event. In addition, two structured interviews with *Darmarka* organiser and community projects partnering with *Darmarka* were conducted online through fixed set of questions that addressed the main themes, discussed later in this article. A small sample of interviewees and the structured nature of questions allowed the authors to build a narrative of evolution and logic behind civic community initiatives as a foundation for a larger and longitudinal study in the future of this phenomena, which is deemed suitable in social science research (Crouch & McKenzie, 2006). The respondents answered question at their own pace and were not interrupted in order to preserve a "story-telling" nature of the conversation. Below is a set of questions presented to interviewees:

1. Tell us about how you founded your company/initiative. How did the idea come about? What were you motivated by?

2. What are your goals for this project? What principles do you use to guide your project?

3. Tell us about cooperation with other organizations. How do joint projects begin?

4. What plans and dreams do you have for the future?

5. What results are you proud of and why?

6. What difficulties have you encountered and continue to experience in your project?

7. Describe in your own words the social awareness of the population about ecology and recycling issues?

8. Do you think your project is contributing to changing people's recycling habits and zero-waste lifestyle?

9. Why is the social aspect of the project, especially the charitable aspect, important to you?

A review of social media posts and videos from *Darmarka* social media profiles on Instagram was also conducted to gather some information and see the engagement of the internet audience, as well as how organisers are promoting their events and values in the digital space.

As this is an exploratory case study, the methodological framework was designed to capture the main details of the *Darmarka* evolution and its links with waste recycling promotion. Moreover, the fact that this is not a longitudinal study, it only gives a glimpse on the main attributes and achievements in the time the study was conducted. The limitation of this study due to the length of data collection and number of respondent interactions is obviously reflected in the number of inferences

that this paper presents. Hence, a further longer fieldwork with participation in multiple events would be needed to capture change and continuity and especially to capture the influence on people's behaviour from participation in *Darmarka* events over time.

4. Data analysis

To understand the path that *Darmarka*, as an initiative went through, it is crucial to understand its origins. *Darmarka* is a civic community project with a motto "Вторая жизнь вещей" ("second life of clothes"). The idea of *Darmarka* is not new and there were already existing initiatives like, clothes swap or garage sale. However, the goal of such initiatives was to expand the lifespan of items and provide a platform for clothes and goods exchange, whereas *Darmarka* wanted to go beyond that. The format of *Darmarka* together with its name was brought to Kazakhstan by Russian eco-activist and trainer Roman Sablin, whose goal is to spread the knowledge about sustainability and connect like-minded eco-community. The first *Darmarka* event was organised in December 2017.

Darmarka started as a small community event and eventually grew to monthly eco-action project, where people can bring their unwanted items, recycle, and buy eco-products, as well as learn and gain knowledge, and exchange opinions with like-minded people, therefore, have a sense of belonging to a larger community. It is important to note that the *Darmarka* project is a non-commercial activity that does not gain profit and is supported through sponsorships and volunteer work. Most of the promotion for the event and the project itself is achieved through social media channels like Facebook and Instagram.

A distinctive point that sets apart *Darmarka* from other environmental projects is its charity component. The merging of clothes swap and support to people in need is an innovative way to "do good" and promote a more sustainable lifestyle.

"Through collaborations with other initiatives, civil society, and eco-projects, we find like-minded people, and learn about their needs. Therefore, we, for example, can purposefully collect items for pet shelters or provide clothes to low-income families affected by floods in other regions of Kazakhstan." (quote from *Darmarka* organisers) Such flexible approach and ability to provide help and address social needs is directly linked to the social entrepreneurs ability to act as change agents (Lehtimäki, Sengupta, Piispanen, & Henttonen, 2021, p. 175). In this respect, there is a combination of social and economic issues together with the support for a circular economy (Lehtimäki et al., 2021, p. 175).

The focus on local actions and the work on that scale is explained due to limited resources and human capital. However, such concentration on a local community

level, also is supported by the literature that acknowledges the role of social entrepreneurs or as Lehtimäki et. al (2021, p. 172) calls them 'social bricoleurs', are needed to address local needs and act as change agents.

One of the aspects of social entrepreneurship is value creation, either at a product or societal levels (Hlady-Rispal & Servantie, 2018). In the case of *Darmarka*, the ethical component is at the heart of the project, and the ability to help people is a guiding principle of the social projects that are partnering with *Darmarka*.

"The project is also aimed at future generations, the fact that we can live a better planet for the next generation. The awareness that one individual can make a difference and inspire others to follow and be mindful of the environmental impact we are living to the next generation." (quote from *Darmarka* organisers)

This is a common sentiment among the environmentalists that focus on the moral responsibility to care for the planet for the sake of future generations.

One of the main challenges for the operation of such projects as *Darmarka* is a lack of stable funding. Similarly, other social entrepreneurs that execute non-commercial projects share this challenge. Access to funds to support operations, stuff salary, and ability to grow, is critical for building a sustainable project. Thus, the lack of support from government or other commercial organisations creates a challenging environment to operate.

Another challenge connected to the previous one, is staff retaining and increasing human capital. Reliance on volunteer work has its advantages and disadvantages. Yet, for a sustainable activity one needs project manager, social media managers, stakeholder engagement managers, which also requires stable office space and meetings scheduling.

Lack of infrastructure in Kazakhstan for waste recycling is an obstacle for many to get involved in it. The necessity to recycle household waste in multiple locations of recycling centres creates an inconvenience for local population, and thus, many are not motivated to sort and recycle their waste, as was discussed previously in this paper. The fact that *Darmarka* events can provide a platform for recycling or different types of household waste at the same place is of great advantage. Moreover, the collected waste also saves time to producers and craftsmen for then reusing it for their purposes rather than them collecting it by themselves.

In the discussion with the organisers of *Darmarka* about their goals and mission, they said the following. "The main goal is to raise awareness about over-consumption, especially pertaining to textile industry and its environmental impact. This is achieved through two stages. At first, a person collects the unwanted items of clothing to bring to *Darmarka* and in this process reflecting on his/her individual consumer choices and habits. People notably bring new or rarely used items, which demonstrates unsustainable consumption patterns. Secondly, while being at the

event, people see how much stuff is brought and the sheer volume of unwanted items, and hence reflect on the overall consumption habits in society. These two trigger points have an immense effect on people." In their study Sarbassov et al. (2019, p. 12) highlighted the fact that active citizenship position and high degree of environmental awareness were one of the two most rated motivations for waste recycling among respondents.

On the basis of the quotes shared by the *Darmarka*'s organizers, one can argue that there are three functions in relation to waste management that *Darmarka* organizers fulfil: raising awareness, waste collection, support of local craftsmen and demonstration of upcycling opportunities. First, information sharing through social media and onsite campaigns serve as a primary aspect of changing people's behaviour. By demonstrating what, how, and how easy it can be to recycle materials, the organizers present the public with a clear message that anyone can (and should) recycle.

Second, the actual collection of waste that cannot be recycled through other means simplifies the act of recycling. The single location recycling also facilitates the likelihood of people bringing goods for recycling, rather than spending time on traveling to different spots.

Third, the presence of craftsmen and local businesses that use upcycling techniques presents a direct visual experience of how waste can be transformed and utilized in a different manner, and by extension reducing the overall pollution in urban landfills.

As the Instagram post from the *Darmarka* profile states the last event on March 17, 2024, the organisers managed to collect 1,775 kilograms of household waste (paper, carton, plastic of different types, aluminium cans, tins, glass, batteries, electric waste, expired medicines, and mercury-containing items). More than 1,500 kilograms of clothes were collected and then sent to people in need in the village of Qaraoi in Ile region. 182 used books were sent through the partner community project to the prison libraries. The visitors of the event had an opportunity to buy products from 16 different eco-businesses. These numbers represent not only the volumes of unwanted items that people brought to the event. More importantly, however, these items that could have ended up in the landfill were transferred to those in need and thus contributing to the circular economy and charitable causes.

My participant observation revealed the interesting example of families that come with kids to *Darmarka*. Children collect and sort their unwanted toys and consciously want for their toys to bring joy to other kids, as well as enjoying a possibility to choose a new toy for themselves. Thus, there is a generational learning component of importance of helping others and being conscious of consumption habits. This phenomenon is discussed largely in the literature as intergenerational ethics and

is particularly being applied in the discussion of climate change and environmental preservation (Nolt, 2017). Moreover, through the presence of programs of transferring unwanted items of clothing, books, vinyl, and others, at *Darmarka* events to those in need, a charitable component of the event, it relates to the ethical components of environmentalism, such as compassion, altruism, respect, appreciation, and value that are discussed by scholars (De Groot, Drenthen, & De Groot, 2011; Palmer et al., 2014; Sandler, 2017).

The above-mentioned findings can be supplemented by the results of the several studies which looked at local residents' behaviour in waste recycling in the urban context in Kazakhstan. Thus, for example, the study by Sarbassov et al. (2019) analysed environmental behaviour through surveys of around 3,000 people living in Astana. Both had some similar findings. Zhidebekkyzy et al. (2023) found out that one third of respondents sort their waste in two categories, while results of the survey by Sarbassov et al. (2019) showed that around 24% of respondents sort their household waste. Both studies revealed that environmental behaviour depends on gender and on the place of residence, where females tend to "sort more" than males, and residents of big cities tend to have a higher level of waste sorting than those from the suburban areas (Zhidebekkyzy et al., 2023; Sarbassov et al., 2019). However, the two groups of authors have differences: for Zhidebekkyzy et al. (2023), environmental behaviour also depends on the level of education, whereas for Sarbassov et al. (2019) a crucial component is age, with older people tending to be more active. Furthermore, the local residents themselves are not aware on the process of waste recycling, as was demonstrated by the study conducted by Zhidebekkyzy et al. (2023, p. 48) and that indicates a huge knowledge gap in this area.

This gap is, however, partially covered by other authors. In one study by Sarbassov et al. (2019), most of the respondents (61%) said that their motivation for active participation in waste sorting activity was active citizenship, while the most demotivating factors were lack of facilities for waste collection (47%) and lack of effective public awareness campaigns (31%). In another study, the reasons for the lack of environmental awareness were stated to be lack of environmental education and government passivity (Kumar, 2022). Furthermore, Adibayeva et al. (2023) note that there is lack of specific government policies and funding to support development in the field of eco-activism as well as low level of civic engagement in the implementation of eco-projects.

By promoting *Darmarka* days as eco-action and an event that goes beyond just waste sorting, through lectures on sustainability, crafts workshops, and craftsmen and eco-products fair, the organisers appeal to a wider audience. Thus, the goal is that more people would join *Darmarka* not for waste sorting, but by participating in

it they will be more motivating to bring the waste for the next eco-action. Therefore, a process of socialisation is at play and a peer-to-peer learning. Cooperation with local government also plays a role in the organisation of the eco-events and is used to have a win-win effect. There is a learning aspect, where government officials learn about the recycling and eco-projects and the needs of the community and local entrepreneurs, and the organisers receive the support for logistical issues of event management.

5. Regional implications

There are wider regional implications from initiatives like *Darmarka* in popularising waste management and sustainable behaviours. First of all, *Darmarka* events are held in other Central Asian cities and across Kazakhstan. This is an indication of the spread of the project and its potential impact beyond the capital cities. The first *Darmarka* event in Tashkent was organised on 23 December 2019 by an environmental community project called Hashar week (Shulepina, 2019). The fair dedicated to the swap of clothing, books, and toys was the first attempt to instil a sense of reducing the waste and extending the lifecycle of items. Similar events now occur on a regular basis in Tashkent and provide clothing and other household items to vulnerable groups. The American University's Centre for Civic Engagement organises eco-events in Bishkek and raises awareness about sustainability and climate change (AUCA, 2024). They also organised *Darmarka* event as part of their Eco-Day project with the clothes being donated to an orphanage at the end.

The fact that *Darmarka* events are picked up across Central Asian region is an indication in the change of the societal awareness of the issues pertaining to climate change and sustainable lifestyle. It is important to indicate that these events are not stand-alone initiatives but rather part of a larger projects that focus on promotion of sustainable behaviour, like Hashar week (Tskhay, 2023). Thus, Hashar week project regularly organises collection of household waste, such as paper, plastics, and metals, and public lectures to raise awareness on the benefits of and ways for recycling[1]. The existence of Tazar mobile application, which helps connect citizens with recycling points and educates them on how to recycle household waste in Bishkek, allows to further promote sustainable lifestyle behaviour (Trevor, 2021).

As *Darmarka* events in Central Asia are yet at the nascent stage and still require time and opportunity to grow. The challenge of upscaling these events in the region inevitably is linked to financial and human capacity limitations. In order to host regular events and extra activities such as public lectures and masterclasses to further promote the educational component of the *Darmarka* activities, a steady

[1] For more details on the events organized by Hashar week, please refer to their Instagram profile page.

flow of funding and personnel is necessary. At the same time, the grass-root nature of these initiatives indicate a way of raising public awareness about waste recycling and upcycling, thus, having a direct point of influence on societal behaviour. Fabienne Bossuyt (2023) believes that the initiatives operating at a local community level have tremendous potential for implementation of climate resilience and adaptation practices, therefore improving environmental situation in the region. She especially focuses on the self-reliance aspect of community initiatives to curb the inefficiencies and restrictions of national governments.

6. Conclusion

This paper delved into the issue of recycling and waste management in Almaty, and the promotion of recycling culture through civic community initiatives. The case of *Darmarka* represents an example of social entrepreneurial campaign that aims at bringing social change and using creative and innovative ways for addressing societal needs, as well as creating opportunities for local initiatives and businesses.

Darmarka achieves a three-pronged outcome through the organisation of the community event in Almaty. It collects and sorts for further reuse and recycle household waste, raises public awareness through lectures and by encouraging for further recycling, and supports eco-entrepreneurs and the use of local and ecological products. This distinguishes this initiative from the government institutions and allows it to achieve results that would not be possible to be accomplished at the public policy level. *Darmarka* and its organisers directly identify and respond to social needs, communicate with local public, and instil recycling behaviour through socialisation. All of these would be hard for the government institutions to achieve due to their bureaucratic nature and concern with national policies.

Studies on social entrepreneurs and their impact, especially in promoting environmental causes in Central Asia, are given small attention in the literature (Tskhay, 2023). The growth of similar start-ups and community initiatives that bring together businesses and civil society are indicative of a cultural shift and more creative and innovative ways of campaigning. Therefore, a comparative and an in-depth study on the proliferation of social entrepreneurs in the region would expand our understanding of these actors, and their societal role.

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Impact of climate change on migration trends in rural Central Asia

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ABSTRACT

Central Asia is considered a region highly vulnerable to climate change impact and susceptible to climate-induced migration. Rural populations throughout the region are particularly at risk of experiencing adverse effects of climate variability and (im) mobility due to increased exposure to environmental hazards and distress that can severely affect agricultural productivity. This paper explores how climate change impacts migration trends in rural areas of Central Asia with an aim to contribute to the research on climate mobility in the region focusing on most vulnerable inhabitants. By examining the ongoing region's environmental degradation with increased aridity and retreating glaciers that affect local agriculture, water and food security, this paper suggests possible outcomes of such effects on rural mobility trends across five Central Asian countries.

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1. Introduction

Although the amount and scope of studies examining climate change impact on Central Asian societies are limited (Vakulchuk et al., 2022), this region has become increasingly important for researching the link between environmental degradation and human (im)mobility (Blondin, 2018; 2022). In general, studies on climate change impact for Central Asia are still limited and inadequate (Hijioka et al., 2014) and require more comprehensive analysis on how the variability in global climate affects different sectors across the region. The percentage of scholarly articles that are focused on climate change in Central Asia is significantly low compared to other topics concerning the region in the last decade. In a timeframe between 1991 and 2021 and a sample of a total 13,488 journal articles in eight key journals for Central Asia research, researchers detected only 33 articles (0.24%) discussing climate change or a related topic. (Vakulchuk et al., 2022). Such scarce academic scope and interest in the topic of climate change in Central Asia leads to unjustified neglect of a very important realm of research that otherwise could reveal multifaceted analysis of intertwined climate factors that affect different areas of study, ranging from socio-economic, political, security and migration studies. Moreover, the significant gap in research on the human dimensions of climate change, including impacts on humans and climate adaptation further prevents a deeper comprehension of climate change - human migration nexus in the Central Asia region.

Central Asia, a landlocked region, consisting of five countries - Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan- is considered a climate “hot spot” prone to negative consequences of global warming that range from natural disasters, food scarcity, landslides, floods to climate migration and even immobility of people trapped in hazardous areas that are usually located in already impoverished, rural areas. In most of the region semi-arid to arid climate is present while there are also parts with a mountainous climate, which makes Central Asia susceptible to extreme weather events such as droughts, melting glaciers, and other natural disasters. Insufficient research on the impact of climate change in the Central Asia region is surprising especially taking into consideration the conclusions that this region is highly vulnerable to the changing nature of global climate and heavily exposed to various environmental hazards (Lukyanets et al., 2020). Due to observed increase in average annual temperature across the region (Clement et al., 2021), combined with the climate characteristics that vary from arid and semi-arid to mountainous climate, many natural disasters, including droughts, glacier melting and floods (Hu and Han, 2022), might become inevitable, more frequent and devastating.

In Central Asia, more than a half the population resides in rural regions whereas agriculture represents an important part of rural livelihoods. However, due to rather

gloomy predictions that the Central Asia region will be severely affected by climate change (Reyer et al., 2015), these rural areas and agricultural productivity might be under serious pressure and threat (Liu et al., 2020). Consequently, such tendencies can lead to increased mobility of people from rural to urban areas and abroad, but at the same time impoverish further already poor rural households and restrict their movements to more friendly environments. Mobility and migration are very common in Central Asian societies, including internal and migration across the borders. Labor migration is also notable within the rural population and many find Kazakhstan and Russia as a major job opportunity hub for acquiring enough means to send home their earnings (Clement et al., 2021). Climate change can intensify migratory flows within and across countries in Central Asia by provoking an environmental crisis and forcing local populations to migrate.

According to the World Bank's report, the number of climate migrants could reach 216.1 million by 2050 globally. Concerning the Central Asia subregion, the report suggests that in every of three projected scenarios, the region will experience an increase in climate migration to a varying degree. Thus, in the pessimistic scenario, the region is expected to record 2.4 million (3.4 percent of the total population) climate migrants, while in the more inclusive development scenario, that number would be 1.9 million (2.5 percent of the total population), and in the more climate-friendly scenario, 1.7 million (2.4 percent of the total population) (Clement et al., 2021). It is expected that climate change will increase migration, usually within the countries and rural to urban migration. For that reason, it is important to assess all possible aspects of the climate variability-migration nexus in order to draw conclusions on more comprehensive predictions and solutions.

The objective of this paper is to examine how climate warming affects concurrently human mobility and immobility in rural areas of the Central Asia region and thus contribute to scarce research on the nature of the relationship between rising temperatures and human migration as well as inability to move in the case of a particularly vulnerable subregion.

2. Central Asia as a Climate Change “Hotspot”

Central Asia is among hotspot regions that are highly susceptible to the adverse effects of rising temperatures (Haag et al., 2019). Due to the region`s vastly dry and semi dry areas with some mountainous parts, “the natural ecosystems of Central Asia are very sensitive and vulnerable to climate variability” (Zhou et al., 2015). It is estimated that out of 400 million hectares in Central Asia, two-thirds represent drylands where even the slightest climate pressures can cause significant negative consequences to the environment and local populations (Quillerou et al.,

2016). According to the 2022 IPCC report, Central Asia has already experienced large increases in temperature extremes while decreased precipitation and increased evapotranspiration observed in the region have contributed to drought conditions (Shaw et al., 2022). The IPCC report (Shaw et al., 2022) also mentions that the glaciers in Central Asia have been decreasing and additionally worsening the water scarcity and supply issues.

Studies suggest that the Central Asia region will experience raising temperatures significantly above the global average due to its arid and semi-arid climate that creates highly drought-prone conditions in vast areas of the region (Liu et al., 2020; Reyer et al., 2017). Although it is projected that the rise of annual mean temperature will vary across the region, the expected warming will be significant in each Central Asian country. According to the Representative Concentration Pathways (RCP) 8.5 group, annual temperature between 2040 and 2059 will increase by 2.75°C in Kazakhstan, 2.55°C in Kyrgyzstan, 2.65°C in Tajikistan, 2.27°C in Turkmenistan, and 2.37°C in Uzbekistan (Clement et al., 2021 in ICRC, 2021). Regional warming might put an additional stress on agricultural communities and further impoverish already affected rural areas in the region.

Climate map of the region shows a diversity of climate characteristics ranging from cold desert to temperate continental climate (Figure 1). Climate across Central Asia includes moderate to cool winters, with mean temperatures ranging from -3°C to 20°C and warm and hot summers with average temperatures differing from 20°C to 40°C (ICRC, 2021). Present variety in climate throughout the region makes regional trends at the level of districts and valleys to differ greatly (Haag et al., 2019). However, meteorological data collected since the end of the 19th century reveal a constant raising of annual and winter temperatures in this region (Lioubimtseva and Henebry, 2009). Other studies suggest that this trend will continue in the 21st century at a rate which is above the global mean increase (Mannig et al., 2013; Hu et al., 2014), which can lead to a series of environmental risks and adverse consequences in agricultural areas.

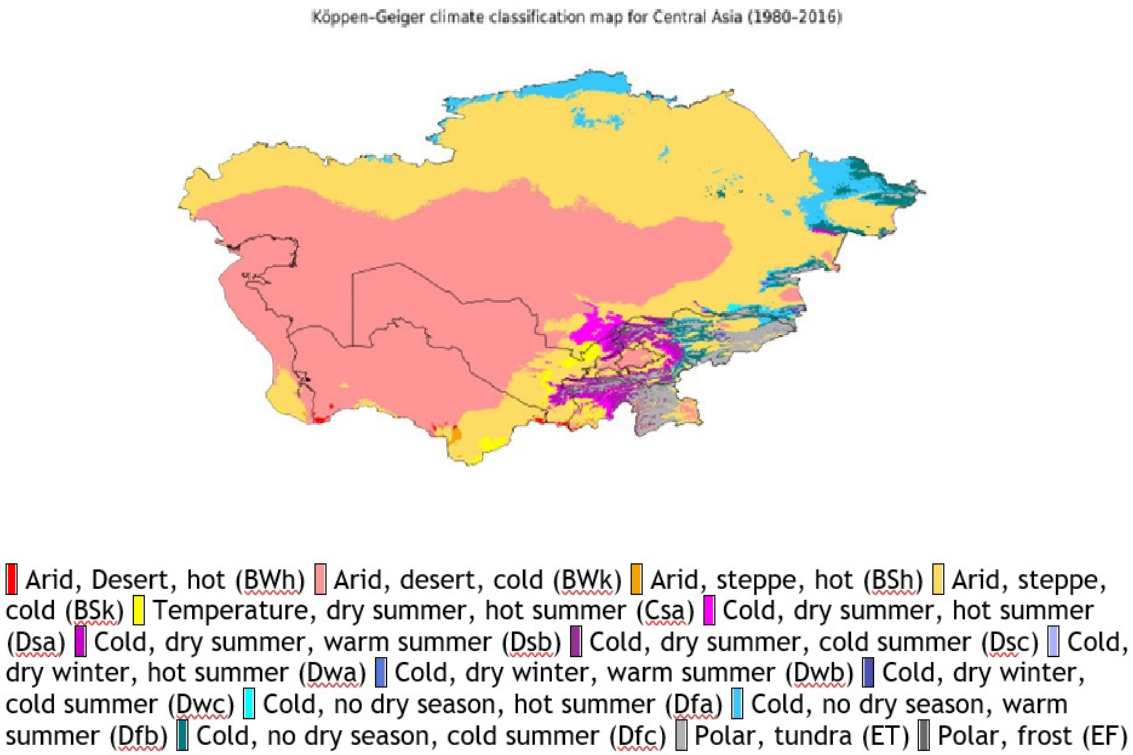

Figure 1. Koppen – Geiger climate classification map for Central Asia (1980-2016) (Beck et al., 2018)

It is predicted that the warming trend will consequently result in a higher evaporation in the basin oases causing growing aridity and a notable retreat of glaciers in the mountainous areas resulting in floods (Yu et al., 2019). There are already negative signs of increased temperatures that cause growing aridity in the region. In 2021, Central Asia experienced an extreme agricultural drought that damaged many crops and caused a deadly effect on livestock. Jiang and Zhou (2023) argue that this episode of serious drought is not an isolated or independent event but a consequence of a dryer trend over the past half century in the region. Melting glaciers, as one of the outcomes of increasing mean temperature, lead to changing water cycles across Central Asian countries. Important mountain ranges of the region such as the Pamir, Altai and Tian Shan Ranges have already recorded alarming decreases of glaciers (Glantz, 2005; Hijioka et al., 2014). Central Asia's glaciers are under significant pressure because they are melting faster than the global average. According to Rounce and others (2023), the region`s glaciers could shrink considerably and experience a loss of 75 percent of their 2015 mass by the year 2100. Predictions suggest that Central Asia will become drier and hotter that will cause changing climate configuration of the region and bring serious environmental challenges to the

most affected areas. Beck et al. (2018) predict that in the period from 2071 to 2100 arid hot areas will significantly increase and affect southern countries of Central Asia, especially Turkmenistan and Uzbekistan, while polar tundra and polar frost areas in the south east will almost disappear suggesting dramatic glacier shrinkages and consequently issues with water supplies in the affected regions (Figure 2).

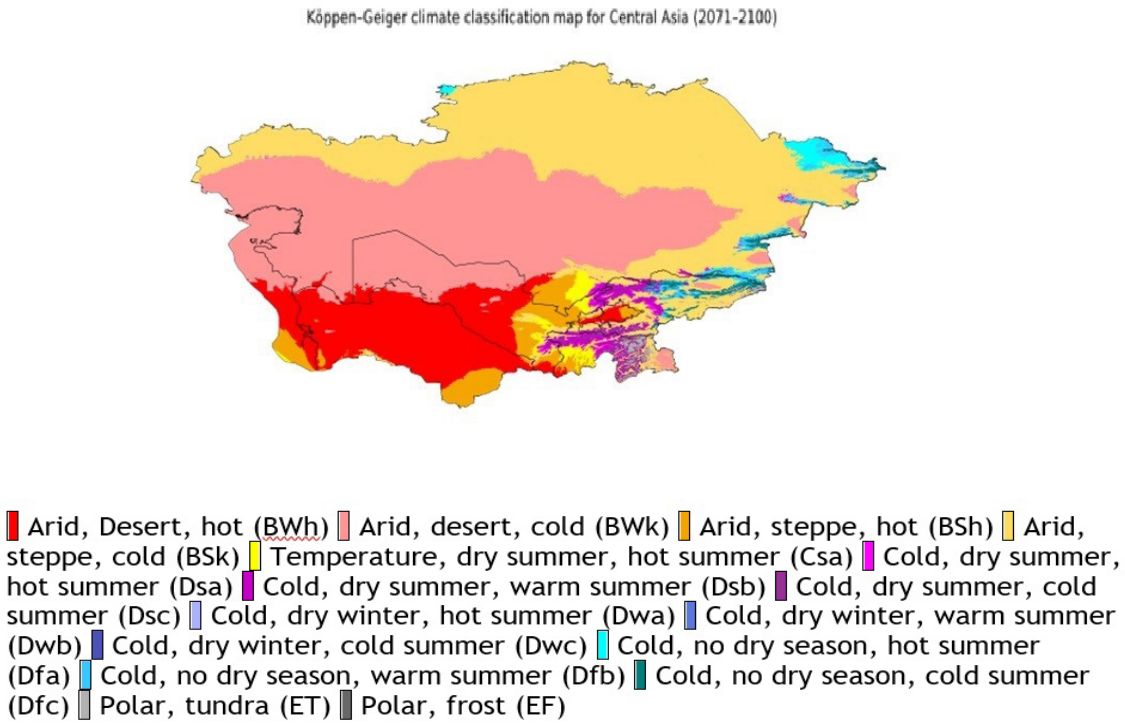

Figure 2. Koppen – Geiger climate classification map for Central Asia (2071-2100) (Beck et al., 2018)

Retreating of glaciers might be also responsible for triggering serious floods and landslides in the region, affecting road infrastructure, livelihood of densely populated areas and migration from affected parts. Some studies suggest that a considerable number of internal migrants migrate for environmental reasons, including mudslides and landslides, floods, hazardous waste and desertification (Jaeger et al., 2009). For instance, the heavily populated and fertile Fergana Valley region is in particular risk of experiencing grave natural disasters such as floods and mudslides, since glaciers surround the valley to the south, the east and the north, which can intensify out-migration from the region (Reyer et al., 2015). Although the melting of glaciers in the short run can bring greater water availability for some communities, in the long run and particularly in the lowlands, with expected increasing aridity, there will be more frequent and more damaging floods and mudflows, as well as increase in water pollution (Kull et al., 2022).

Water availability plays a significantly important role in agricultural areas. Land productivity depends on irrigation and any disturbance including climate change can decrease agricultural output and force affected populations to migrate to more secure areas. The arid and semi-arid parts of Central Asia heavily depend on water supply. However, in the past three decades, this region has suffered from uneven distribution, over consumption, and pollution of water resources causing serious water supply issues and hindering regional sustainability and growth (Yu et al., 2019). With accelerated effects of climate change, water management will probably encounter more issues due to the need for intensified cross-border cooperation and rational usage of remaining water resources.

Most of the major Central Asian rivers and lakes represent trans-border water bodies. Currently, the mountainous regions in Tajikistan and Kyrgyzstan, as places where many regional rivers originate, have enough water for domestic use, however, countries such as Uzbekistan, Turkmenistan and Kazakhstan suffer from water scarcity (Yu et al., 2019) Due to uneven distribution of water resources in the region, trans-border water management cooperation is crucial. However, political rivalries and conflicting economic interests among five Central Asia countries continue to maintain a harmful practice of regional water mismanagement (Howard and Howard, 2016). Dramatic shrinkage of the Aral Sea over the years is an example of how irresponsible irrigation practices and poor water management between countries in the region can harm the local environment (Yu et al., 2019). It is less likely that the countries of Central Asia will start putting more effort in trans-national water cooperation, especially considering their history of water mismanagement. Prolonged water crises can lead to increased out-migration because of its deteriorating effects on local livelihoods, development and security.

Researchers predict that the population living in hotspots that will be particularly affected by climate change will increase for Tajikistan, 55.4 % in Uzbekistan, 41.3 % for Turkmenistan and 31.3 % for the Kyrgyz Republic (Reyer et al., 2017). Rising temperature combined with projected increase of population exposed to climate change will probably increase incidents of drought, prolonged dry periods and poverty rates, which consequently might reduce agricultural productivity and put many rural households in a very vulnerable position.

3. Methodology and Data

This research relies on a non-systematic literature review incorporating assessment of available, although scarce, academic and research studies and reports discussing the topic of climate mobility in Central Asia. A great source of information and data, especially in terms of migration and remittances-related statistics, poverty

data and agricultural productivity information, has been collected from World Bank development indicators databases (World Development Indicators, 2019, 2021). Reports of international and development organizations and agencies, such as IPCC (Hijioka et al., 2014, Shaw et al., 2022), World Bank (Clement et al., 2021), and Asian Development Bank (Chapman et al., 2021), also contributed as a valuable source of information on current climate change impact and migratory trends across the region. Process of collecting information mostly relied on excessive online search concerning climate change, environmental degradation, rural migration and climate justice in Central Asia and beyond. Most commonly used key search words and phrases were “climate change”, “rural migration”, “climate -induced migration”, “(im)mobility”, “Central Asia”, etc.

Several extensive studies on climate change impact and environmentally-induced migration in Central Asia (Reyer et al., 2017; Blondin, 2018, 2021) have been a great source of information that were available online and in English language at the time of writing this research paper. . Such studies also helped in discovering more valuable articles and research through following their referencing work ranging from general studies on climate change impact to case studies focusing on the climate risk and tendencies assessments reports of a single or group of countries. However, even after extensive research and search for articles and reports lack of scholarly attention and research on climate-induced mobility in Central Asia has remained evident. As Hermans (2024) concludes that even though in the past two decades, research on climate change and migration has been widely conducted, but limited to Africa, South Asia, and the United States, Central Asia continues to be “a major blind spot in climate-migration studies”, thus, leaving “critical knowledge gaps”. Although some research limitations related to language and only desk-based research might have affected the paper`s overall comprehensives, still the issue of knowledge gap in the field of climate change impact on migration in Central Asia remains problematic.

4. Lack of Research on Climate-Induced Migration in Central Asia: Overview and Reasons

The Central Asian countries have already experienced serious environmental-induced migration issues. In Kyrgyzstan, between 1992 and 1997, at least 17,000 people had to move from their place of residence because of landslides, mudflows, floods and earthquakes (Sulaimanova, 2004). In 1996, about 100,000 people were forced to resettle due to a severe environmental crisis in the Aral Sea region alone (Small et al., 2001 in ADB, 2012). Furthermore, during the drought period between 1999 and 2001, that is deemed to be responsible for a regional widespread unemployment, about 273,000 people from Karakalpakstan, an autonomous region in Uzbekistan

(about 20% of the region's total population), migrated to Kazakhstan and to the Russian Federation in search of more prosperous economic and job opportunities (Glantz, 2005 in ADB, 2012).

Central Asia has been traditionally sending region and rural to urban migration has been a common trend for a long time. The region represents a strong source for one of the most steady and large-scale external migration outflows in the world, only in 2021 it accumulated around US$ 15 billion in remittances (Figure 3). Many Central Asian countries perceive remittances as a necessary financial lifeline and migration as an effective strategy for alleviating countries` poverty. For instance, remittances in 2020 accounted for around a third of GDP in the Kyrgyz Republic and Tajikistan (Ratha and Ju Kim, 2022).

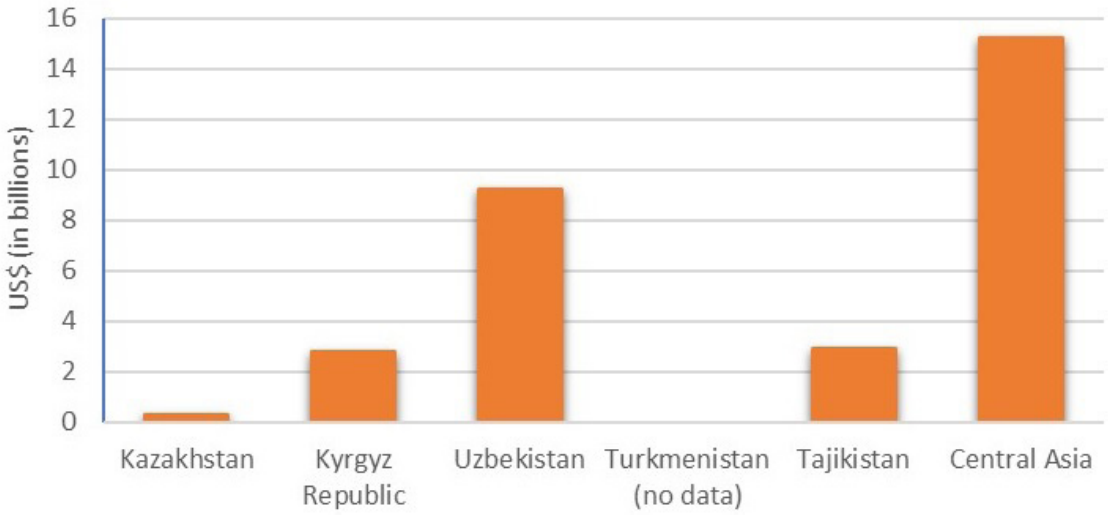

Figure 3. Personal remittances, received (current US$) in 2021 (World Bank, World Development Indicators, 2021)

It is difficult to assess the number of labor migrants from Central Asia, many work illegally or cross the borders multiple times for the purpose of conducting seasonal jobs or do not report migration within the country. As a result, labor migration from Central Asian countries remains typically undetected in both home countries and in the main destination country - Russia. Moreover, to identify the number of rural migrants is even more challenging due to the lack of data and the aforementioned reasons. There are only estimations that most Central Asian migrant workers are from poorer rural areas who are under greater pressure to obtain necessary means for living due to impoverished economic situation and unstable land productivity in the rural environment (Jung and Newson, 2022).

Both internal and migration across the borders in Central Asia are perceived mostly as economically driven necessity. Poverty, lack of job opportunity, low income and limited access to agricultural land are usually identified as major factors for out-migration, whereas climate change is largely neglected and overlooked. However, all of these factors can be repercussions of climate variability (Blondin, 2018). Environmental change inevitably interacts with a range of economic, social, demographic and even political factors, making assessing its effect on migration flows more arduous.

Moreover, absence of information and knowledge on climate change effects among the local population represents a significant challenge for researchers to conduct surveys and interviews concerning climate-induced mobility in rural Central Asia. Even though in some cases, the local population might be aware of environmental issues in their places of residence, connecting such issues with the decision to migrate remains complex and unclear. The 2016 IOM study on environment, climate change and migration in the Kyrgyz Republic questioned 500 households about the reasons motivating people from their village to migrate. While 27% selected unemployment as a main reason for mobility, some chose environmental reasons such as landslides (12%), drought (11%), floods (9%), land degradation (4%) and climate change (3%) (Chandonnet et al., 2016). Local populations in rural areas often recognize social and economic factors as responsible for migratory dynamics in the area of their residence while perceiving environmental factors as mostly a contributing reason for mobility.

The chronic underinvestment in research and lack of financial support, especially to young scientists and researchers in the Central Asian countries also impose constrains on conducting and developing more comprehensive research on climate change-migration nexus in Central Asia (Suleimenov, 2021). Xenarios et al., (2019) draw attention to the negative effects of the scientific and infrastructural vacuum created after the end of the Soviet-era that contribute to knowledge gaps in climate-glacier-water and hazard interactions especially in the Pamir and Tien Shan mountains areas prone to climate-induced distress.

5. Rural Migration and Climate Change in Central Asian Countries

More than half of the population in Central Asia resides in rural areas (Figure 5). Majority of rural inhabitants work in the agricultural sector and depend on its productivity. With growing risk of droughts and other natural disasters caused by climate change, agriculture is under serious threat of decreased output, food scarcity and poverty directly affecting rural residents in the region. Climate variability can intensify migration within a country, especially rural-urban mobility that plays an important role in overcoming the burden of poverty in rural areas of Central Asia.

World Bank (Clement et al., 2021) reports that climate change mostly affects and intensifies internal movements and that, in the best-case scenario, Central Asia will still have 1.7 million climate migrants by 2050.

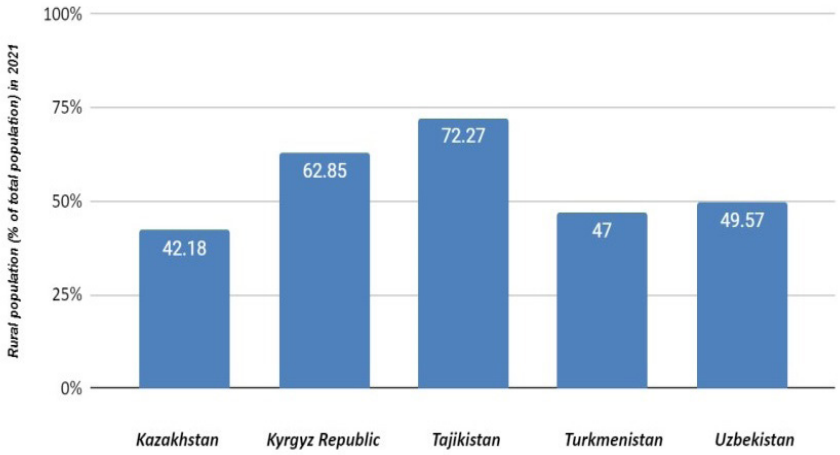

Figure 4. Share of rural population in the Central Asia region in 2021, by country (*World Bank, World Development Indicators,* 2021)

Although scarce data concerning the share of people migrating from and within Central Asia hinder research on regional migration trends, tracking remittances and exploring independent research efforts about migration flows in particular Central Asian countries, can help mapping some common mobility trends and their causes. According to the World Bank (Clement et al., 2021) remittances play a significant part in some of Central Asian countries` GDP, helping impoverished households to meet their basic needs. Sending money from abroad by migrant workers, employed mainly in Russia, contributes to the livelihoods of poor communities in rural areas, (Clement et al., 2021). Many Central Asian countries perceive remittances as a necessary financial lifeline and migration as an effective strategy for alleviating countries` poverty. For instance, remittances in 2020 accounted for around 30 % of GDP in the Kyrgyz Republic and Tajikistan (Ratha and Ju Kim, 2022).

It is difficult to assess the number of labor migrants from Central Asia, many work illegally or cross the borders multiple times for the purpose of conducting seasonal jobs or do not report migration within the country. As a result, labor migration from Central Asian countries remains typically undetected in both home countries and in the main destination country - Russia. Moreover, to identify the number of rural migrants is even more challenging due to the lack of data and the aforementioned reasons. There are only estimations that most Central Asian migrant workers are from poorer rural areas who are under greater pressure to obtain necessary means for living due to impoverished economic situation and unstable land productivity in the rural environment (Jung and Newson, 2022).

A significant share of Central Asians lives in poverty and in rural areas that often lack proper infrastructure, resources and power to resolve many vulnerabilities, inter alia, environmental degradation and ongoing adverse climate change effects. According to Asian Development Bank Data (2021), 25.3% of the total population in Kyrgyzstan still lives below the poverty line. In Kyrgyzstan, labor migration is notable, particularly in rural regions where poverty is especially persistent (Khashimov et al., 2020). Being one of the most remittance-dependent nations in the world, Kyrgyzstan heavily relies on its labor out-migration that represents an important and usually a major source of income for rural households in particular. Environmentally-related hazards such as drought, land and mudslides, flash floods, and glacier lake outburst floods are very common in the country, which increases vulnerabilities and risk exposure for many rural households (Chapman et al., 2021). The Third National Communication of the Kyrgyz Republic report (2016), identifies the agriculture, water management, and energy sectors as most exposed to harmful effects of climate change, while women, children, rural and poorest communities remain the most vulnerable parts of population to climate variability in the country. Considering current migration trends, slow development process and anticipated climate-driven increase of floods and landslides, it is expected to witness an increase in rural-urban as well as external migration in Kyrgyzstan.

Similar to Kyrgyzstan, Tajikistan suffers from a high rate of poverty and unemployment. Although Tajikistan has experienced significant reduction in poverty and improvement of economic conditions in the past decade, yet more than quarter of the total country's population lives below the poverty line and the economy cannot cope with the growing population in terms of job creation and more stable economic environment (World Bank, 2022). This mountainous Central Asian country is highly vulnerable to climate change and environmental disasters, which can exacerbate already serious economic challenges and encourage migration especially from rural areas. The World Bank (2022) estimated that in the period from 1992 to 2016, natural and climate-related calamities inflicted GDP losses of around US$ 1.8 billion, affecting almost 7 million people in Tajikistan. In the country, the rural population represents a highly significant percentage of the total population (72.27%), while agriculture remains a main sector for employment in rural areas (Chapman et al., 2021). Hofman (2021) argues that a high level of external migration in Tajikistan is predominantly a consequence of the lack of meaningful domestic employment opportunities and a response to hardships in rural areas of the country. Moreover, Hofman adds that rural-urban migration is less common due to lack of substantial employment opportunities across the country. It is estimated that the increased drought periods caused by climate change will have indirect impacts on agriculture and direct effects on potable water supply that will consequently negatively affect

some of Tajikistan's poorest communities (Chapman et al., 2021). Even though the poverty rate in Uzbekistan (11.5%) is lower compared to Kyrgyzstan and Tajikistan, this country suffers from water scarcity and population growth that in the near future can represent a serious challenge and cause increased eco-migration. It is one of the most populous country in Central Asia (Khashimov, 2020) with the population of the republic increasing an average of 650 - 700 thousand people annually; following the current trend, it is estimated that Uzbekistan's population will reach 39 million by 2030 (Eureporter.org, 2021). However, experts suggest that such population increase will also raise water demands by 18-20% and add additional pressure to the already scarce water supply in the country (Eureporter.org, 2021). Another factor that makes Uzbekistan highly vulnerable to climate change impact is that 78% of the country's total area is desert, which increases risks of prolonged periods of droughts and water scarcity (Climateadaptationplatform.org, 2021). Rural to urban migration will probably increase in the foreseeable future, especially due to estimations that the Ferghana Valley in Uzbekistan and Tajikistan, as well as southern Uzbekistan along the Amu Darya will become hot spot pockets reflecting projected reductions in water availability and agricultural productivity (Clement et al.,. 2021).

Despite being one of the most developed country in the Central Asia region, Kazakhstan suffers from a negative net migration (Khashimov, 2020) and is also susceptible to adverse climate change impacts. Kazakhstan's Seventh National Communication and Third Biennial Update Report (2017) recognizes the agricultural sector, water resource and human health as most vulnerable to climate change in the country. The joint report of World Bank and Asian Development Bank on climate risk in Kazakhstan (Chapman et al., 2021) expects that increased droughts in the country might reduce crop yields, cause death of livestock, endanger drinking water supplies, and accelerate the process of soil degradation. Considering current migration trends and expected adverse climate change impact, it is highly likely that Kazakhstan`s rural areas will be the most affected and prone to internal as well as external migration.

Due to the tight state control over media and information services in Turkmenistan, it is very difficult to acquire any official data including the country's migration statistics. However, this Central Asian country, similar to other countries in the region, has experienced a negative migration net ever since the collapse of the Soviet Union (Khashimov, 2020). Turkmenistan, as most of the region, is highly dependent on water supply because of its arid climate. Land scarcity is another serious issue that affects Turkmenistan since about 80% of the country is covered by desert (Duan et al., 2019). Even though this country is rich in oil and gas resources, it remains an underdeveloped, primarily rural country with the majority of population depending on agriculture whose livelihoods are especially vulnerable to climate change (Lioubimtseva et al., 2014).

Reyer and others (2017) argue that climate change might intensify internal mobility of people in Central Asia as well as from the region to the Russian Federation. The rural–urban migration research has received little attention in the region; few infrequent scholarly work reveal connection between migration and environmental degradation, which can be considered as an important breakthrough in eco-migration studies in Central Asia. These rare studies on climate mobility in rural parts of Central Asia suggest that internal migration can be intensified with deteriorating irrigation and water supply scarcity (Bekchanov and Lamers, 2016), as a repercussion of food scarcity (Aleksandrova et al., 2014), or by the subsequent adverse change of decreased agricultural labor productivity (Reyer et al., 2017). These worsening environmental processes can all be attributed to climate change to various extent. Agriculture, as one of the important sectors of the economy across the region, is highly exposed and vulnerable to the adverse effects of climate change. According to World Bank data in 2019, the share of agriculture in the GDP of the countries in the region accounted from 4.5% to 25% (Figure 4), exposing a rich diversity of agricultural production in Central Asia.

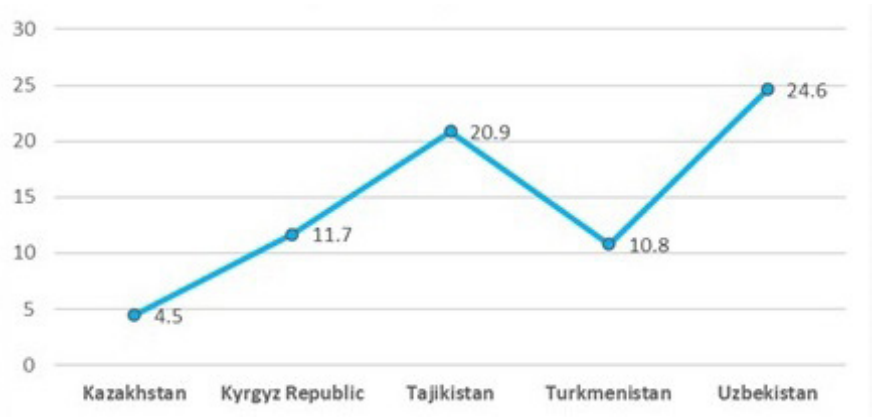

Figure 5. Agriculture, forestry, and fishing, value added (% of GDP) in 2019 (World Bank, World Development Indicators, *2021)*

Rural population is directly affected by changes in agricultural productivity and they are first in line to experience any repercussions of changing land cultivation, such as reduced income or food shortages. Decreased agricultural yield usually causes income reduction in agricultural areas that consequently leads to increased rural poverty, and eventually to intensified rural migration (Christmann at el., 2019). However, the effect of climate change for agriculture does not necessarily have to be negative. Some estimations suggest that rising temperature could have a positive impact on cooler and northern areas of the region including extended growing season, expansion of the land available for agricultural production and

higher agricultural output (Liu at el., 2020). In such an optimistic scenario, areas with increased agricultural productivity might increase in-migration and reduce local mobility by providing better and more secure livelihoods with enhanced land outputs (Blondin, 2018). Nonetheless it is not possible to assess with certainty to what extent such changes may contribute to rural-rural movements or rural-urban mobility to the northern parts of the region (Reyer et al., 2017). Agriculture in Central Asia will be exposed to various challenges as well as opportunities due to climate variability, including changes in migration trends within the region.

6. Rural Immobility

Even though adverse effects of climate change can increase out-migration, especially internal migration, there are concerns that the most vulnerable will stay put, suffering the most due to lack of resources to move or simply because they feel attached to the land and communities of their residence (Blondin, 2018). Involuntary as well as voluntary immobility in the context of climate change deserves greater attention especially in studies concerning eco-migration in Central Asia.

Lack of mobility in the region is particularly evident in the poorest rural areas, which are most affected by natural disasters and changing climate. Some research suggests that the poorest who are highly exposed to food insecurity, water deficit and thus most vulnerable to adverse effects of climate change, usually are more likely to remain trapped than to migrate to more prosperous environments (Zaveri et al., 2021; Zickgraf, 2019). In Central Asia, women and children in rural areas are especially vulnerable to climate variability due to increased male-migration and greater exposure to hazard-prone areas. For instance, women residing in rural areas of Kyrgyzstan with frequent floods and landslides incidents are forced to be more involved in agriculture and livestock activities because of considerable male migration, which places them in more unsafe situations (Kelly et al., 2013). The poorest rural dwellers in Central Asian countries, besides being among the most exposed to negative consequences of ongoing climate change, are also more susceptible to the risk of involuntary immobility due to lack of means to migrate or absence of information on mobility options and the possible risks they are faced with.

Voluntary immobility phenomenon has recently acquired more scholarly attention, especially in the context of ongoing debate regarding negative consequences of climate change on rural communities in Central Asia (Blondin, 2018; 2021). The variety of cultural, emotional, spiritual, and social bonds can form a strong feeling of place attachment (Blondin, 2021) that often plays a critical role in the decision to remain rather than move to less affected areas. Blondin (2021; 2022). Many locals are not keen to migrate because they develop a strong bond to their place

of residence and local communities. The notion of the watan (homeland) for some Tajik local population is highly significant that migration is perceived as the ultimate, unfavorable solution, exercised only in cases of extreme environmental incidents. Some households, if they are eventually forced to move, decide to relocate closest to their previous place of residence in order to maintain the social and emotional ties to their villages (Blondin, 2018).

Several studies suggest that gender can have a significant influence on immobility (Schewel, 2019), especially in the context of climate risks (Tripathy Furlong at el., 2022), emphasizing separated gender roles that perceive women as those who stay behind being responsible for maintaining households and taking care of children and elderly members of their families, while men migrate in search for better economic opportunities. Although some countries of Central Asia have experienced increased feminization of migration (Asel, 2020), mobility is still male dominated across the region. Through the prism of the immobility dimension, women, children, elderly and poorest rural dwellers remain the most vulnerable category to climate risks across the region, regardless if staying put is reality based on a voluntary or involuntary reasoning.

7. Concluding remarks

Adverse changes in the habitual human environment provoked by global warming that range from abrupt and disastrous to long-term and gradually deteriorating ones, can exacerbate rural economic and security situations, prompting affected populations to migrate or at least consider moving to a more bearable environment (Lukyanets et al., 2020; Jäger et al., 2009). Although some studies suggest that the evidence for a connection between migration and climate change is largely frail mostly due to gap in the knowledge base and the complexity and abundance of other push and pull factors that dictate migration flows alongside environmental change (Reyer et al., 2015; Asian Development Bank (ADB), 2012), there are still strong conclusions that environmentally-induced migration will become more prominent and that many countries, including Central Asian countries, have already been affected by this phenomena

Due to its geographical position and climate configuration, Central Asia is significantly prone to the climate crisis consequences. In addition, this region is susceptible to both internal and external migration that may intensify in the future because of deteriorating environmental conditions especially in rural areas. Researching climate migration has become a significantly important area of study because of its global reach and effect. However, studying the climate change-mobility nexus in Central Asia represents a great challenge for various reasons. First of all,

lack of data and research on the impact of climate change in the region, which might be contributed to the general lack of interest due to more pressing socio-economic and political issues affecting Central Asian countries. Furthermore, finding a solid proof for a connection between migration and climate change is a challenging matter not only due to gaps in the knowledge base but also because of the complexity and abundance of other push and pull factors that dictate migration flows alongside climate variability.

Recent research study on eco-migration predicts that Central Asia, even in the most optimistic scenario, will experience intensified climate migration in the foreseeable future (World Bank, 2021). Moreover, the region is already considered a climate hotspot with rising temperatures considerably above the global mean. Rural areas and populations in particular are expected to bear the majority of negative consequences of climate change because of their dependency on agricultural productivity that can be affected the most by the ongoing climate crisis with more frequent and devastating natural disasters. Since more than a half of the Central Asian population resides in rural parts who are highly exposed to intensified environmental degradation, the volume of rural out-migration will probably increase. Across the region, climate change will bring increased aridity and intensified melting glaciers that can force many households to consider moving to more bearable environments.

While researching the climate mobility trends in Central Asia, it is important to include situations where impoverishment or other social and emotional bonds prevent people from migrating despite apparent environmental risks and hazards. Often the most vulnerable parts of the population such as women, children and elderly in affected rural areas are faced with lack of mobility either due to gender or poverty reasons. Migration in Central Asia is still male dominated while women usually stay behind to tend the households in environmentally insecure areas. Involuntary immobility in the context of ongoing climate crisis should therefore be equally considered when drafting development and adaptation climate agendas. However, voluntary immobility, based on a feeling of attachment to the place of residence or origin, is also present in some remote rural areas in the region and important for further research.

Climate change does not affect everyone equally and not everyone is equally responsible for the climate crisis. However, often the poorest, rural inhabitants who are more exposed to devastating natural disasters and at risk of being forced to migrate or trapped in their place of residence, unjustifiably suffer more from negative consequences of climate variability. Being highly susceptible and vulnerable to climate change impact as well as to climate (im)mobility trends and climate injustice, the rural population in Central Asia should receive greater scholarly attention in climate change and eco-migration research.

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Coal mine methane in Kazakhstan: economic and environmental case study

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ABSTRACT

The study aimed to evaluate the economic and financial viability of a coal mine methane (CMM) utilization project in Central Kazakhstan, demonstrating a methodology for similar initiatives. The analysis was based on the 2013 project proposed by the US Environmen-tal Protection Agency (EPA) that intended to capture methane emissions from six coal mines for electricity generation, yet was never implemented. The study's relevance stems from Kazakhstan's 2030 methane pledge, recent progress in the country's climate change-related policy, mineworker mortality in 2023, and the shift of mines ownership. Building upon the technical specifications of the 2013 US EPA project, this research em-ployed standard financial and economic cost-benefit analysis (CBA). The financial model utilized a traditional discounted free cash flow approach, while the economic model in-corporated additional factors like the value of statistical life (VSL), shadow pricing, as well as benefits associated with mitigating ozone health impacts, crop damage, mine ex-plosion risks, and CO2 emissions. The economic model has indicated a positive net pre-sent value of $243 mln and 42% internal rate of return. The financial analysis also sug-gests potential profitability under fair electricity and carbon pricing market conditions. To assess project robustness under varying economic and financial assumptions, the study included a sensitivity analysis. The research has likewise leveraged prior CMM-related studies in Kazakhstan and provides valuable guidance for analyzing similar projects. In addition, it also highlights the need for certain adjustments in the current legislation to incentivize such projects, as well as to promote environmental sustainability and social development by mitigating methane emissions, which aligns with Kazakhstan's climate goals.

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1. Introduction

A series of methane explosions at Central Kazakhstan's coal mines between 2021 and 2023 claimed 57 lives. Such incidents highlight not only the human cost but also the safety risks associated with uncontrolled methane release during coal mining (Küçük & Ilgaz, 2015). Echoing similar events from 2004-2011 with 104 casualties as shown in Table I., these accidents prompted the Kazakh government to push for a change in the ownership of ArcelorMittal Temirtau JSC (AMT) that resulted in ArcelorMittal, an international steel group, selling its stake to a local investor in 2023, and the company's rebranding as Qarmet JSC (Qarmet) (GMK Center, 2023).

Table I. Explosions at AMT coal mines in 2004-2023.

Mine	Accident reason	Fatalities	Injured	Date
Lenina	Methane explosion	23	3	2004
Lenina	Methane explosion	41	12	2006
Abayskya	Methane explosion	30	-	2008
Tentekskaya	Coal and gas blast	5	-	2008
Tentekskaya	Coal and gas blast	3	1	2009
Kuzembayeva	Coal and gas blast	2	-	2010
Abai	Gas and coal blast	6	2	2021
Kazakhstanskaya	Fire	5	-	2023
Kostenko	Methane explosion	46	-	2023
TOTAL		161	18	

Local news sources in Kazakhstan (Tengrinews, 2023).

Beyond the immediate human cost, methane is also recognized as a potent greenhouse (GHG) gas with a global warming potential (GWP) of 28-36 and 84-87 times that of CO2 over 100 years and 20 years, respectively, a significant increase from earlier estimates (US EPA, 2023). The coal mining industry is one of the major contributors, accounting for roughly 11% of global methane emissions from human activities (Miller et al., 2013; Schwietzke et al., 2016).

Recognizing the urgency of reducing methane emissions, international efforts are underway. Discussions like these in Miller et al. (2021) deem methane a "super pollutant", as well as emphasize capturing methane from various sources and improving agricultural practices. Implementing such strategies, alongside a global methane agreement, could significantly reduce near-term warming. Following COP26, the Glasgow Climate Pact solidified the international commitment to this goal, aiming for 30% reduction in methane emissions by 2030; and was followed by the Global Methane Pledge (GMP) endorsed by over 120 countries collectively responsible for 50% of global human-caused methane emissions (UNEP & CCAC, 2022).

The Republic of Kazakhstan (RK), a country possessing vast energy resources, is well-positioned to contribute to these efforts, and has committed to 30% reduction in methane emissions by 2030 at COP28 (GMP, 2023). As the world's 9th largest country, Kazakhstan boasts substantial oil, natural gas, and coal reserves, making it a significant actor in the international energy market. However, its domestic electricity supply is poorly diversified, with aging power-generation assets heavily relying on fossil fuels (KEGOC, 2022). Local supply often struggles to meet demand, with peak periods requiring imports, primarily from Russia (Kursiv Media, 2023).

Recognizing the need to diversify energy sources and enhance environmental protection, Kazakhstan has set ambitious renewable energy (RE) goals – the country aims for 50% of its 2050 energy supply to come from renewables and nuclear, ultimately achieving carbon neutrality by 2060 (President of the RK, 2023). KEGOC, the national grid operator, has outlined these goals within the framework of the Energy Balance of Kazakhstan until 2035. This plan assumes expanding the installed generation capacity up to 44 GW by building new renewable and traditional generation systems LS (2023).

One promising diversification avenue lies in utilizing coalbed methane (CBM), a natural gas found in coal seams. Kazakhstan possesses abundant CBM reserves estimated at 2.0-4.3 tn m^3 (Wang et al., 2024). Yet, CBM remains largely untapped, presenting a unique opportunity.

This context highlights the timely opportunity to revisit and update the comprehensive pre-feasibility study sponsored by the US EPA in 2013 that focused on implementing a Coal Mine Methane (CMM) Drainage and Utilization system across six AMT-owned mines in Central Kazakhstan (US EPA, 2013). While it provides a valuable foundation, recent events necessitate updating data on mine conditions, methane emissions, and potential CBM reserves to ensure a robust cost-benefit analysis (CBA) of the proposed project.

It is noteworthy that this research targeted CBA and not updating the EPA study itself. Qarmet, the current owner of the coal mines, is best positioned to harvest and upgrade the information on CMM reserves and potentially implement

technological advancements within their specific context. Against this background, this study aimed to demonstrate how valuation techniques can be applied to this real-world energy project via a comprehensive CBA.

Furthermore, Qarmet's current financial standing – characterized by acquisition costs ($286 mln), debt obligations ($450 mln in deferred payments) (GMK Center, 2023), as well as ambitious expansion plans targeting 64% increase in steel output and 47% boost in coal mining (Forbes Kazakhstan, 2024) – requires careful review. These factors, coupled with the recent tragic accidents, underscore the urgency of addressing methane emissions effectively.

By providing a comprehensive CBA with complete methodology, this paper aims to evaluate the economics of the EPA-proposed project and inform investment decisions, contributing to a cleaner and safer future for Kazakhstan's energy sector. It targets not only Qarmet and Kazakhstan's government, but also the academic community, contributing to the knowledge base on cost analysis of alternative energy sources in developing countries. The paper is structured as follows: Section 2 describes the methodology and key assumptions of the CBA model; Section 3 presents the model outputs, sensitivity analysis, and discussion; and, Section 4 contains conclusions.

2. Model description

2.1. Methodology

The primary goal of this study was to conduct an economic analysis of project feasibility from the perspectives of three key categories of project participants: (i) financial investors in the power plant (both equity and debt holders), (ii) coal mine owner, and (iii) society at large. To achieve this, the research team has developed a comprehensive economic model based on the standard discounted cash flow (DCF) approach.

This study comprised a thorough collection and review of data from public sources, including academic literature, business journals, news agencies, ArcelorMittal's official press releases, as well as state agencies and international organizations; and, expert opinions from the energy and financial sectors. Additionally, the authors conducted site visits to relevant projects, including a pilot coal methane power plant at the Lenina Mine operated by ArcelorMittal and a larger-scale coal methane power plant in Doncaster, United Kingdom. These visits took place several years ago when ArcelorMittal was still the owner of Qarmet, and included interviews focused primarily on the technical aspects of operations.

The economic model applied in this study was specifically designed to assess the net benefits accruing for each participant category:

1. Financial analysis for investors has estimated the private net benefits for financial stakeholders, focusing on revenues from electricity sales and carbon allowances. The model evaluated the power plant profitability from the point of view of equity and debt investors;

2. Financial analysis for mine owner has captured the private net benefits specific to the coal mine owner, including increased mine productivity, reduced compensation costs for accidents and injuries, decreased environmental fees, and revenues from gas sales;

3. Economic analysis for society has expanded the analysis to consider broader social benefits, incorporating both private gains and additional public advantages. The social benefits include GHG reductions, enhanced public health, improved agricultural production, and lower mine explosion risks. The benefits underwent quantification and monetization to render a comprehensive understanding of the project's impacts on social welfare.

Fig. 1. below visually summarizes the methodology, outlines the linkages between different models, and highlights the economic techniques applied at each stage of the analysis. The following sections describe key project assumptions, types of benefits (private and social), and specific economic techniques used.

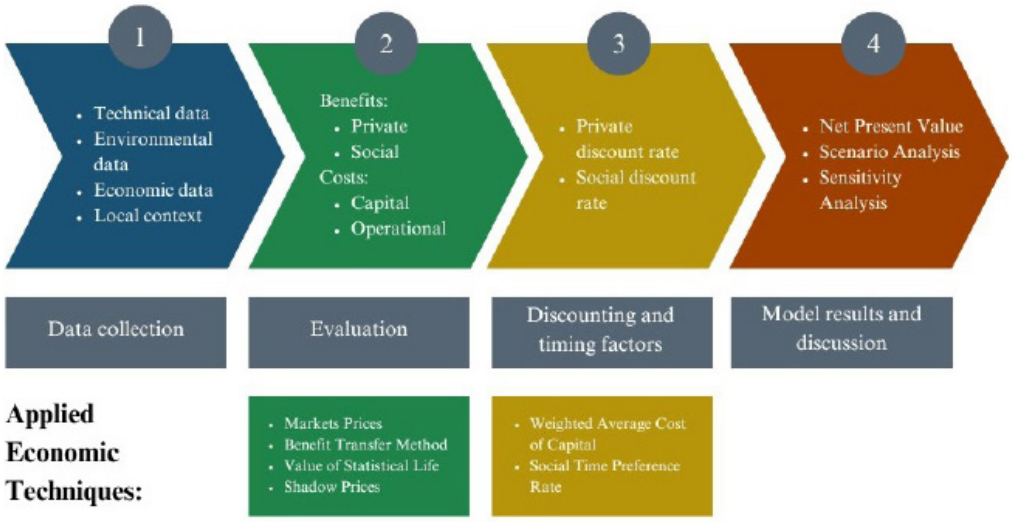

Figure 1. Methodology matrix

2.2. Theoretical framework and background (literature review)

The academic literature on cost-benefit analysis has evolved significantly over the past century, with early contributions focused only on public sector investments

in infrastructure, health, and environmental protection (Johansson, 1993; Prest & Turvey, 1965). In high-income countries, CBA methodologies have been subject to progressive refinement to include a wider array of economic and social benefits. However, in middle-income and resource-rich countries, the application of CBA to energy projects, particularly renewable energy, was relatively limited until the early 2000s, largely due to unique economic and regulatory challenges (Ramadhan & Naseeb, 2011; Yang, 2009).

In the context of coal methane utilization, in the late 1990s and early 2000s the literature was also scarce focusing primarily on technical and regulatory aspects, with little emphasis on comprehensive economic evaluations (IEA, 2009; US EPA, 1998). Yet, recent years have witnessed a noticeable growth of studies examining the economic feasibility of CMM projects, particularly in large and resource-rich countries.

For example, (Hummel et al., 2018) explored methane drainage optimization in Indian coal mines. The study by (Nepsha et al., 2023) examined the economic benefits of CMM utilization in Russia, highlighting the potential for cost savings and emissions reductions. Similarly, Sander & Connell (2012) study on enhanced coal mine methane drainage in Australia underscored the importance of supportive policies, such as CO2 penalties and electricity pricing, for project viability. Wang et al. (2023) research on coalbed methane in China further confirmed the economic and environmental benefits of methane utilization, although it also noted the impact of policy uncertainties on project growth.

This study aims to contribute to this expanding body of literature by providing a detailed economic evaluation of a CMM project in Kazakhstan, a country with significant CMM emissions but limited previous thematic research. This research not only fills a gap in the existing literature but also offers a replicable framework that can be applied to similar projects in Central Asia and other developing regions. The methodology and findings presented herein are intended to inform future research and policy decisions, particularly in countries where energy market dynamics differ from these in high-income economies, ensuring the continued relevance and applicability of CBA in diverse economic settings.

2.3. Project description

Qarmet JSC owns and operates eight underground coal mines in Central Kazakhstan, six of which are classified as highly gassy with methane content ranging between 8.5 and 27.0 m^3 per ton (US EPA, 2013). To address safety concerns and improve methane capture capabilities, the implementation of methane drainage systems is necessary. As regional gas consumption and local prices are insufficient for direct coal mine methane (CMM) consumption by households and businesses, the

EPA study concluded that utilizing CMM for electricity and heat generation was the most viable option, and suggested the construction of several small power plants (2-3 units per mine) connected by a single gas pipeline. These power plants would utilize captured CMM as fuel to generate electricity, which then could be sold to the market or used in Qarmet's steel production.

The (US EPA, 2013) study estimated CMM levels to be sufficient for building an energy complex with the total installed capacity of 40 MW in two phases: the 19 MW phase followed by the 21 MW phase, with the second phase contingent on the success of the first, as shown in Table II. The total project investment was estimated at $54 mln, including $38.6 mln under Phase 1 and $15.4 mln under Phase 2. The combined capacity of the power plants was estimated at 298 mln kWh per annum, with the estimated project's operational life of 30 years, totaling 32 years due to the potential delay in completing Phase 2. The project was expected to achieve annual methane consumption exceeding 226 mln m^3.

Table II. Project installed capacity by phase and mine.

Mine	Phase 1 installed capacity (MW)	Phase 2 installed capacity (MW)	Total installed capacity (MW)
Kuzembayeva	3	4	7
Saranskaya	2	10	12
Abayskaya	8	3	11
Kazakhstanskaya	2	0	0
Lenina	3	3	6
Tentekskaya	1	1	2
Total	19	21	40

Based on the pre-feasibility study's assumptions, the project was expected to have a positive net present value (NPV) of $7.6 mln at 10% discount rate with the internal rate of return (IRR) of 13.3% for a 10-year equity-financed scenario. The sale of carbon credits, if included into the analysis, can significantly improve the project's financial viability, pushing the NPV up to $53.3 mln and IRR up to 30.9%, as well as shortening the payback period from six to four years. Consequently, the EPA recommended conducting a full feasibility study, incorporating an in-depth analysis of Kazakhstan's current climate change regulations. It is important to note that the financial results described above come from the US EPA's pre-feasibility study of 2013 and may not reflect current market conditions. The original study referred to ArcelorMittal Temirtau JSC as the owner of the mines, updated to Qarmet JSC in this paper to reflect the current owner.

2.4. Model assumptions

The EPA pre-feasibility study contained important and detailed information on the capital cost structure and technical feasibility of executing the project. However, the model required further improvements, especially in terms of accuracy of the project's valuing costs and benefits, and clarification of funding sources (debt to equity structure). As the EPA study was published in April 2013, it didn't capture the annual devaluation of Tenge (Kazakhstan currency) during 2014-2022. The EPA's main financial analysis scenario also suggested that electricity prices would rise faster (11.4% annually) than operating and maintenance (O&M) costs (7.4%), which may not be necessarily true as evidenced by the historical data from the Consumer Price Index (CPI) and electricity tariffs statistics (can be explored in more detail in the Supplementary Data file attached to the study). Hence, the CBA presented in this paper manifests an advanced version of the EPA's financial model with additional economic analysis and certain other factors detailed as shown in Table III.

Table III. Model assumptions

Parameter	Value	Source/Comment
Annual electricity output	298 mln kWh	(365 days x 24 hours x 40 MW) / 1,000 based on 75% of Engine Capacity Factor
Electricity price	¢3.00 per kWh	Mean electricity tariffs obtained by the Single Purchaser in 2H2023 converted to USD at official rates set by the National Bank (RFC for RES, 2024)
O&M costs	¢1.82 per kWh	EPA's assumption based on data obtained from potential suppliers and adjusted to January 2024 prices using US Bureau of Labor Statistics' CPI Inflation calculator (US BLS, 2024)
Average number of employees	35	5 employees per site x 6 sites + 5 admin stuff
Mean gross salary per employee	$830 per month	Mean salary in the region, according to Kazakhstan's statistical agency (QazStat, 2023)
Annual methane consumption	226 mln m^3	EPA estimates based on data obtained from AMT
Funding structure	40% - equity 60% - debt	Observed data in Kazakhstan

Cont. Table III.

Debt financing terms	7 years for each of the two installments at 7.3% annual interest rate	Observed data in Kazakhstan, National Bank of the RK
Annual CO2 mitigation	1.8 mln tons	EPA estimates with some adjustments to utilization rate (85% versus 100% assumed by EPA)
Total capital costs	$72 mln	EPA assessment adjusted to January 2024 prices using US Bureau of Labor Statistics' CPI Inflation calculator (US BLS, 2024)

2.5. Valuation of private benefits

As the project was suggested for implementation by separate entities, two project participants receive private benefits: the mine owner (Qarmet, in particular) and financial investors, including equity and debt investors. Private benefits have a monetary form and will be received in cash by each of the participants.

While the calculation of private benefits for project investors (presented in the Supplementary Data file attached hereto) is a standard procedure based on the formula below, the benefits for the coal mine owner require an additional review, detailed in further sections.

To calculate the project's net benefits, a standard discounted cash flow (DCF) model was used with the standard financial NPV applied (Damodaran, 1994):

$$NPV_{INV} = \sum_{i=1}^{n} \frac{FCF_i}{(1+r)^i} \quad (1)$$

$$FCF = EBIT * (1 - CIT) - Capex + D\&A + \Delta WC \quad (2)$$

, where

FCF is free cash flow,

EBIT is earnings before interest and tax (calculated separately for each type of project participant and explained in this section below),

CIT is corporate income tax (20% in Kazakhstan (Zan.kz, 2024)),

Capex is capital expenditure,

D&A is depreciation and amortization,

ΔWC is changes in working capital,

r is discount rate,

and n is number of periods.

Increased mine productivity. Project implementation will help boosting and stabilizing gas utilization, boosting the productivity of labor and operations by avoiding mine shut downs usually due to high methane content in ventilation systems. In its turn, higher productivity will lead to higher coal production and/or higher profit margins (IEA, 2009).

The data from previous years suggests that coal mining can reach up to 8.3 mln tons annually (ArcelorMittal, 2022, 2023a). The new owner (Qarmet JSC) aims to achieve an even higher target of 9.0 mln tons (Forbes Kazakhstan, 2024). Considering the average net margin of 17.5% within Kazakhstan's coal sector (KASE, 2024), a conservative estimate of 0.1% improvement in profitability due to the project's efficiency gains can yield significant financial benefits for Qarmet. It is important to acknowledge that while the project is expected to significantly reduce mine shutdowns, it may not eliminate them entirely. Therefore, the conservative assumption of 0.1% profitability improvement serves a cautious estimate to ensure a realistic assessment of the project's financial impact.

As Qarmet produces steel, there is potential to shift towards "green steel" production by involving processes that significantly reduce GHG emissions based on renewable energy and other advanced technologies like hydrogen or carbon capture (Muslemani et al., 2021). Yet, this model does not account for additional benefits related to the steel's reduced carbon footprint, as it assumes that the electricity generated will be sold to the Single Purchaser and not used directly in steel production. Additionally, coal pricing was not factored into the model as Qarmet owns both the steel production facilities and the coal mines. If the coal was owned by a different entity, the potential to sell less carbon-intensive coal at a higher price could be explored, and the pricing dynamics might differ, requiring separate examination.

Reduction of compensations for fatalities and injuries. The reduced risk of explosions diminishes expected compensations paid by Qarmet for fatalities and/or injuries as the result of mine explosions. The Kostenko Mine disaster in October 2023 serves a stark example of the financial repercussions of such accidents.

ArcelorMittal, the former owner, incurred significant costs (ArcelorMittal, 2023b), in-cluding a one-off payment equivalent to 10 years' salary (up to $180,000 in total, assuming the reported average coal worker salary at $1,500/month Anon (2023), covering all fu-neral and memorial expenses (around $5,270 per person as reported by Ranking.kz (2022), purchasing housing, repaying personal loans (deceased and family members) and covering education fees for children up to the age of 23 – bringing the total potential compensation per deceased worker to at least $300,000.

By mitigating the risk of explosions, the project has the potential to significantly reduce the aforementioned costs. The economic benefit from reduced expected compensation (BC), therefore, can be expressed mathematically as:

$$BC=E(C_1)-E(C) \quad (3)$$

, where

BC is benefit from reduced expected compensation,

$E(C_1)$ is expected compensation costs after project implementation and safety improvements,

and E(C) is expected compensation costs before project implementation.

In simpler terms, implementing the project will allow Qarmet to potentially reserve less cash for anticipated compensation pay-outs in the event of mine accidents.

Reduction of environmental payments. According to the Tax Code of the RK, local emitters pay a tax of ¢8.0 for each ton of me-thane emitted Code of the Republic of Kazakhstan (2024). The project is expected to prevent the emission of 192 mln m^3 of methane annually. Using the EPA's Coalbed Methane Outreach Program data (US EPA, 2024), where 1.0 m^3 of methane weighs 0.6802 kg, this reduction equates to approximately 131,000 tons of methane emissions. At the rate of ¢8.0 per ton, the project implementation is expected to save Qarmet approximately $10,448 annually on these taxes (factored in the model).

Total net benefits for Qarmet. The net benefits for Qarmet JSC, therefore, represent a sum of all benefits excluding investment required inside the mines:

$$NPV_{QARMET} = \sum_{i=1}^{n} \frac{GS_i + BPI_i + BC_i + SE_i - I_i}{(1+r)^i} \quad (4)$$

, where

GS is gas sales (revenues from methane sold (set at "0" in this study),

BPI is benefits from improved coal mining productivity,

BC is benefits from reduced compensations for deaths and injuries,

SE is savings on ecological payments,

I is investment in coal mines,

r is discount rate applied by coal miner,

and n is number of i periods.

The detailed calculation of net benefits for the mine owner is presented in the Supplementary Data file attached to the study.

2.6. Valuation of social benefits

Social or public benefits can be defined as an increase in social welfare. As discussed in the next sections in more detail, methane emissions contribute to global warming, ground-level formation of ozone – a harmful air pollutant responsible for an

estimated 500,000 premature deaths annually and damaging ecosystems and crops (UNEP & CCAC, 2021), and safety hazards within coal mining operations. In case of execution, the project may offer the following potential social benefits:

1) lower carbon dioxide (CO2) and methane (CH4) emissions;

2) due to capturing methane, significantly reduced risk of explosions and associated fatalities at coal mines;

3) mitigating methane emissions can contribute to lower ozone levels, potentially reducing respiratory illnesses and improving crop yields.

Valuating social benefits, particularly these related to environmental improvements, poses a challenge due to the absence of established market prices. Traditionally, economists address this through revealed preference (RP) analyzing individuals' actual behavior in the marketplace to infer their preferences for non-marketed goods, and stated preference (SP) methods, which rely on surveys or experiments to directly ask individuals about their willingness to pay (WTP) or accept (WTA) compensation for changes in environmental quality. These methods, along with the development of economic theory, have led to the emergence of various valuation techniques. Further details on RP, SP, and specific valuation techniques can be found in the relevant textbooks (Baker & Ruting, 2014; Haab & McConnell, 2002).

As the literature database has continued to include more studies on appraisal of different types of non-market goods, the Benefit Transfer Method has evolved (Johnston et al., 2015). In general, it suggests that an analyst may “borrow” a value of non-market good received in an original study and use this value to appraise benefits in the project or policy under analysis. This paper also employs this method, and when readily available market prices exist for goods or services directly linked to the specific benefits, they can be directly used in the valuation process as well. The following sections delve deeper into the chosen valuation methods for each social benefit.

Valuating benefits from GHG emissions reduction. Mitigating GHG emissions offers social benefits by improving air quality and reducing potential environmental damage. The project is estimated to annually prevent emission of 1.8 mln tons of CO2.

Economists utilize various methods to estimate the value of carbon reductions, particularly the Social Cost of Carbon (SCC), which estimates “the total damage from now into the indefinite future of emitting an extra unit of GHG’s now” (Stern, 2007); and the Marginal Abatement Cost (MAC), which focuses on the most cost-effective ways to achieve a specific emission reduction target. Kontovas & Psaraftis (2010) provided a sufficient overview of the main methods to price carbon emissions. There is also a significant number of papers calculating WTP for GHG reductions, available in databases like EVRI and GEVAD .

While SCC and MAC do offer valuable insights, inherent limitations exist. Market prices directly reflect supply and demand, making them suitable for this analysis. The established carbon trading schemes likewise provide valuable benchmarks, e.g. $38.73/ton in California (CARB, 2023), and EUR 63.9/ton in the EU (EC, 2024). Yet, directly applying data from mature markets is inappropriate due to differing economic realities. Kazakhstan also has a carbon allowance market, still nascent due to limited trading activity (no official data was recorded in 2023 with the latest transaction registered in September 2022 at the carbon allowance price of 397 Tenge/ton (less than $1) Recycle.kz (2022). The conversations with local experts, including representatives of the International Green Technologies and Investment Projects Center and Ecojer Association , revealed offers around $3.2/ton during 2023, although lacking official verification.

Thus, considering the limited data and evolving market, a provisional value of $3.2 per ton was adopted based on industry insights. The limitations of this valuation highlight the need for further research. As Kazakhstan's carbon market matures and official data become available, economists can refine the analysis to incorporate more accurate market-driven values.

Benefits from mine risk reduction. Between 2004 and 2023, several severe mine accidents resulted in fatalities and injuries. As the CMM utilization leads to a significant reduction of accident risks and improved coal mine safety (Karacan et al., 2011; Mahdevari, 2019; Wang et al., 2023), the execution of the target project is expected to notably slash the number of such emergencies.

While valuating benefits from mortality risk reduction, economists use the Value of Statistical Life (VSL) concept. VSL can be defined as a WTP for a “1” in N risk reduction aggregated over N individuals (Robinson et al., 2018). Traditionally, there are two main approaches to calculating VSL. Whereas the first approach is based on contingent valuation when individuals are directly asked about their WTP for mortality risk reduction, the second suggests designing the *compensating differential model* based on labor market statistics.

According to Polat (2014), most of the existing VSL literature is based on the US data, and only a few studies were completed for developing markets, including Giergiczny (2008) study for Poland and Parada-Contzen et al. (2013) study for Chile. Giergiczny (2008) clarifies that during the last 20 years, only a few wage-risk studies were carried out in Europe, with most of them in the UK.

Polat (2014) provides at least two reasons, explaining why VSL valuation in middle-income countries differs from this in high-income countries. The first is that labor markets in the former are more segmented, with informal jobs having a higher proportion in the market structure. This implies lower expenditures for safety technologies and less control over safety issues. The second reason is that companies

in middle-income countries show wider heterogeneity in size and finance (limited capital), which mainly means that the proportion of small and medium business dominates in the overall economy structure. Smaller enterprises with limited capital have lower access to safety technologies and are less prepared to adopt them.

Hence, for the purpose of valuating the VSL for the target project, the model uses Giergiczny (2008) study for Poland considering the similarities in economic transitions between this country and Kazakhstan. The Giergiczny (2008) model has the following semi-logarithmic functional form:

$$Ln(W_i) = \alpha_1 + \alpha_2 FAT_i + \alpha_3 FAT_i^2 + \beta X_i + \varepsilon_i \qquad (5)$$

, where

W is wage,

FAT is the fatal injury,

FAT2 is the fatal injury risk squared,

and X is a vector of 15 variables controlling the worker and job-specific attributes.

(Giergiczny, 2008) ran four separate regressions with varying breakdown levels by industry: one-digit, two-digit and three-digit levels according to the European classification of economic activity (NACE) (EC, 2022). As the result, VSL can be found through:

$$VSL = (\hat{\alpha}_2 + 2 * \bar{r} * \hat{\alpha}_3) * \overline{w} * 2000 * 10000 \qquad (6)$$

, where

$\bar{\alpha}_2$ is the risk coefficient,

$\bar{\alpha}_3$ is the coefficient for risk squared variable,

$\bar{r}$ is the mean risk in the sample (number of fatal injuries per 10,000 workers),

and w is the mean hourly wage.

Number of working hours is 2000.

Transfer of function was applied to value VSL for the target project. Hourly wage data for Qarmet's mine workers was crucial for this analysis and was obtained from the publicly available collective labor agreement for 2022-2024 containing wage information for AMT coal mine workers (Metallurgical Trade Union Zhaktau, 2023). The data was then adjusted to reflect 2022 and 2023 inflation rates using the official CPI, i.e. 20.3% for 2022 and 9.8% for 2023 (QazStat, 2024b). The hourly rate also included monthly and annual bonuses (both are guaranteed by the collective labor agreement), as well as pension contribution of 10%. That resulted in the estimated

average hourly wage of a worker in Qarmet's coal division at $5.2 per hour. This level was applied to the (Giergiczny, 2008) model with 1.64 fatal injuries per 10,000 workers. The outcomes of the exercise are presented in Table IV below.

Table IV. VSL for Qarmet

	Model 1 No ind. dummy variables	Model 2 Ind. dummy variables at one-digit NACE level	Model 3 Ind. dummy variables at two-digit NACE level	Model 4 Ind. dummy variables at three-digit NACE level
Fatal at five-digit level				
Coefficient by fatality	0.01960	0.00717	0.00411	-0.00134
Coefficient by fatality_sq.	-0.001750	-0.000926	-0.000735	-0.000379
Linear combination of coefficients by fatality and fatality_sq.	0.014	0.0041	0.0017	-0.0025
VSL ($)	**1,453,247**	**433,323**	**178,164**	**-270,845**
Fatal at three-digit level				
Coefficient by fatality	0.0808	0.0572	0.0355	0.0273
Coefficient by fatality_sq.	-0.0107	-0.00769	-0.00461	-0.0038
Linear combination of coefficients by fatality and fatal_sq	0.046	0.032	0.02	0.015
VSL ($)	**4,792,150**	**3,352,827**	**2,136,797**	**1,555,582**

Giergiczny (2008) concludes that the estimates that are based on three-digit occupational risk provide a more reliable VSL estimation. The negative result in Model 4 at five-digit level is probably due to flaws in risk measure data. Hence, the VSL for the Qarmet project is expected to range between $1.6 mln and $4.8 mln, i.e. two times higher compared to Giergiczny (2008) estimate for Polish VSL in 2002. This seems to be logical as the mean wage at that time was about $2.6 per hour versus $5.2 applied in this study's model. As Polat (2014) found an even smaller VSL for Turkey (ranging between $14,000 and $1,473,000), a lower VSL boundary for the Qarmet project ($1.6 mln) was applied in the model.

Valuating public health and agricultural benefits of reduced methane emissions. Methane plays a crucial role in the formation of ground-level ozone as it reacts with other chemicals in the atmosphere (e.g. nitrogen oxides and volatile

organic compounds) in the presence of sunlight. The oxidation process creates various compounds, including these stimulating ozone formation, where methane acts as a key precursor for the creation of tropospheric ozone, also known as ground-level ozone – one of the major air pollutants. Unlike the beneficial ozone layer in the stratosphere shielding us from UV radiation, ground-level ozone harms human health, causing respiratory issues, cardiovascular problems, and premature deaths; as well as damages crops, reduces yields, and contributes to smog formation (Abernethy et al., 2021; Dentener et al., 2005; EDF, 2023; Sampedro et al., 2023). This means that by mitigating methane emissions the target project may offer significant public health and agricultural productivity benefits.

To quantify them, the study has leveraged the estimates from the "Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions" published by UNEP in 2021 (UNEP & CCAC, 2021). This UNEP assessment provides monetary values (presented in 2018-level $/ton) for various methane emission effects across the countries, including Kazakhstan. The bullet points below summarize how these values were adjusted to reflect the 2023 economic conditions:

- Inflation Adjustments: The Consumer Price Index (CPI) inflation calculator from the US Bureau of Labor Statistics was used to account for general inflation between 2018 and 2023 (US BLS, 2024);

- Crop-Specific Adjustments: For the agricultural sector, adjustments were derived from the US Department of Agriculture (USDA, 2024) data to account for specific price changes in wheat, soybeans, maize, and rice.

Table V. below breaks down the estimated benefits per ton of methane emissions after inflation and crop-specific adjustments.

Table V. Value of economic benefits

Impact	$/t (2018)	$/t (2023)	Adjustment factor	
Value of reduced risks of ozone-related deaths in Kazakhstan	8.1	9.9	1.22	CPI calculator
Cost of asthma-related accident and emergency department visits due to ozone exposure in the closest peer country (Russia)	0.01	0.02	1.54	CPI calculator

Table V. Cont.

Negative impact on crop production	38.3	65.4	1.71	USDA data
Wheat	11.7	21.9	1.87	USDA data
Soybeans	6.6	10.0	1.52	USDA data
Maize	6.8	13.2	1.95	USDA data
Rice	13.2	20.3	1.53	USDA data
Forest	20.0	24.5	1.23	CPI calculator
Total	66.4	99.9	1.50	

Mitigating methane emissions offers a substantial economic benefit of $99.9 per ton, reflecting improvements in public health and agricultural productivity. The largest contributor to the economic benefits is the reduced negative impact on crop production, valuated at $65.4/ton. Public health enhancements also play a significant role, with a combined value of $9.9/ton for reduced risks of ozone-related deaths and asthma-related emergencies.

2.7. Shadow prices

Unlike financial analysis, which relies solely on observed market prices, economic analysis adopts a wider perspective by considering the "social value" of project inputs and outputs, encompassing social welfare on the national or regional levels. This necessitates adjusting these values to reflect their true impact on society. While the sections above shed light on the assessment of non-market benefits produced by the project, this section focuses on costs, specifically utilizing the concept of "shadow prices". Shadow prices recognize that market prices often diverge from their true social value due to various factors like (Drèze & Stern, 1988):

- Market imperfections: Monopolies and oligopolies distort market mechanisms, causing price deviations from optimal levels;

- Government intervention: Price controls or subsidies imposed by the government can artificially alter market prices.

In such situations, prices from the financial analysis that uses available market prices should be adjusted by conversion rates when transferred to the economic analysis.

The EU Commission Guide EC (2014) proposes that conversion rates should be reported by national planning agencies. Yet, when conversion rates are not available from the government, the Guide recommends applying the Standard Conversion Factor (SCF) for most cash flows.

Among all the project parameters, only electricity prices were obtained from an imperfect market, which is heavily regulated by Kazakhstan's government, mainly

through the so-called mechanism of "marginal tariffs" set for most conventional energy producers and limiting their ability to increase prices. Hence, to calculate the Standard Conversion Factor for electricity prices the following formula was used:

$$SCF = RES / P = 4.31 / 3.00 = 1.44 \quad (7)$$

, where

RES is the weighted average tariff from 2023 renewable energy auctions as calculated in in the Supplementary Data file attached to the study (Qazaq Green, 2023),

and P is electricity price used in the private benefits calculation section.

Renewable energy auctions are a market-based mechanism that Kazakhstan's government uses to determine electricity prices for various types of RE sources. As this is a market-based mechanism, the authors believe it fairly reflects the markets realities and social value of electricity from the newly built sources.

2.7. Discounting and timing factors

Cost-benefit analysis necessitates discounting future benefits and expenditure due to the time value of money (Boardman, Greenberg, Vining, 2018). The standard weighted average cost of capital (WACC) was used to discount private benefits and costs in the model. The calculation and explanation of WACC are presented in the Supplementary Data file attached hereto.

For social benefits and costs, the social discount rate (SDR) should be used reflecting societal preferences for present versus future consumption (Pearce et al., 2003). One ap-proach to determining the SDR is the social opportunity cost rate (SOCR), which argues that public projects should be financed at a rate no lower than the returns from private invest-ments. Under this concept, if the government has an alternative private-sector project with a specific return, the discount rate for public projects should match or exceed that return (Lind, 1990). This study, however, adopts the alternative concept of the social time preference rate (STPR), calculated using the formula proposed by Ramsey (1928):

$$STPR=p+eg \quad (8)$$

, where

p is the utility discount rate. According to QazStat (2024a), in 2009-2022 Kazakhstan's mean death ratio totaled 0.8%, which was applied to the model (refer to Fig. 1.);

e is elasticity of marginal utility of consumption. Calculating e requires substantial data unavailable for Kazakhstan in this project. Thus, following the

common practice for developing economies (Kula, 2004), the value of 1.64 was adopted from a relevant study in India;

g is an assumed long-term average growth of real consumption per capita. Kazakhstan's real GDP growth averaged 5.12% between 1996-2022 (World Bank, 2022).

As the result, 9.2% was used as the discount rate for the project's economic net benefits.

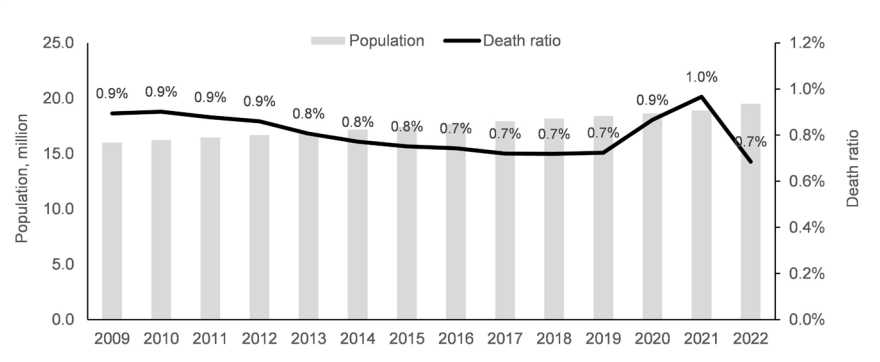

Figure 2. Death ratio in Kazakhstan in 2009-2022.

According to the EPA study, the project was planned for execution in phases over 32 years, with each phase lasting 30 years, and the 2nd phase starting 2 years after project initiation. Due to the difficulty of predicting future electricity prices and operation & maintenance costs, the key project parameters (Table II) are assumed to remain constant throughout the operational life. All prices within the model are expressed in constant 2023 US dollars, implying no inflation is considered, which means that the model is real, i.e. not nominal.

3. Model results and discussion

The proposed project offers significant economic and environmental benefits, including utilization of 226 mln m^3 of methane, resulting in a reduction of 1.8 mln tons of CO2 equivalent emissions, and generating 350 mln kWh of electricity annually. Economically, the project offers potential savings of $15.4 mln annually due to reduced health (ozone exposure) costs and improved crop yields. It is likewise estimated to create 35 new jobs and significantly decrease mine explosion risks, leading to potentially fewer worker fatalities and higher mine productivity. These factors contribute to a positive social value reflected in the calculated NPV of $243 mln and IRR of 42% under the economic model (detailed calculations are presented in the Supplementary Data file attached hereto).

Table VI summarizes the outputs of the financial and economic models.

Table VI. Model outputs at different levels of methane price

Parameter	Economic model outputs (public benefits)	Financial model outputs (private benefits)		
		Financial investor model	Mine owner model	Consolidated model
Discount rate	STPR = 9.2%	WACC = 9.5%	WACC = 9.5%	WACC = 9.5%
Sale of carbon allowances is not included				
NPV ($ mln)	Not applicable	- 46.2	15.6	- 27.7
IRR	Not applicable	0.5%	Not applicable	4.5%
B/C or PI	Not applicable	PI = 0.3	Not applicable	PI = 0.6
Sale of carbon allowances is included				
NPV ($ mln)	243	- 0.2	15.6	15.6
IRR	42%	9.5%	Not applicable	12.0%
B/C or PI	B/C = 4.1	PI = 1.0	Not applicable	PI = 1.2

* Due to the assumption that the owner of mines bears no project implementation costs, it is not possible to calculate IRR and PI.

Whereas the financial investor model exhibits negative NPV (minus $46.2 mln) and low IRR (0.5%), suggesting the target project might not be financially attractive for investors, the mine owner model shows positive NPV ($15.6 mln), assuming no incremental implementation costs. However, the overall NPV remains negative (minus $27.7 mln) with the project's IRR of 4.5%.

The inclusion of carbon allowance sales ($3.26/ton of CO2) significantly improves the financial attractiveness – up to $15.6 mln of consolidated NPV and 12.0% IRR. Yet, as the NPV remains negative for financial investors (minus $0.2 mln), it clearly shows that the project cannot be successfully implemented without the mine owner's participation.

Compared to the 2013 EPA study, the current financial model paints a significantly less optimistic picture for the project's financial viability. While the 2013 study projected a positive NPV ($7.6 mln) and high IRR (13.3%), the new model shows an overall negative NPV (minus $27.7 mln) and low IRR (4.5%), both models excluding carbon allowances. Under the carbon allowance case, the project remains unattractive for private investors with a negative NPV ($0.2 mln). This highlights a stronger dependency on the mine owner's participation, with this model showing a positive NPV ($15.6 mln). Therefore, the current model suggests the project's success relies heavily on securing carbon pricing mechanisms and full financial engagement of the coal mine owner.

The detailed calculation of financial benefits is presented in the Supplementary Data file attached to the study.

3.1. Sensitivity analysis

A sensitivity analysis was conducted on the economic model to assess its robustness under varying assumptions. Two key parameters underwent evaluation: carbon price and ozone-related cost avoidance. As discussed earlier, the initial estimate for carbon allowances was $3.25 per ton, which was based on discussions with local experts in Kazakhstan. Due to the nascent state of global carbon markets and the lack of documented evidence for a specific price in Kazakhstan, the sensitivity analysis explored the range of $0 to $10 per ton to account for potential future market fluctuations.

Similarly, the initial estimate for benefits from reduced ozone exposure was $100 per ton of methane avoided, resulting in $15.4 mln annual benefits. Given the potential for uncertainty surrounding the valuation of public health and crop productivity benefits in Kazakhstan's context, the analysis examined the range of $0 to $100 per ton to assess the impact on the project's viability.

As shown in Table VII., the project's economic net present value (NPV) remains positive even in extreme scenarios where both parameters are zero. This indicates that the project's economic viability is primarily driven by the benefits from reduced worker fatalities and fair market electricity pricing (as explained above in the Shadow Prices section, in the economic model tariffs were adjusted to the market prices obtained from 2023 renewable energy auctions) independent of carbon credit markets or the full extent of public health improvements from reduced ozone exposure.

Table VII. Sensitivity analysis of the economic model (NPV in $ mln)

		Price of carbon credit, $/t					
		0.0	2.0	**3.3**	4.1	7.0	10.0
Ozone-related cost avoided, $/t	0	48	81	**101**	115	163	212
	50	119	152	**172**	186	234	283
	75	154	187	**208**	221	269	319
	80	161	194	**215**	228	276	326
	90	176	208	**229**	243	291	340
	100	**190**	**223**	**243**	**257**	**305**	**354**

Furthermore, evaluating the model with the zero VSL (assuming no improvement in coal operations and explosion risks), the economic NPV drops to "0" with the IRR of 9.2%. This suggests that even without mortality reduction benefits, the project

remains economically neutral from the societal perspective, indicating that the public is unlikely to oppose its execution.

The sensitivity analysis was also performed for the financial model, focusing on capital expenditure (capex) and electricity prices. The initial EPA assessment estimated capex at $54 mln (in 2013 prices) adjusted to $72 mln in this study's model to reflect 2023 pricing levels (as presented in Table 3. above). The sensitivity analysis considered potential underestimation of equipment price growth by examining a range of capex values, as construction costs can fluctuate over time. Additionally, electricity price, a significant economic driver, was tested between $3.00 and $4.50 per kWh, reflecting the latest (at the time of this paper), renewable energy auction results in Kazakhstan (Qazaq Green, 2023). Table VIII summarizes the financial model sensitivity analysis assuming Qarmet JSC as the investor and excluding carbon credits.

Table VIII. Sensitivity analysis of financial model (Qarmet as project developer).

		Capex, $ mln					
		54.0	57.6	64.8	**72.0**	79.2	86.4
		-25%	-20%	-10%	**0%**	10%	20%
Electricity tariff, ¢/kWh	**3.00**	**-11.0**	**-14.1**	**-20.8**	**-27.7**	**-34.7**	**-41.6**
	3.50	1.6	-1.5	-7.7	**-14.0**	-20.2	-27.0
	3.75	8.0	4.9	-1.2	**-7.4**	-13.7	-20.0
	4.00	14.3	11.2	5.1	**-1.0**	-7.3	-13.5
	4.30	21.8	18.8	12.7	**6.5**	0.4	-5.8
	4.50	26.8	23.7	17.6	**11.5**	5.4	-0.7

The project demonstrates lower sensitivity to capex variations compared to electricity prices. For instance, 10% increase in capex leads to 25% decrease in NPV (from minus $27.7 mln to minus $34.7 mln), suggesting a multiplier effect of 2.5, while 17% increase in electricity prices (from ¢3.0 to ¢3.5 per kWh) leads to 51% improvement in NPV, suggesting a multiplier effect of 3.0. Overall, positive NPV is achieved at electricity tariffs exceeding ¢4.30 per kWh (a rounded average of the 2023 renewable energy auctions), subject to capex ranging between $54 and $79 mln.

The CBA and sensitivity analysis revealed that social benefits, particularly CO2 emissions mitigation, constitute the project's primary value. This aligns with Kazakhstan's national policy objectives for diversifying its energy supply and developing alternative RE sources (as discussed in the Introduction section above). Given the dominance of social benefits, the findings suggest that the government of Kazakhstan should explore policy options to incentivize private sector participation in

CMM utilization projects. This could involve revising the benefit distribution scheme to create a more attractive investment environment.

3.2. Cash flow gaps analysis

Assessment of cash flow gaps represents a crucial aspect of CBA for private investors. This analysis determines whether a project can generate sufficient cash flow to service debt obligations, thereby indicating financial feasibility.

Fig. 3. below illustrates the four scenarios run in the financial model:

- Scenario 1: Excludes carbon allowances, with project financing secured via two 7-year USD-denominated loans at the interest rate of 7.3%;

- Scenario 2: Includes carbon allowances, with project financing via two 7-year USD-denominated loans at the interest rate of 7.3%;

- Scenario 3: Includes carbon allowances, with project financing via two 7-year green bond issues at the interest rate of 7.3%;

- Scenario 4: Excludes carbon allowances, but electricity prices adjusted to ¢4.3/kWh (an average level of the 2023 renewable energy auctions).

All scenarios assume Qarmet JSC acting as the sole investor, eliminating complexities associated with benefit distribution among multiple private investors.

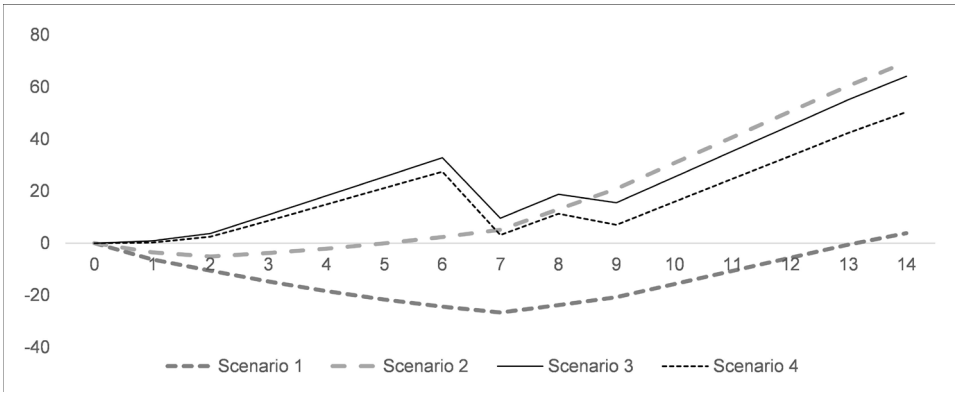

Figure 3. Cash flow gaps analysis ($ mln as of year-end).

The analysis reveals that financing through green bonds (Scenario 3 and 4) emerges as the most favorable option, because financing via loans leads to significant cash flow gaps. These findings suggest that the project's feasibility hinges on three critical conditions:

- Full benefit sharing: Qarmet should participate as both investor and developer. If Qarmet is not willing to engage in the project and allows third-party investors to implement it, the company should transfer all of its project benefits to such investors;

- Functional markets: The project requires access to a well-functioning local carbon market with available carbon allowance sales, or coal methane-based power plants should be allowed to participate in RE auctions, similar to biogas power plants. Comparison with similar studies support this need. For instance, Hummel et al. (2018) achieved IRRs of 20% and 28% for methane drainage at Indian collieries, while Nepsha et al. (2023) showed the 5.2-year payback period for CMM utilization at Kuzbass coal mines in Russia. In contrast, this study's model for Qarmet's project shows 12% IRR and 10-year payback period. These differences are mainly due to lower tariffs in Kazakhstan's heavily regulated energy market, compared to higher tariffs in Russia and India. Roshchanka et al. (2017) provides a more comprehensive discussion of the possibilities for state incentives to support the project;

- Green bond financing: Utilizing green bonds with their characteristic end-of-term repayment structure allows avoiding regular debt servicing burdens and should be seen as the most preferred option for the project's debt financing element, irrespective of its execution by Qarmet or third-party investors.

The cash flow gap analysis highlights the importance of strategic financing choices and favorable market conditions to ensure project viability for private investors in the context of methane capture projects.

4. Conclusion

This study aimed at conducting an exhaustive analysis of the Coal Mine Methane (CMM) Drainage and Utilization project in Kazakhstan, utilizing a detailed cost-benefit approach to evaluate its economic viability and environmental impacts. The findings demonstrate that incorporating carbon allowance sales substantially enhances the project's economics, demonstrating a promising net present value and internal rate of return. This financial upswing, marked by the increased NPV up to $15.6 mln and IRR up to 12.0%, illustrates the critical influence of carbon credits on the project's economic landscape.

However, a nuanced understanding of the study findings uncovers a critical challenge: in the context of current economic and policy conditions, the project's financial viability remains precarious for individual investors, evidenced by the residual negative NPV. This aspect of the findings points to the essential truth – the project's successful execution is heavily reliant on full engagement and support from the mine owner, i.e. Qarmet JSC. Without their active participation – in the form of self-financing or transferring all project monetary benefits to third-party investors – the financial model indicates the project may not achieve its intended objectives. This highlights the interconnected nature of financial feasibility and stakeholder involvement in environmental initiatives. To mitigate this risk, the government

could also introduce measures such as securing stable electricity prices for methane-based power plants, enhanced carbon credit mechanisms, and targeted investment incentives to forge a more favorable investment climate.

Contributing to the broader discourse on sustainable energy development, this research provides key insights into the feasibility and benefits of CMM projects. It not only validates the economic and environmental viability of the CMM initiative in Kazakhstan's context but also presents a replicable model for similar regional or global efforts. The study offers a comprehensive framework for advancing sustainable energy solutions that align economic growth with environmental stewardship, informing policy, industry, and academic discussions.

Looking ahead, future research should delve into the socio-economic impacts of CMM utilization, assess the scalability of the technology in various settings, and examine the long-term effects of policy reforms on the RE sector. Investigating the development of advanced cost-effective technologies for methane capture and utilization remains a priority for enhancing global climate change mitigation efforts.

In sum, this paper underscores the CMM Drainage and Utilization project's potential as a contribution to Kazakhstan's energy and environmental strategy. By demonstrating the project's alignment with economic viability and environmental sustainability, alongside highlighting the crucial role of stakeholder participation, this study lays the groundwork for future endeavors aimed at fostering a sustainable and prosperous energy future.

Glossary

AMT: ArcelorMittal Temirtau
CARB: California Air Resources Board
CBA: cost-benefit analysis
CBM: coalbed methane
CCAC: Climate and Clean Air Coalition
CMM: coal mine methane
CPI: Consumer Price Index
DCF: Discounted Cash Flow
EC: European Commission
EDF: Environmental Defense Fund
GMP: Global Methane Pledge
GWP: Global Warming Potential
IEA: International Energy Agency
IRR: Internal Rate of Return
KEGOC: Kazakhstan Electricity Grid Operating Company

MAC: Marginal Abatement Cost
NPV: Net Present Value
O&M: operating and maintenance
RE: renewable energy
SCC: Social Cost of Carbon
SCF: Standard Conversion Factor
UNEP: United Nations Environment Programme
US BLS: United States Bureau of Labor Statistics
US EPA: United States Environmental Protection Agency
USDA: United States Department of Agriculture
VSL: Value of Statistical Life
WACC: Weighted Average Cost of Capital

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ЦЕНТРАЛЬНОАЗИАТСКИЙ ЖУРНАЛ ИССЛЕДОВАНИЯ КЛИМАТА И УСТОЙЧИВОГО РАЗВИТИЯ (2024) 3(1): 126-157
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Факторы потребления энергии домохозяйствами Ферганской долины

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Данная версия является переводом статьи “Determinants of household energy use in the Fergana Valley”, опубликованной в журнале 3 апреля 2024 г.

ABSTRACT

В июле – августе 2023 года Институт ЦАРЭС, Исследовательский институт «Общественное мнение» и Институт АБР провели социологическое исследование по потреблению энергии домашними хозяйствами в Ферганской долине, расположенной на территории Кыргызской Республики, Таджикистана и Узбекистана. На основе результатов данного исследования проанализированы факторы, определяющие выбор того или иного источника энергии для отопления домохозяйств. Данный анализ представлен в настоящей статье. Авторы статьи приходят к заключению, что высокие расходы домохозяйств на покупку угля и осведомленность населения о вреде, который ископаемое топливо наносит окружающей среде и здоровью членов семьи, недостаточны для стимулирования крупномасштабного перехода на экологически чистую энергию. Реальным стимулом к переходу на более чистые виды энергии могло бы стать значительное повышение цен на ископаемое топливо по сравнению с электроэнергией и другими видами экологически чистой энергии. Это могло бы быть осуществлено посредством введения налога на уголь, но нужно обратить внимание на то, что расходы на отопление уже составляют до одной трети всех расходов домохозяйств. В связи с этим во избежание социальных потрясений и негативной реакции на такой налог увеличенные расходы домохозяйств с низким и средним уровнем доходов должны быть компенсированы.

КЛЮЧЕВЫЕ СЛОВА

чистая энергия, факторы, определяющие выбор топлива домохозяйствами, Ферганская долина

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1. Введение [1]

В данной статье изучен один из аспектов перехода на экологически чистые источники энергии: доступность и наиболее распространенные виды энергии, а также потребительские предпочтения домохозяйств по использованию энергии для целей отопления жилых помещений. Информированность о предпочтениях домохозяйств крайне важна для формулирования мер государственной политики, в том числе стимулов, нацеленных на продвижение устойчивых технологий отопления и ускорения перехода к низкоуглеродным способам потребления энергии как для целей отопления, так и для охлаждения помещений и приготовления пищи.

В статье приведены результаты опроса, проведенного в Ферганской долине. Географически это относительно компактный регион, который при этом охватывает части территорий трех стран: Кыргызской Республики, Таджикистана и Узбекистана. Особенность данного субрегиона дает хорошую возможность изучить сходства и различия потребления энергии домохозяйствами, находящимися под тремя разными юрисдикциями и системами снабжения энергией.

Главные темы опроса касались часто упоминаемых в литературе проблем: энергетической бедности, доступности энергии для населения, надежности поставок энергии и др. Важным аспектом также выступило влияние разных источников энергии на здоровье населения. Риски вреда здоровью населения, включая заболевания дыхательной системы, сердечно-сосудистые заболевания и смерти, вызванные загрязнением воздуха внутри помещений, из-за использования для приготовления еды таких традиционных видов топлива, как биомасса и уголь, зафиксированы многочисленными исследованиями.

Доступ домохозяйств к источникам энергии не в последнюю очередь определяется социально-демографическими характеристиками, в частности уровнем дохода, образованием, полом и трудоустройством. В свою очередь, улучшение доступа к энергии может увеличить производительность, способствовать развитию деятельности, приносящей доход, и снизить уровень бедности. Одновременно с этим демографические характеристики оказывают влияние на готовность к переходу на новые источники энергии.

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1 Статья подготовлена на основе данных проекта, инициированного Институтом Центральноазиатского регионального экономического сотрудничества (ЦАРЭС) в партнерстве с Институтом Азиатского банка развития (АБР). Институт ЦАРЭС – это межгосударственная организация, куда входят 11 государств: Афганистан, Азербайджан, Грузия, Казахстан, Кыргызская Республика, Монголия, Пакистан, КНР, Таджикистан, Туркменистан и Узбекистан. Опрос был проведен Исследовательским институтом «Общественное мнение», Республика Казахстан. Проект профинансирован Азиатским банком развития. С докладом по проекту можно ознакомиться на сайте Института РЭЦЦА (https://www.carecinstitute.org/publications/new-research-report-reveals-insights-on-household-access-to-energy-in-the-fergana-valley/).

В связи с растущей озабоченностью по поводу проблемы изменения климата и необходимостью сокращения парниковых газов экологически чистые технологии для отопления обретают повышенный интерес. Электрификация систем отопления за счет возобновляемых источников энергии, например ветряной или солнечной энергии, может существенно снизить выбросы парниковых газов, связанных с отоплением. Однако этот подход серьезно зависит от декарбонизации поставок электричества, обеспечивающей экологическую чистоту отопления электричеством. Сегодня в литературе также часто упоминаются все еще дорогостоящие тепловые насосы, которые тем не менее могут быть высокоэффективными, особенно в умеренном климате, и могут использовать возобновляемые источники энергии, такие как геотермальное или воздушное тепло.

В целом, изучению технологических решений, нацеленных на улучшение доступа домохозяйств к энергии, посвящен значительный объем литературы. Изучаются вопросы увеличения доступности электричества, распределяемого через сети, и оптимизации электрификации домохозяйств благодаря автономным решениям, таким как солнечные домашние системы, микроэнергетические системы и т. д., внедрение более экологически чистых технологий для приготовления пищи, включая усовершенствованные печи и кухонные плиты, биогазовые перерабатывающие заводы, солнечные печи/плиты и т. п. Ряд исследований посвящен оценке эффективности, масштабируемости и устойчивости этих технологий в различных условиях. Проведенный опрос до некоторой степени также охватил эти аспекты.

Литература также подчеркивает важность энергоэффективных строительных технологий в целях снижения потребления энергии для отопления. Такие стратегии, как надлежащая изоляция, герметизация вентиляционных отверстий, пассивное солнечное проектирование, могут сберечь тепло, следовательно, снизить потребности энергии для отопления и повысить общую эффективность энергопотребления.

В целом, в литературе отмечается, что для достижения существенного сокращения выбросов парниковых газов с одновременным обеспечением энергетической безопасности и доступности энергии необходима комбинация экологически эффективных технологий, учитывающих местные условия и доступность ресурсов.

Другая тема, обсуждаемая в литературе, – это динамика развития энергопотребления в городской и сельской среде. Если в сельской местности сталкиваются в основном с проблемами отсутствия достаточной инфраструктуры и бедностью, то в городской местности испытывают трудности с финансовой доступностью и надежностью поставок энергии, а также загрязнением окружающей среды.

Крайне важное направление для исследований также представляет изучение эффективности разных политик, регуляторных мер и стимулов по содействию доступу к энергии. Опросник для проекта, проведенного в Ферганской долине, разработан с учетом большинства упомянутых обсуждаемых в литературе вопросов.

1.1. Недавние исследования других авторов

Результаты опроса доступа домохозяйств к энергии в Ферганской долине во многом схожи с результатами свежих публикаций по теме.

Так, к факторам влияния на выбор источника энергии для отопления относят уровень дохода, уровень образования и осведомленность о проблемах окружающей среды (Bai et al., 2023). Другие авторы обозначили, что на принятие решений, связанных с вопросами энергии, также влияют финансовые соображения и доступ к информации (Brown et al., 2023).

Есть мнение, что углеродный след домохозяйств зависит от комбинации социально-экономических, демографических и экологических факторов (Gao et al., 2024). Такие демографические характеристики, как размер домохозяйства, его сельская или городская принадлежность также имеют значение, равно как и нельзя игнорировать культурные нормы (Mbaka et al., 2019).

В формировании спроса на энергию ключевую роль играет потребительское поведение и отношение к потреблению энергии (Brown et al., 2023). Существенное значение на углеродный след домохозяйств оказывают модели потребления (Huang et al., 2024).

Другой важный вопрос – это доступность энергоэффективных технологий (Guo et al., 2023). Надежность и финансовая доступность имеет основополагающее значение для формирования устойчивого подхода домохозяйств к проблемам изменения климата (Deng et al., 2023). Некоторые исследования особенно подчеркивают важность финансовой доступности в принятии решений домохозяйств относительно внедрения экологически чистых технологий (Li et al., 2023). В связи с более низким уровнем доходов и ограниченности доступа к альтернативным источникам энергии особенно уязвимы к росту расходов на энергию сельские домохозяйства (Nie et al., 2024).

Однако повышение осведомленности о проблемах окружающей среды и введение мер государственной политики, направленной на решение вопросов по изменению климата, тоже имеют значение. Данные действия, к примеру, привели к изменению модели энергопотребления, а также к снижению выбросов двуокиси углерода литовскими домохозяйствами (Jakučionytė-Skodienė et al., 2023). А сельские домохозяйства в Китае продемонстрировали желание платить больше за экологически чистые варианты отопления (Bai et al., 2023).

Большая часть литературы достаточно оптимистично оценивает потенциал мер государственной политики, направленных на изменение поведения домохозяйств в части энергопотребления как минимум в долгосрочной перспективе, при условии, что такие меры будут сформулированы надлежащим образом. Множество статей отмечают, что меры, нацеленные на внедрение экологически чистых видов отопления в сельской местности, могут быть эффективны с точки зрения сокращения загрязнения окружающей среды и улучшения состояния здоровья населения (Bai et al., 2023). Авторы этих статей выражают мнение, что политические меры по продвижению энергоэффективности и использованию возобновляемых источников энергии могут внести вклад в смягчение последствий изменения климата на уровне домохозяйств (Jakučionytė-Skodienė et al., 2023). Максимизировать социальные выгоды и продвинуть устойчивое развитие может интегрированная политика, нацеленная как на обеспечение доступа к энергии, так и на обеспечение целей экологически устойчивого развития (Xin et al., 2024).

Рекомендации исследователей указывают на то, что политики и меры должны быть направлены на то, чтобы оказывать влияние на потребительское поведение путем предоставления стимулов и повышения осведомленности об устойчивых энергетических практиках (Brown et al., 2023). Ученые делают упор на интенсификацию низкоуглеродного поведения и перехода на возобновляемые источники энергии в целях достижения целей устойчивого развития (Huang et al., 2024). Политики должны управлять информацией о поведении потребителей для формулирования эффективных стимулов и побуждений, которые подтолкнут домохозяйства к внедрению устойчивых практик (Caballero et al., 2024).

В изменении потребительского поведения значимая роль уделена финансовым стимулам. Экономические стимулы имеют критически важное значение в мотивировании домохозяйств к переходу на энергоэффективные и устойчивые технологии (Caballero et al., 2024).

Политические меры и программы государства должны делать упор на улучшение финансовой доступности энергии через адресные субсидии и финансовые механизмы, а также на развитие возможностей для роста доходов (Li et al., 2023).

Адаптация мероприятий для удовлетворения различных потребностей и предпочтений домашних хозяйств в соответствии с различными демографическими и другими характеристиками имеет важное значение для продвижения чистой энергии и устойчивого развития (Mbaka et al., 2019).

Группа авторов полагает, что в вопросе продвижения перехода на чистые источники энергии большее значение имеют технологические предпосылки. Приверженцы соответствующих позиций считают, что политика должна акцентировать внимание на продвижение энергоэффективных и технологических

решений (Lingyan Li et al., 2023), быть нацеленными на устранение различий в углеродном следе между городскими и сельскими местностями путем содействия справедливому доступу к экологически чистым энергетическим технологиям (Gao et al., 2024).

При этом авторы обращают внимание на то, что для эффективного планирования и распределения ресурсов необходимы локализованные подходы, учитывающие местные особенности и потребности конкретного сообщества (Guozhu Li et al., 2016).

1.2. Вопрос исследования

В статье, основанной на опросе домашних хозяйств в Ферганской долине о доступе к энергии и ее потреблении, предпринята попытка ответить на вопрос о том, что определяет выбор источников энергии домохозяйствами региона для отопления жилых помещений и какие политические рекомендации следуют из полученных результатов.

2. Методология проведения исследования

Следующий раздел посвящен описанию выборки, методов сбора и анализа данных, а также профиля респондентов.

2.1. Выборка

Опрос проведен среди жителей населенных пунктов Кыргызской Республики (Джалал-Абадская, Ошская и Баткенская области и город Ош), Республики Таджикистан (Согдийская область) и Республики Узбекистан (Ферганская, Наманганская и Андижанская области), расположенных в Ферганской долине или в непосредственной близости от нее.

Для выявления возможных гендерных различий в ответах респондентов была предусмотрена квота по полу, предполагающая опрос по выборке 50 % мужчин и 50 % женщин, являющихся главами домохозяйств. Члены домохозяйств самостоятельно определяли главу или члена домохозяйства, ответственного за принятие решений по финансовым и другим вопросам обслуживания домохозяйства (к примеру, покупки продуктов питания, оплаты коммунальных услуг, топлива (для отопления или приготовления еды и т. д.). Исследования домохозяйств, проведенные ранее национальными и международными организациями, отмечали разное отношение женщин и мужчин к вопросам финансовых затрат, затрат на покупку горючего и т. д. Это исследование также выявило гендерные различия.

В Таблице I представлены основные параметры выборки для трех стран.

Таблица I. Основные социологические параметры исследования

Страны/ Параметры	Кыргызская Республика	Таджикистан	Узбекистан
География опроса	3 региона и 1 город – Джалал-Абадская обл., Ошская обл., Баткенская обл., Город Ош	1 регион – Согдийская обл.	3 региона – Ферганская обл., Наманганская обл., Андижанская обл.
Количество респондентов	522	500	500
Возраст респондентов	18 лет и старше	18 лет и старше	18 лет и старше
Количество вопросов в опроснике	62	62	62
Количество социально-демографических параметров	12	12	12
Метод опроса	Личные интервью с использованием компьютера (CAPI)	Личные интервью с использованием компьютера	Личные интервью с использованием бумажной анкеты
Язык опроса	Кыргызский, Русский	Таджикский, Русский	Узбекский, Русский
Ошибка выборки	+/-4.38 при 95%-ном доверительном интервале	+/-4.38 при 95%-ном доверительном интервале	+/-4.38 при 95%-ном доверительном интервале
Процент отказа	561	44	607

2.2. Метод проведения интервью

Во всех трех странах был использован единый вид проведения беседы – личное интервью. В Кыргызской Республике и Таджикистане интервью проводились с помощью планшетов (личные интервью с использованием компьютера, CAPI), а в Узбекистане с помощью бумажной анкеты (личные интервью с использованием бумажной анкеты, PAPI).

2.3.Полевые работы

Опрос проводился в июле – августе 2023 года с использованием единого опросника, который состоял из основной части и социально-демографического блока (фиксировались параметры: возраст, пол, уровень образования, социальный статус, занятость).

2.4. Профиль респондентов

Респондентами опроса выступили главы домохозяйств или другие члены семьи, принимающие решения по вопросам выбора поставщика энергии или основного источника энергии, отопления и охлаждения дома. Выбор респондентов осуществлялся по квоте, что обеспечило получение мнений женского и мужского населения в равной пропорции, а также мнений респондентов разных возрастов, национальностей, уровня образования и форм занятости. В опросе приняли участие 130 городских и 392 сельских жителя Кыргызской Республики, 137 городских и 363 сельских жителя Таджикистана, 290 городских и 210 сельских жителей Узбекистана. В опросе участвовало приблизительно равное количество мужчин и женщин, являющихся главами домохозяйств.

Всего было опрошено 1522 респондента – главы домохозяйств или члены семей, ответственные за вопросы выбора основного источника энергии, организацию отопления и охлаждения дома: 522 человека в Кыргызской Республике (262 мужчины и 260 женщин), 500 человек в Таджикистане (245 мужчин и 255 женщин) и 500 человек в Узбекистане (256 мужчин и 244 женщины) (Таблица II).

Таблица II. Респонденты в разрезе пола

Варианты ответа	Кыргызская Республика		Таджикистан		Узбекистан	
	Кол-во	%	Кол-во	%	Кол-во	%
Мужчины	262	50,2	245	49,0	256	51,2
Женщины	260	49,8	255	51,0	244	48,8
Всего	522	100,0	500	100,0	500	100,0

2.5. Семейный статус

Большинство участников опроса обладают опытом семейной жизни, лишь 5 % узбекистанцев, 11,6 % таджикистанцев и 13,4 % кыргызстанцев заявили, что никогда не состояли в браке. Состояли в браке на момент проведения интервью 81 % респондентов из Узбекистана, 78,7 % респондентов из Кыргызской Республики и 72 % – из Таджикистана. Большинство респондентов из Кыргызской Республики и Узбекистана проживали в семьях от 4 до 7 человек, включая их самих. Большинство респондентов из Таджикистана проживали в семьях от 3 до 7 человек. Среднее количество членов семьи в принявших участие в опросе домохозяйствах составило 6 человек в Кыргызской Республике и 5 человек – в Таджикистане и Узбекистане.

2.6. Занятость

Наибольшую долю респондентов составили домохозяйки (и некоторое количество домохозяев) – 29,7 % от выборочной совокупности для опроса в Кыргызской Республике или 155 респондентов (149 женщин и 6 мужчин), 21,8 % или 109 женщин в Узбекистане и 16,8 % или 84 респондента в Таджикистане (66 женщин и 18 мужчин) (Таблица III). Другими относительно большими группами, принявшими участие в опросе, стали пенсионеры, фермеры, государственные служащие, индивидуальные предприниматели, а также наемные работники в частном секторе и в бюджетной сфере.

Таблица III. Ответы на вопрос «Какова Ваша текущая занятость?»

Варианты ответов	Кыргызская Республика		Таджикистан		Узбекистан	
	Кол-во	%	Кол-во	%	Кол-во	%
Я работаю на себя – индивидуальная занятость (индивидуальное предпринимательство без найма работников)	32	6,1	61	12,2	23	4,6
Я работаю на себя – предприниматель (нанимаю работников)	9	1,7	40	8,0	21	4,2
Самозанятый / не имею официального/постоянного места работы	33	6,3	48	9,6	40	8,0
Наемный работник в частном секторе	47	9,0	53	10,6	18	3,6
Наемный работник в бюджетной сфере	9	1,7	39	7,8	49	9,8
Государственный служащий	56	10,7	53	10,6	64	12,8
Студент	22	4,2	28	5,6	6	1,2
Пенсионер	74	14,2	46	9,2	126	25,2
Домохозяйка/домохозяин	155	29,7	84	16,8	109	21,8
Безработный	18	3,5	29	5,8	42	8,4
Фермер	67	12,9	10	2,0	2	0,4
Отказ от ответа	-	-	9	1,8	-	-
Всего	522	100,0	500	100,0	500	100,0

3. Результаты

3.1. Основной источник энергии для целей отопления

Домохозяйства стран, расположенных в Ферганской долине, значительно различаются по выбору основного источника энергии, используемого для отопления. В то время как в Таджикистане 70 % опрошенных домохозяйств с автономной системой отопления используют электроэнергию, в Узбекистане и

Кыргызской Республике электричеством для целей обогрева жилых помещений пользуются лишь 13 % и 6,7 % опрошенных домохозяйств соответственно (Таблица IV).

Таблица IV. Ответы на вопрос «Если у Вас автономная система отопления, какой источник энергии Вы используете для обогрева своего дома в зимний период?»

Варианты ответов	Кыргызская Республика		Таджикистан		Узбекистан	
	N=466		N=500		N=500	
	Кол-во	%	Кол-во	%	Кол-во	%
Каменный уголь	413	**88,6**	68	13,6	273	**54,6**
Горючее масло/	-	-	2	0,4	3	0,6
Природный газ из подземных трубопроводов	2	0,4	-	-	76	15,2
Пропан (баллонный газ)	-	-	03	0,6	43	8,6
Электричество	31	6,7	351	**70,2**	65	13,0
Биотопливо (прессованный навоз/ кизяк)	5	1,1	10	2,0	1	0,2
Керосин	-	-	-	-	-	-
Дрова	15	3,2	64	12,8	39	7,8
Солнечные батареи	-	-	-	-	-	-
Мусор и отходы (резина, пластик, бумага и др.)	-	-	2	0,4	-	-
Всего	466	100,0	500	100,0	500	100,0

Примечание. На вопрос отвечали только респонденты с автономной или смешанной системой отопления.

В то же время почти для 55 % домохозяйств в узбекской части Ферганской долины и 89 % домохозяйств в кыргызской части Ферганской долины основным источником энергии для отопления является каменный уголь. Природный газ играет значимую роль как источник энергии для отопления в Узбекистане; дровяное отопление в определенной степени важно во всех трех странах.

Очевидным предпочтением для объяснения того, что определяет выбор источника энергии, выступает фактор разницы относительной стоимости того или иного вида топлива и, как следствие, расходы домохозяйств на определенный источник энергии. Предпочтения того или иного вида топлива в зависимости от демографических характеристик главы домохозяйства или лица, принимающего соответствующие решения, а также от различной степени осведомленности о вреде ископаемого топлива для окружающей среды и здоровья семьи также могут объяснить выбор источника энергии.

На прямой вопрос о том, что определяет выбор источника энергии для отопления, около одной трети респондентов в трех странах Ферганской долины выбрали вариант «наименьшая финансовая нагрузка» (Таблица V). В Кыргызской Республике и Узбекистане частыми вариантами ответов также выступали «надежность поставок источника энергии» и «фактор существующих систем отопления». В Таджикистане факторы защиты окружающей среды и здоровья играют большую роль по сравнению с другими двумя странами – объяснением тому может служить тот факт, что делать «зеленые» заявления легче, когда большая часть отопления уже на электричестве.

В следующей части статьи прослеживается, в какой степени ответы на прямой вопрос соотносятся с результатами опроса в отношении определения текущего используемого источника энергии и возможных планов по замене соответствующего источника на другой.

Таблица V. Ответы на вопрос «Что определяет Ваш выбор основного источника энергии для отопления?»

Варианты ответов	Кыргызская Республика		Таджикистан		Узбекистан	
	N=466		N=500		N=500	
	Кол-во	%	Кол-во	%	Кол-во	%
Я выбираю, исходя из соображений наименьшего вреда окружающей среде	2	0,4	158	**31,6**	80	16,0
Я выбираю, исходя из соображений наименьшего вреда здоровью членам моей семьи	51	10,9	130	**26,0**	5	1,0
Я выбираю, исходя из соображений наименьшей финансовой нагрузки	144	**30,9**	143	**28,6**	175	**35,0**
Я выбираю, исходя из соображений бесперебойности/надежности поставок источника энергии	192	**41,2**	33	6,6	140	**28,0**
Я выбираю, исходя из соображений наличия существующей системы отопления	77	**16,6**	-	-	100	**20,0**
Затрудняюсь ответить	-	-	34	6,8	2	0,4
Ответы, зафиксированные на основании заявлений респондентов						
Я стараюсь подготовиться к зиме	-	-	1	0,2	-	-
Каждый год есть проблемы с электричеством	-	-	1	0,2	-	-
Всего	466	100,0	500	100,0	500	100,0

Примечание. На вопрос отвечали только респонденты с автономной или смешанной системой отопления.

3.2. Расходы на энергию в зависимости от доходов

Рисунок 1 демонстрирует распределение расходов на энергию (уголь, газ и электричество) по категориям доходов и позволяет получить первое впечатление о структуре расходов. Вертикальная линия на гистограммах отмечает среднее значение общей выборочной совокупности для каждой страны. Для справочных целей в гистограммы добавлены графики плотности нормального распределения. Как и ожидалось, более бедные домохозяйства тратят меньше на энергию по сравнению с более обеспеченными домохозяйствами: во всех трех странах в группах с низким уровнем доходов основная часть распределения расположена левее среднего значения.

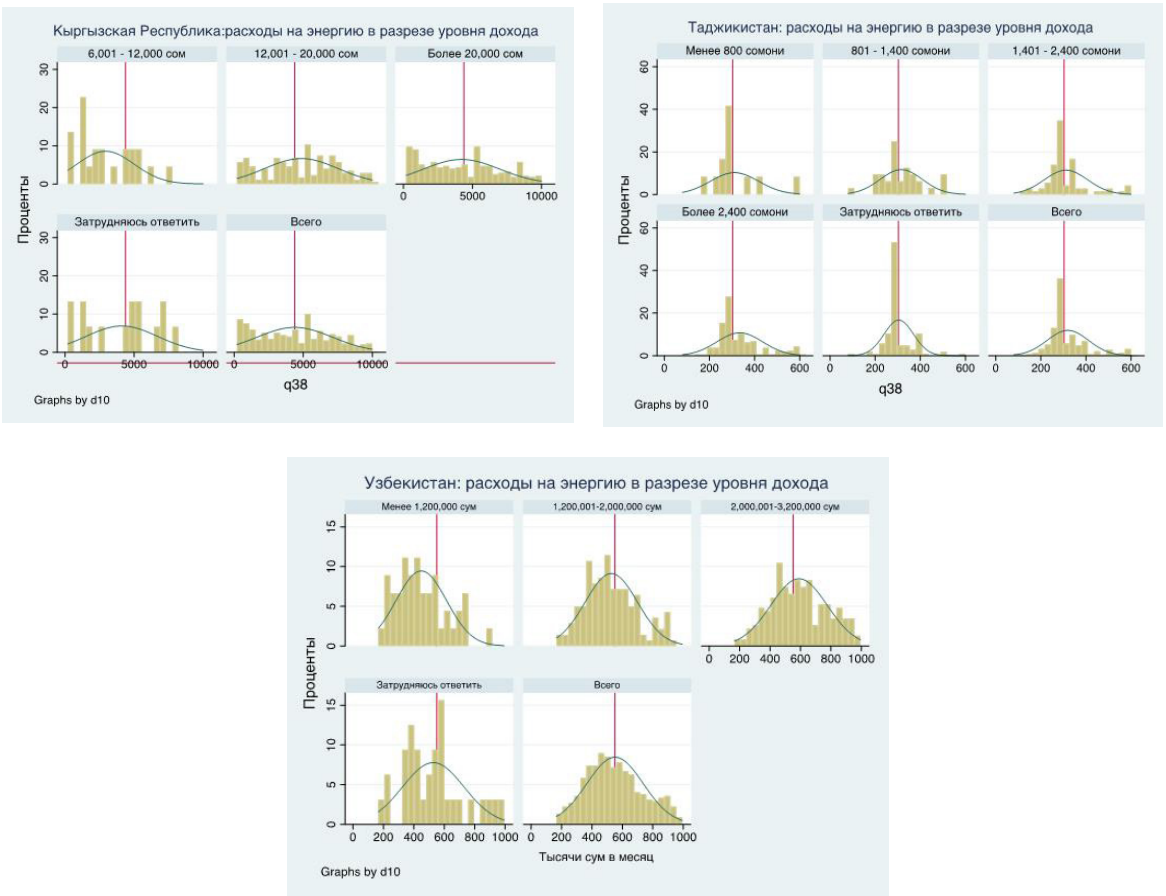


Рисунок 1. Расходы на энергию (уголь + газ + электричество) в зависимости от уровня дохода

Таблица VI демонстрирует общую тенденцию, отмеченную во всех трех странах Ферганской долины: домохозяйства тратят значительную часть дохода на энергию. Если рассмотреть два диапазона доходов, предположив, что центр диапазона – это грубо средний доход в этом диапазоне, то можно получить следующие результаты: в Кыргызской Республике медианные расходы наиболее

бедной подгруппы из группы среднего дохода составили 2 325 кыргызских сомов. Это составляет 26 % от среднего дохода в группе со средним уровнем дохода. Респонденты следующей более высокой по уровню доходов группы тратят на энергию уже 33 % (медиана) от среднего дохода в соответствующей группе. В Таджикистане цифры составляют 27 % и 15,5 % соответственно, а в Узбекистане обе группы со средним и более высоким уровнем доходов расходуют на энергию 17 % от среднего дохода в группе. Таблица VI также подтверждает, что в целом более обеспеченные домохозяйства тратят на энергию больше, чем более бедные домохозяйства. В Кыргызской Республике и Таджикистане разница затрат на энергию в зависимости от уровня дохода значима – с вероятностью ошибки 0,48 % и 5,36 % соответственно. Однако в Кыргызской Республике группа респондентов с уровнем дохода более 20 000 сомов тратит меньше респондентов с уровнем доходов от 12 001 до 20 000 сомов. Результаты по Узбекистану также показывают, что более богатые узбекские респонденты тратят на энергию больше, однако вероятность ошибки результатов для обеих групп составляет 17 %.

Таблица VI. Месячные расходы на энергию – в разрезе уровней доходов

Уровень месячного дохода домохозяйства		Расходы в месяц на уголь, газ и электричество				
	Частота	Медиана	Среднее значение	Стандартная ошибка	[95% доверительный интервал]	
Кыргызская Республика (Анализ дисперсии: скорректированный коэффициент детерминации (Adj R-squared) = 0,0203; p-значение **(Pr > F) = 0,0048)**						
Менее 6,000 кыргызских сомов	0 (0,0 %)	-	-	-	-	-
6,001–12,000 кыргызских сомов	22 (4,5 %)	**2.325**	**2.938**	442	2.069	3.808
12,001–20,000 кыргызских сомов	175 (35,9 %)	**5.150**	**4.863**	202	4.466	5.260
Более 20,000 кыргызских сомов	276 (56,6 %)	**4.100**	**4.208**	167	3.880	4.536
Затрудняюсь ответить	15 (3,1 %)	**4.900**	**4.114**	668	2.802	5.426
Всего	488 (100,0%)	**4.450**	**4.382**	124	4.139	4.626
Таджикистан (Анализ дисперсии: скорректированный коэффициент детерминации (Adj R-squared) = 0,0119; p-значение **(Pr > F) = 0,0536)**						
Менее 800 таджикских сомони	15 (3,3 %)	**295**	**307**	24	259	355
801–1,400 таджикских сомони	38 (8,5%)	**297**	**311**	15	282	340
1,401–2,400 таджикских сомони	90 (20,0 %)	**294**	**308**	10	289	328
Более 2,400 таджикских сомони	186 (41,4 %)	**297**	**333**	7	319	347

Таблица VI. продолж.

Затрудняюсь ответить	120 (26,7 %)	**296**	**304**	6	292	317
Всего	449 (100,0 %)	**296**	**318**	4	309	326
Узбекистан* (Анализ дисперсии: скорректированный коэффициент детерминации (Adj R-squared) = 0,0059; p-значение (Pr > F) = 0,1708)						
Менее 1,200 тыс. узбекских сум	45 (10,9 %)	**250**	**375**	36	303	446
1,200–2,000 тыс. узбекских сум	68 (16,5 %)	**265**	**345**	28	290	399
2,000–3,200 тыс. узбекских сум	70 (17,0 %)	**413**	**420**	32	358	483
Более 3,200 тыс. узбекских сум	197 (47,9 %)	**430**	**418**	17	383	452
Затрудняюсь ответить	31 (7,5%)	**550**	**447**	46	356	538
Всего	411 (100,0 %)	**400**	**404**	12	380	428

*Кыргызстан: Расходы ограничены суммой ниже или равной 10,000 сомов в месяц, чтобы исключить выбросы; Таджикистан: Расходы ограничены суммой ниже или равной 600 сомони в месяц, чтобы исключить выбросы; Узбекистан: *Расходы в тыс. сум; расходы ограничены суммой в промежутке от 100 тыс. до 1,000 тыс. сум в месяц, чтобы исключить выбросы.*

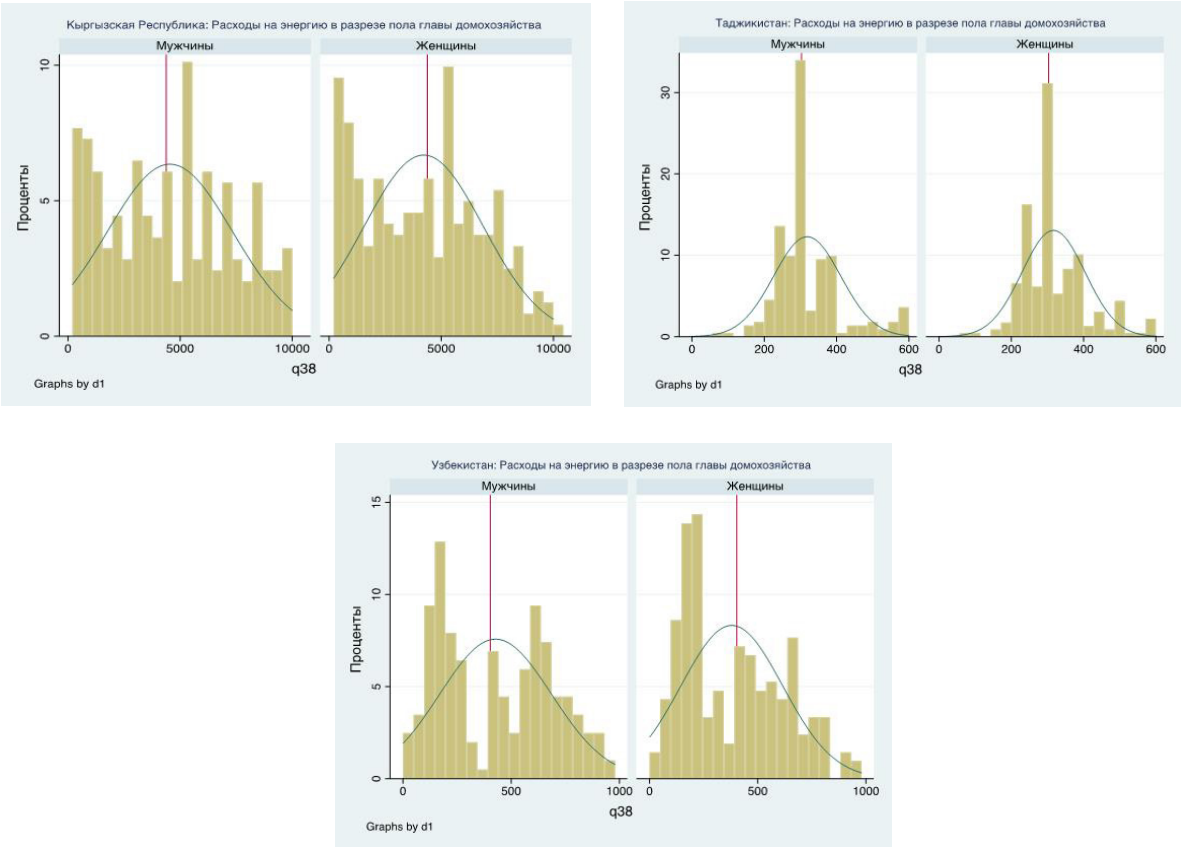


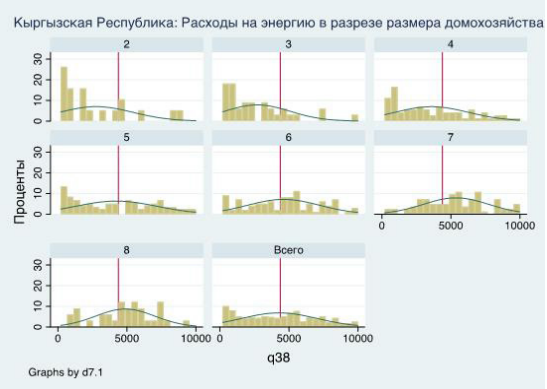
Рисунок 2. Расходы на энергию в разрезе пола

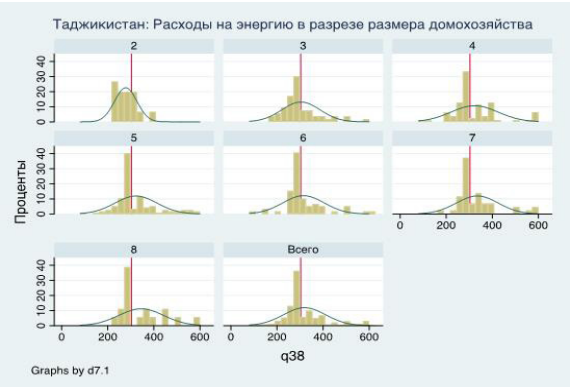
На Рисунке 2 и в Таблице VII показано, что в Кыргызской Республике и Узбекистане домохозяйства, главами которых выступают женщины, тратят на энергию несколько меньше, чем домохозяйства, где главами являются мужчины. Такой результат соответствует другому результату опроса: в категории с высоким уровнем дохода значительно меньше домохозяйств, респондентами которых выступают женщины (вероятность ошибки 10 %). Что касается Таджикистана, то здесь, как в части затрат на энергию, так и в части уровня дохода домохозяйств в разрезе пола главы домохозяйства, картина не столь ясна.

Таблица VII. Расходы на энергию в разрезе пола главы домохозяйства

	Кыргызская Республика			Таджикистан			Узбекистан		
	Частота	Медиана	Среднее значение	Частота	Медиана	Среднее значение	Частота	Медиана	Среднее значение
Мужчины	247 (50,6 %)	4.500	4.545	221 (49,2 %)	295	319	202 (49,1 %)	430	428
Женщины	241 (49,4 %)	4.250	4.216	228 (50,8 %)	296	317	209 (50,9 %)	330	380
Всего	488 (100,0 %)	4.450	4.382	449 (100,0 %)	296	318	411 (100,0 %)	400	404

Домохозяйства с большим количеством членов тратят в целом больше, чем более мелкие домохозяйства (Рисунок 3 и Таблица VIII). Во всех трех странах домохозяйства, в которых более 6 членов, тратят больше всего, домохозяйства, в которых 1–3 человека, тратят меньше всего.





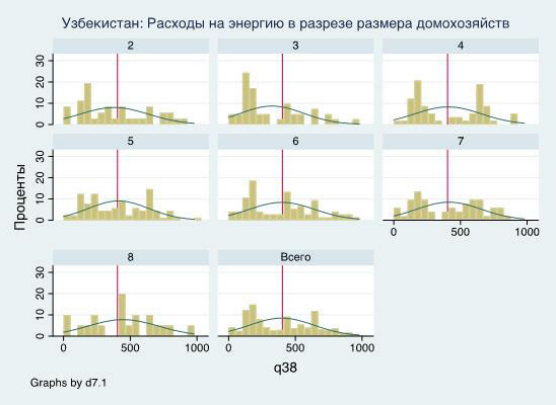


Рисунок 3. Расходы на энергию в разрезе количества человек в домохозяйстве

Таблица VIII. Расходы на энергию в разрезе количества человек в домохозяйстве

	Кыргызская Республика			Таджикистан			Узбекистан		
	Частота	Медиана	Среднее значение	Частота	Медиана	Среднее значение	Частота	Медиана	Среднее значение
1	1*	8,250	8,250	41 (9,1%)	293	302	6 (1,5%)	225	292
2	19 (3,9%)	1,700	2,775	15 (3,3%)	274	278	36 (8,8%)	318	380
3	33 (6,8%)	1,750	2,711	53 (11,8%)	295	304	41 (10,0%)	200	326
4	72 (14,8%)	2,950	3,604	78 (17,4%)	296	323	58 (14,1%)	326	408
5	118 (24,2%)	4,075	4,231	117 (26,1%)	296	322	89 (21,7%)	400	412
6	98 (20,1%)	4,750	4,615	59 (13,1%)	294	315	75 (18,2%)	425	399
7	83 (17,0%)	5,500	5,370	43 (9,6%)	298	335	52 (12,7%)	438	415
8	33 (6,8%)	5,280	4,879	18 (4,0%)	297	345	20 (4,9%)	450	447
>8	31 (6,4%)	5,500	5,502	25 (5,6%)	294	316	34 (8,3%)	582	481
Всего	488 (100%)	4,450	4,382	449 (100%	296	318	411 (100%)	400	404

** Вероятнее всего, является выбросом.*

Несмотря на то что опрос выявил разницу в затратах на энергию в зависимости от уровня дохода, пола, размера домохозяйства, эти факторы объясняют лишь небольшую долю дисперсии: уровень доходов во всех трех

странах объяснял лишь 2 % дисперсии в затратах (см. Таблицу VI). Это приводит к заключению, что, несмотря на то что расходы на энергию съедают значительную часть доходов домохозяйств и определенная разница в тратах у групп по уровню доходов существует, расходы домохозяйств на энергию не сильно зависят от сумм доходов соответствующих домохозяйств.

3.3. Расходы на энергию в разрезе основного источника энергии для отопления

Как показывает анализ дисперсии, во всех трех странах Ферганской долины различия затрат домохозяйств в зависимости от основного источника энергии для отопления являются статистически значимыми (Таблица IX). Однако несколько удивительно то, что во всех трех странах средние расходы домашних хозяйств, использующих электричество в качестве основного источника энергии для целей отопления, оказались ниже расходов домашних хозяйств, использующих для этих целей уголь; это несмотря на то, что в Кыргызской Республике и Узбекистане уголь является основным источником энергии для отопления. За исключением Кыргызской Республики, медианные значения затрат на электричество также ниже медианных значений затрат на уголь как основной источник топлива для отопления.

Таблица IX. Месячные расходы на энергию в разрезе основного источника для отопления

Основной источник энергии для отопления	Месячные расходы на уголь, газ и электричество					
	Частота	Медиана	Среднее значение	Стандартная ошибка	[95% доверительный интервал]	
Кыргызская Республика (Анализ дисперсии: скорректированный коэффициент детерминации (Adj R-squared) = 0.0895; p-значение **(Pr > F) = 0.0000***)						
Уголь	382 (88,4%)	**4.581**	**5.137**	120	4,901	5,373
Природный газ из подземных трубопроводов	2 (0,5%)	3.988	5.200	4,400	-3,448	13,848
Электричество	29 (6,7%)	**5.720**	**2.324**	460	1,420	3,229
Биотопливо (прессованный навоз/кизяк)	5 (1,2%)	4.236	2.766	1,066	671	4,861
Дрова	14 (3,2%)	**4.955**	**3.318**	957	1,437	5,198
Таджикистан (Анализ дисперсии: скорректированный коэффициент детерминации (Adj R-squared) = 0,0161; p-значение **(Pr > F) = 0,0110***)						
Уголь	54 (12,0%)	**302**	**340**	13	314	367

Таблица IX. Продолж.

Горючее масло/ дизель	2 (0,4%)	336	336	43	251	421
Пропан (газ в емкостях)	2 (0,4%)	331	331	246	-152	814
Электричество	319 (71,0%)	**295**	**318**	5	308	328
Биотопливо (прессованный навоз/ кизяк)	8 (1,8%)	398	364	28	309	419
Дрова	62 (13,8%)	**297**	**291**	9	274	309
Мусор и отходы	2 (0,4%)	280	280	71	141	418
Узбекистан* (Анализ дисперсии: скорректированный коэффициент детерминации (Adj R-squared) = 0,2160; p-значение **(Pr) = 0,0000****)						
Уголь	203 (49,4%)	**575**	**531**	17	498	563
Горючее масло/ дизель	3 (0,7%)	195	275	88	103	447
Природный газ из подземных трубопроводов	69 (16,8%)	**200**	**283**	23	239	327
Пропан (газ в емкостях)	40 (9,7%)	**188**	**224**	20	184	264
Электричество	58 (14,1%)	**210**	**313**	27	259	367
Биотопливо (прессованный навоз/кизяк)	1 (0,2%)	250	250	-	-	-
Дрова	37 (9,0%)	**190**	**280**	34	213	348

Кыргызстан: Из-за низкого количества наблюдений природный газ и биотопливо исключены из дисперсионного анализа Anova; чтобы исключить выбросы, расходы ограничены суммой менее или равной 10,000 сомов в месяц;

*Таджикистан: *Из-за низкого количества наблюдений масло/дизель, пропан, биотопливо исключены из дисперсионного анализа Anova; чтобы исключить выбросы, расходы ограничены суммой менее или равной 600 сомони в месяц;*

*Узбекистан: *Тысячи сум; **Из-за низкого количества наблюдений масло/дизель и биотопливо исключены из дисперсионного анализа Anova; чтобы исключить выбросы, расходы ограничены суммой между 100 тыс. и 1,000 тыс. сум в месяц.*

Рисунок 4 демонстрирует сравнение расходов на энергию домохозяйств, использующих в качестве основного источника энергии для отопления уголь и электричество. Т-тест для этих двух источников энергии показывает, что для Кыргызской Республики нулевая гипотеза о том, что разницы в зависимости от

вида источника энергии нет, может быть отвергнута с вероятностью ошибки 0,00 % при средних расходах в 5,137 сомов на уголь и 2,324 сома на электричество.

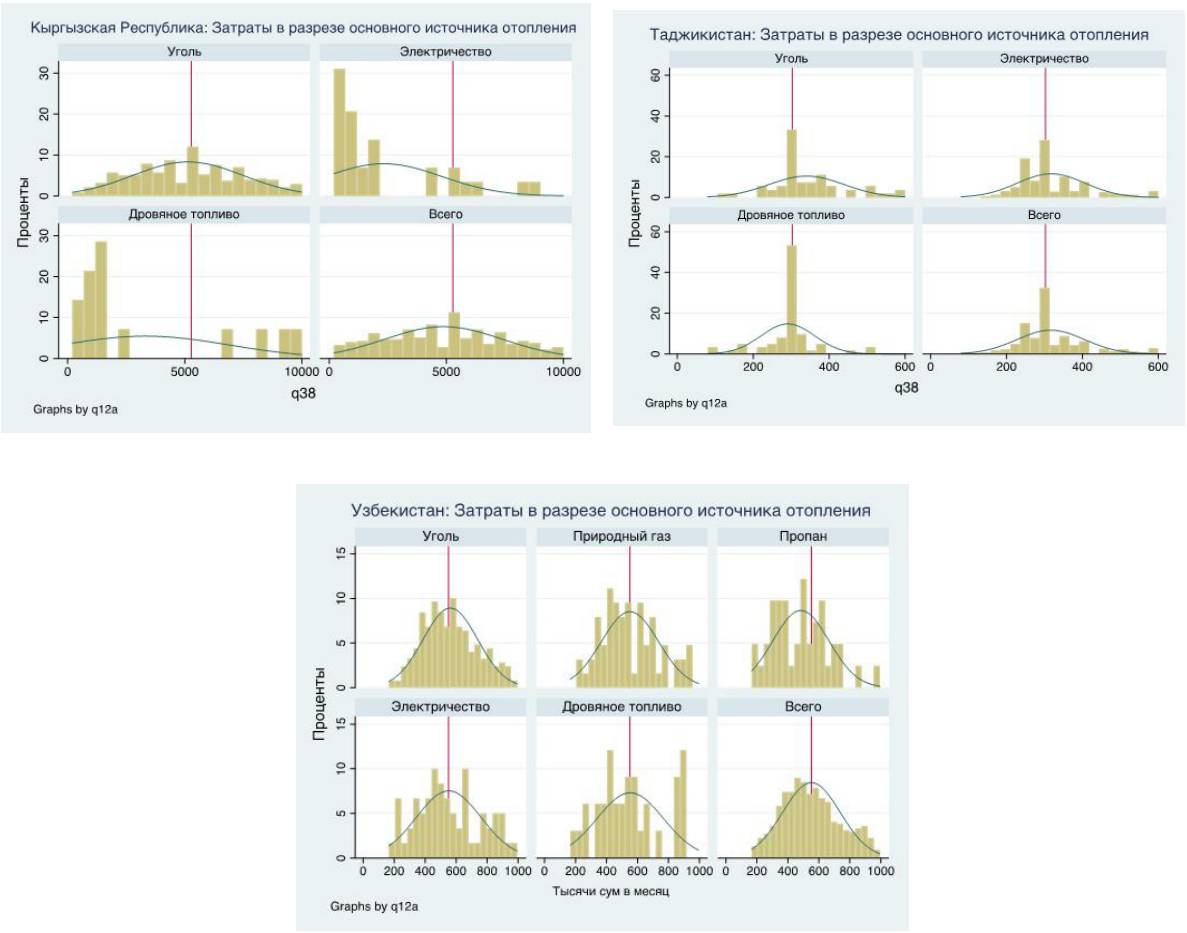


Рисунок 4. Расходы на энергию в зависимости от основного источника энергии для отопления

В Таджикистане средние расходы составляют 340 сомони на уголь и 318 сомони на электричество; вероятность ошибки, что разница существует, составляет 4,7 %. В Узбекистане средние расходы составляют 531 000 сум на уголь и 313 000 сум на электричество; вероятность ошибки – 0,00%. Следовательно, домашние хозяйства в Узбекистане и Кыргызской Республике, отапливающие свое жилье углем, склонны тратить больше, чем домохозяйства, использующие для отопления электричество. Это приводит к заключению, что несмотря на довольно сильный упор на фактор финансовых затрат в ответах о причинах выбора того или иного источника энергии, относительные расходы не являются решающим фактором для выбора источника энергии домохозяйствами.

3.4. Планы и причины по замене системы отопления домашних хозяйств

Другой способ изучения факторов, определяющих выбор источника энергии, заключается в изучении планов и причин по замене систем отопления. Нужно отметить, что наше предположение, что более состоятельные семьи, имеющие больше финансовых возможностей, будут более склонны заменить свою систему отопления по сравнению с менее обеспеченными семьями, не подтвердилось. Тест хи-квадрат показал низкую статистическую значимость во всех трех странах, более того, в Таджикистане и Узбекистане среди семей с более высоким уровнем дохода доля тех, кто планировал бы заменить отопительную систему своего дома ниже, чем среди семей с более низким уровнем дохода (Таблица X).

Таблица X. Планируют поменять отопительную систему дома в течение 5 лет (в разрезе доходов)

Частота	Планируют менять	Не планируют менять	Всего	Планируют менять, % от общего кол-ва категорий
Кыргызская Республика (хи-квадрат Пирсона (4 степени свободы) = 1.3009; р-значение **(Pr) = 0.729**)				
Менее 6.000 сомов	-	-	-	-
6.001–12.000 сомов	**5**	15	**20**	25.0
12.001–20.000 сомов	**53**	115	**168**	31.5
Более 20.000 сомов	**73**	191	**264**	27.7
Затрудняюсь ответить	**3**	11	**14**	21.4
Всего	**134**	332	**466**	28.8
Таджикистан (хи-квадрат Пирсона (4 степени свободы) = 3.4099; р-значение **(Pr) = 0.492**)				
Менее 800 сомони	**4**	14	**18**	22.2
801–1.400 сомони	**4**	36	**40**	10.0
1.401–2.400 сомони	**13**	84	**97**	13.4
Более 2.400 сомони	**21**	201	**222**	9.5
Затрудняюсь ответить	**14**	109	**123**	11.4
Всего	**56**	444	**500**	11.2

Таблица X. Продолж.

Узбекистан (хи-квадрат Пирсона (4 степени свободы) = 0.3039; р-значение **(Pr) = 0.990**)				
Менее 1.200.000 сум	**8**	39	**47**	17.0
1.200.001–2.000.000 сум	**12**	62	**74**	16.2
2.000.001–3.200.000 сум	**14**	70	**84**	16.7
Более 3.200.000 сум	**41**	213	**254**	16.1
Затрудняюсь ответить	**8**	33	**41**	19.5
Всего	**83**	417	**500**	16.6

Несмотря на то, что подавляющее большинство респондентов во всех трех странах осознает, что уголь наносит вред окружающей среде и здоровью их семей, подтверждений тому, что эта осведомленность оказывает влияние на планы по замене отопительной системы в домах, отсутствует. Так, в Кыргызской Республике планируют осуществить замену системы отопления по 28,7 % как от числа тех, кто осведомлен о вреде угля, так и от числа тех, кто не слышал о вреде ископаемого топлива. В Узбекистане среди планирующих заменить систему отопления доли осведомленных и неосведомленных о вреде угля для окружающей среды и здоровья внутри своей подгруппы также почти одинаковы и равны 20 % (Таблица XI). В Таджикистане, где большая часть домов уже отапливается электричеством, планируют заменить систему отопления 11,5 % среди осведомленных о вреде угля и 8,6 % среди тех, кто не знает о вреде ископаемого вида топлива. В случае с Таджикистаном разница между двумя группами существует, но ее нельзя назвать существенной.

Таблица XI. Планируют поменять отопительную систему дома в течение 5 лет (в разрезе осведомленности главы домохозяйства о потенциальном вреде здоровью и окружающей среде)

Частота	Планируют менять	Не планируют менять	Всего	Планируют менять, % от общего кол-ва категорий
Кыргызская Республика (хи-квадрат Пирсона (1 степень свободы) = 0,0623; р-значение **(Pr) = 0,969**)				
Осведомлены	107	266	373	28.7
Не осведомлены	25	62	87	28.7
Затрудняюсь ответить	2	4	6	33.3
Всего	134	332	466	28.8

Таблица XI. продолж.

Таджикистан (хи-квадрат Пирсона (1 степень свободы) = 0,4451;р-значение **(Pr) = 0,800**)				
Осведомлены	46	354	400	11.5
Не осведомлены	5	53	58	8.6
Затрудняюсь ответить	5	37	42	11.9
Всего	56	444	500	11.2
Узбекистан (хи-квадрат Пирсона (1 степень свободы) = 0,0277; р-значение **(Pr) = 0,986**)				
Осведомлены	54	271	325	19.9
Не осведомлены	28	140	168	20.0
Затрудняюсь ответить	1	6	7	16.7
Всего	83	417	500	19.9

При этом чаще всего замену системы отопления намерены осуществить не те домохозяйства, которые отапливают свои дома углем. В Кыргызской Республике наиболее часто хотят осуществить замену системы отопления домохозяйства, использующие для отопления электричество в качестве основного источника энергии. В Таджикистане и Узбекистане думают о замене системы отопления домохозяйства, которые используют дрова в качестве основного источника энергии для отопления (Таблица XII).

Таблица XII. Планируют поменять отопительную систему дома в течение 5 лет (в разрезе текущего основного источника энергии для отопления)

Частота	Планируют менять	Не планируют менять	Всего	Планируют менять, % от общего кол-ва категорий
Кыргызская Республика (хи-квадрат Пирсона (1 степень свободы) = 5,5383; р-значение (**Pr) = 0,063*)**				
Уголь	**112**	**301**	**413**	**27.1**
Природный газ из подземных трубопроводов	0	2	2	0.0
Электричество	**14**	**17**	**31**	**45.2**
Биотопливо (прессованный навоз/ кизяк)	2	3	5	40.0
Дрова	**6**	**9**	**15**	**40.0**

Таблица XII. продолж.

Таджикистан (хи-квадрат Пирсона (2 степени свободы) = 9,4894; р-значение **(Pr) = 0,009***)				
Уголь	**10**	**50**	**60**	**16.7**
Горючие масла/ дизель	1	1	2	50.0
Пропан (газ в емкости)	0	3	3	0.0
Электричество	**27**	**313**	**340**	**7.9**
Биотопливо (прессованный навоз/ кизяк)	1	9	10	10.0
Дрова	**11**	**46**	**57**	**19.3**
Мусор и отходы	0	1	1	0.0
Всего	50	423	473	10.6
Узбекистан (хи-квадрат Пирсона (4 степени свободы) = 20,1766; р-значение **(Pr)** = **0,000***)				
Уголь	**45**	**228**	**273**	**16.5**
Горючие масла/ дизель	1	2	3	33.3
Природный газ из подземных трубопроводов	**11**	**65**	**76**	**14.5**
Пропан (газ в емкости)	1	42	43	2.3
Электричество	**10**	**55**	**65**	**15.4**
Биотопливо (прессованный навоз/ кизяк)	0	1	1	0.0
Дрова	15	24	**39**	**38.5**
Всего	83	417	500	16.6

*Кыргызстан: *Природный газ и биотопливо исключены из-за низкого количества наблюдений;*

*Таджикистан: *Масла/дизель, пропан и биотопливо исключены из-за низкого количества наблюдений;*

*Узбекистан: *Масла/дизель и биотопливо исключены из-за низкого количества наблюдений.*

Отмечена некоторая разница в готовности поменять систему отопления в зависимости от уровня образования главы домохозяйства. В Кыргызской Республике и Таджикистане домохозяйства, главы которых имеют более высокий уровень образования, показывают наиболее высокую склонность к изменениям (Таблица XIII). Однако эта тенденция не наблюдается в Узбекистане, и для всех трех стран результат не имеет статистически значимого результата.

Таблица XIII. Планируют поменять отопительную систему дома в течение 5 лет (в разрезе уровня образования респондента – главы домохозяйства или лица, принимающего решения по организации отопления дома)

Частота	Планируют менять	Не планируют менять	Всего	Планируют менять, % от общего кол-ва категорий
Кыргызская Республика (хи-квадрат Пирсона (1 степень свободы) = 2.6644; р-значение **(Pr) =** 0.446)				
Неполное среднее (9 классов)	**11**	27	**38**	**28.9**
Среднее (11 классов)	**69**	180	**249**	**27.7**
Среднее техническое и профессиональное образование (колледж, техникум)	**21**	64	**85**	**24.7**
Высшее образование (специалист, бакалавр, мастер, кандидат наук, доктор наук, PhD)	**33**	61	**94**	**35.1**
Всего	134	332	466	28.8
Таджикистан (хи-квадрат Пирсона (2 степени свободы) = 1.3226; р-значение **(Pr) = 0.516***)				
Неполное среднее (9 классов)	4	47	51	7.8
Среднее (11 классов)	**17**	120	**137**	**12.4**
Среднее техническое и профессиональное образование (колледж, техникум)	**11**	114	**125**	**8.8**
Высшее образование (специалист, бакалавр, мастер, кандидат наук, доктор наук, PhD)	**24**	163	**187**	**12.8**
Всего	56	444	500	11.2
Узбекистан (хи-квадрат Пирсона (2 степени свободы) = 0.7969; р-значение **(Pr) = 0.671***)				
Неполное среднее (9 классов)	2	12	14	14.3
Среднее (11 классов)	**35**	158	**193**	**18.1**
Среднее техническое и профессиональное образование (колледж, техникум)	**28**	161	**189**	**14.8**
Высшее образование (специалист, бакалавр, мастер, кандидат наук, доктор наук, PhD)	**18**	86	**104**	**17.3**
Всего	83	417	500	16.6

*Таджикистан: *Неполное среднее исключено из-за низкого количества наблюдений;*

*Узбекистан: *Неполное среднее исключено из-за низкого количества наблюдений.*

По поводу готовности осуществить замену системы отопления во всех трех странах разницы в ответах городских и сельских жителей практически не наблюдается: 26 и 29 % соответственно в Кыргызской Республике, 16 и 17 % в Таджикистане, и 11 и 12 % в Узбекистане. Тест хи-квадрат крайне незначителен (Таблица XIV).

Таблица XIV. Планы по замене системы отопления в следующие 5 лет (в разрезе городских и сельских домашних хозяйств)

Частота	Планируют менять	Не планируют менять	Всего	Планируют менять, % от общего кол-ва категорий
Кыргызская Республика (хи-квадрат Пирсона (1 степень свободы) = 0,4073; р-значение **(Pr) = 0,523**)				
Город	**19**	55	**74**	25,7
Село	**115**	277	**392**	29,3
Всего	**134**	332	**466**	28,8
Таджикистан (хи-квадрат Пирсона (1 степень свободы) = 0,0435; р-значение **(Pr)** = **0,835**)				
Город	**16**	121	**137**	11,7
Село	**40**	323	**363**	11,0
Всего	**56**	444	**500**	11,2
Узбекистан (хи-квадрат Пирсона (1 степень свободы) = 0,0439; р-значение **(Pr) = 0,834**)				
Город	**49**	241	**290**	16,9
Село	**34**	176	**210**	16,2
Всего	**83**	417	**500**	16,6

Результаты корреляций ответов относительно замены системы отопления и пола респондента статистически несколько более значимы, чем корреляции с уровнем дохода, уровнем осведомленности о вреде ископаемого вида топлива, уровня образования или в разрезе город – село. Однако вероятность ошибки по данному показателю менее 10 % только для Кыргызской Республики (Таблица XV). Главы домохозяйств – мужчины несколько более склонны планировать изменения систем отопления, чем женщины: доля таких мужчин выше женщин-респондентов на 2,9 % в Таджикистане и на 7,4 % в Кыргызской Республике. Учитывая, что этот результат не сильно объясняется другими демографическими характеристиками, вероятно, лучшим объяснением тому может служить более высокая склонность мужчин к «техническим изменениям и планированию».

Таблица XV. Планы по замене системы отопления в следующие 5 лет (в разрезе пола)

Частота	Планируют менять	Не планируют менять	Всего	Планируют менять, % от общего кол-ва категорий
Кыргызская Республика (хи-квадрат Пирсона (1 степень свободы) = 3,0731; р-значение **(Pr) = 0,080)**				
Мужчины	**77**	161	**238**	**32,4**
Женщины	**57**	171	**228**	**25,0**
Всего	**134**	332	**466**	28,8
Таджикистан (хи-квадрат Пирсона (1 степень свободы) = 1,0198; р-значение **(Pr) = 0,313**)				
Мужчины	**31**	214	**245**	**12,7**
Женщины	**25**	230	**255**	**9,8**
Всего	**56**	444	**500**	11,2
Узбекистан (хи-квадрат Пирсона (1 степень свободы) = 2,4458; р-значение **(Pr) = 0,118**)				
Мужчины	**49**	207	**256**	**19,1**
Женщины	**34**	210	**244**	**13,9**
Всего	**83**	417	**500**	16,6

Также замечена некоторая тенденция относительно большей готовности молодых людей осуществить замену отопительной системы по сравнению с более старшими поколениями. Опять же вероятность ошибки при этом грубо в пределах нормы лишь в Кыргызской Республике (Таблица XVI).

Таблица XVI. Планы по замене системы отопления в следующие 5 лет (в разрезе возраста)

Частота	Планируют менять	Не планируют менять	Всего	Планируют менять, % от общего кол-ва категорий
Кыргызская Республика (хи-квадрат Пирсона (1 степень свободы) =2,5640; р-значение (**Pr) = 0,109**)				
Возраст 19-45	**99**	220	**319**	**31,0**
Возраст 45+	**35**	112	**147**	**23,8**
Всего	**134**	332	**466**	28,8
Таджикистан (хи-квадрат Пирсона (1 степень свободы) =0.0323; р-значение **(Pr) = 0.857**)				
Возраст 19-45	**41**	320	**361**	**11,4**
Возраст 45+	**15**	124	**139**	**10,8**
Всего	**56**	444	**500**	11,2
Узбекистан (хи-квадрат Пирсона (1 степень свободы) =0.7786; р-значение **(Pr) = 0.378**)				
Возраст 19-45	**46**	209	**255**	**18,0**
Возраст 45+	**37**	208	**245**	**15,1**
Всего	**83**	417	**500**	16,6

На вопрос, чем обоснованы планы по замене отопительной системы, главы домохозяйств наиболее часто отвечают «проблемы с существующей». Следующие по популярности ответы: «удобство», более холодные зимы и финансовые причины (рис. 5). Наличие новых технических решений также играет роль. Окружающая среда и здоровье учитывается лишь у 11 % респондентов в Таджикистане, 7,5 % – в Кыргызской Республике и 2,1 % – в Узбекистане.

Рисунок 5. Ответы на вопрос «Из-за каких причин Вы планируете замену системы отопления?» (%)

Результаты ответов на предыдущий вопрос во многом соответствуют ответам на вопрос «Что определяет Ваш выбор основного источника энергии для отопления?», представленный в Таблице 5. В то же время, судя по ответам на вопрос о будущих планах, проблемы с поставкой энергии в прошлом не являются настолько существенной причиной, чтобы сподвигнуть домохозяйства поменять отопительную систему. В Кыргызской Республике лишь 33,5 % респондентов, испытавших в прошлом проблемы с поставкой основного источника энергии для отопления, отметили свою готовность поменять систему отопления. Доля планирующих замену среди тех, кто не испытывал проблем, и того меньше – она составила 21,6 % (Таблица XVII). Для Таджикистана соответствующие значения составили 12,5 % и 8,6 % соответственно (нужно отметить, что уровень статистической значимости результатов для этой страны составил лишь 20 %). В Узбекистане 90 % респондентов отметили наличие проблем с поставкой

основного источника энергии для отопления в зимний период, но лишь 15,6 % из них планируют замену системы отопления против в 25 % домашних хозяйств, которые не испытывали проблем с поставкой основного источника энергии для своего отопления (при этом необходимо отметить, что общее число тех, кто не испытывал проблем, крайне мало (52 домохозяйства). Последнее также могло повлиять на высокую долю планирующих поменять систему отопления в этой подгруппе (13 домохозяйств).

Таблица XVII. Планы по замене системы отопления в следующие 5 лет (в разрезе наличия/отсутствия проблем с поставками основного источника энергии для отопления в прошлом)

Частота	Планируют менять	Не планируют менять	Всего	Планируют менять, % от общего кол-ва категорий
Кыргызская Республика (хи-квадрат Пирсона (1 степень свободы) =7.6211; р-значение **(Pr) = 0.006)**				
Испытывали проблемы в зимний период	**94**	187	**281**	**33.5**
Не испытывали проблем в зимний период	**40**	145	**185**	**21.6**
Всего	**134**	332	466	28.8
Таджикистан (хи-квадрат Пирсона (1 степень свободы) = 1.6578; р-значение **(Pr) = 0.198**)				
Испытывали проблемы в зимний период	**42**	295	**337**	**12.5**
Не испытывали проблем в зимний период	**14**	149	**163**	**8.6**
Всего	**56**	444	**500**	11.2
Узбекистан (хи-квадрат Пирсона (1 степень свободы) = 2.9579; р-значение **(Pr)= 0.085**)				
Испытывали проблемы в зимний период	**70**	378	**448**	**15.6**
Не испытывали проблем в зимний период	**13**	39	**52**	**25.0**
Всего	**83**	417	**500**	16.6

4. Заключение и рекомендации

Около 80,5 % респондентов в Кыргызской Республике, 80 % в Таджикистане и 65 % в Узбекистане обозначили свою осведомленность о потенциальном вреде ископаемого топлива для окружающей среды и здоровья. Тем не менее, доминирующим источником энергии для систем отопления в Кыргызской Республике и Узбекистане остается уголь. Это при том, что домохозяйства, отапливающие свое жилье углем, показали более высокие затраты на отопление, по сравнению с домохозяйствами, использующими электричество.

В связи с этим масштабные изменения по переходу домохозяйств на использование чистой энергии требуют значительных мер государственной политики.

Относительные цены на чистую энергию, например, на электричество и на уголь, должны быть существенно скорректированы в пользу чистой энергии. Это требует дополнительного налогообложения в отношении угля (например, введение дополнительного налога (увеличение размера действующего) одновременно с отказом от субсидирования угля и/или административным установлением ценовых лимитов. В то же время домашние хозяйства в Ферганской долине уже тратят на отопление до одной трети своих доходов. Для того чтобы не усугубить финансовую нагрузку и не привезти к социальному кризису и неприятию реформ, к примеру, введения налога на уголь, более высокие затраты на отопление домашних хозяйств должны быть компенсированы финансовыми трансфертами.

Все больше научной литературы, как в том числе и результаты исследования по Латинской Америке (Feng et al., 2018), показывают, что перераспределение даже небольшой доли финансовых поступлений от отмены субсидий или налогообложения энергоносителей может быть достаточно, для того чтобы защитить уязвимые домашние хозяйства от последствия повышения цен на энергоносители. В то же время наличие литературы, исследующей влияние налогов на энергоносители на конечное потребление в жилых домах в контексте развивающихся стран, а также в рамках «комплексного подхода, учитывающего социально-экономические и ситуационные факторы», ограниченно (Borozan, 2019). Последнее замечание еще более актуально в отношении изучения влияния введения налога на уголь. В то же время исследование по Индии привело к заключению, что увеличение специального дополнительного налога на уголь в Индии «существенно сократит смертность, связанную с загрязнением окружающей среды, увеличит доходную часть бюджета… и станет наиболее эффективной мерой по сокращению углеродных выбросов» (Parry et al., 2017). А правительству Индонезии было рекомендовано «увеличить налог на уголь,

чтобы последний служил де-факто углеродным налогом» (Sumarno and Laan, 2021). Для принятия информированных решений относительно возможных мер по стимулированию перехода домашних хозяйств на более чистую энергию необходимы дополнительные исследования о потенциальном воздействии введения нового косвенного налога на уголь в Центральной Азии.

Если обратиться к контексту ЕС, то в странах с более экономным потреблением энергии высокие налоги на энергию сильнее воздействуют на потребление энергии домашними хозяйствами по сравнению со странами с традиционно более высоким уровнем потребления энергии (Borozan, 2019). Такое заключение может быть актуально и в отношении домашних хозяйств, потребляющих больше угля. Их высокое потребление может объясняться простой причиной отсутствия фактического выбора финансово доступных альтернативных технических решений.

Новая волна зеленой электрификации должна удовлетворить потенциально более высокий спрос на электричество со стороны домашних хозяйств и других секторов экономики, таких как электромобили и производство углеводорода. Фактически волна формирования более чистой энергетики уже началась во всех трех странах Ферганской долины – в Узбекистане основной фокус направлен на солнечную и ветряную энергетику, в Таджикистане и Кыргызской Республике – на гидроэнергетику. По мнению ученых, в Казахстане и Кыргызской Республике «доступ к более чистой и современной энергетической инфраструктуре, как, например, к газопроводам и централизованному отоплению, сократит использование твердого топлива, особенно в сельских районах» (Azhgaliyeva et al., 2021).

Для использования сравнительных преимуществ каждой страны по генерации электрической энергии и содействия нахождению баланса спроса и предложений в разные сезоны и в разное время суток необходимо более тесное сотрудничество между странами региона, модернизация связывающих страны электросетей и интенсификация торговли электроэнергией друг с другом.

«Кроме того, рекомендуются постепенные и широко освещаемые реформы, позволяющие бизнесу и домохозяйствам адаптироваться в ожидании более высоких цен на энергетические ресурсы, а также предоставляющие больше времени для принятия необходимых мер социальной защиты» (Parry, 2017). Одновременно с такими реформами для стимулирования широкомасштабного движения в сторону использования более чистой энергии необходимо проводить информационные кампании в социальных сетях и других коммуникационных каналах о возможностях, которые открывает использование чистых и возобновляемых источников энергии.

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