Food and Agriculture
Organization of the
United Nations

European Bank
for Reconstruction and Development

ADOPTION OF CLIMATE TECHNOLOGIES IN THE AGRIFOOD SYSTEM

INVESTMENT OPPORTUNITIES IN THE KYRGYZ REPUBLIC

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Country Investment Highlights
Number 2

ADOPTION OF CLIMATE TECHNOLOGIES IN THE AGRIFOOD SYSTEM
INVESTMENT OPPORTUNITIES IN THE KYRGYZ REPUBLIC

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Prepared under the FAO/EBRD cooperation

Food and Agriculture Organization of the United Nations
Rome, 2022

Required citation:
del Mar Polo, M., Santos, N., Berdikeev, S. 2022. *Adoption of climate technologies in the agrifood system: investment opportunities in the Kyrgyz Republic.* Rome, FAO.
https://doi.org/10.4060/cb6812en

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ISBN 978-92-5-134954-0
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Art direction and design: Sonia Malpeso & Naz Naddaf
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Acknowledgements

This publication is a joint product of the Food and Agriculture Organization of the United Nations (FAO) and the European Bank for Reconstruction and Development (EBRD). The study was led by Nuno Santos, Economist (FAO), in collaboration with Astrid Motta, Principal, Energy Efficiency and Climate Change (EBRD). The authors at FAO Investment Centre Division are Maria del Mar Polo, Agricultural Economist, Nuno Santos, Economist, and Sulaiman Berdikeev, Economist. At an early stage, the team was supported by Tommaso Alacevich, Economist, Geoffrey Dyce, Economist, Jonathan Moncada and Luis Rincon, Energy Specialists, and other technical officers at FAO. Special thanks are owed to Arianna Carita, Economist, Giulia Conchedda, Agri-environmental Data Analyst, and Francesco Tubiello, Senior Statistician. Other key contributions came from Samvel Ghazaryan, Irrigation Specialist, Anne Mottet, Livestock Specialist, and Luis Dias Pereira, Economist, for their contribution to reviews and improving the business models of different technologies.

The authors would also like to thank the experts, government representatives, development partners and private technology providers and adopters operating in the agrifood sector in the Kyrgyz Republic for the assistance provided to the project team during the data collection and technology assessments.

The authors would like to thank Dorjee Kinlay, former FAO Representative in the Kyrgyz Republic, and his team for support provided throughout the implementation of the study, the related field missions and the preparation of the workshop where the study results were presented to stakeholders.

Valuable support at the final stages of the publication and dissemination was provided by Hannah Fried, Economist, Naz Naddaf, Graphic Designer, Nada Zvekic, Communications Officer, and Esther Lake, Communications Specialist at the FAO Investment Centre.

The authors would like to thank Mohamed Manssouri, Director, FAO Investment Centre, and Gianpiero Nacci, Head of Sustainable Resource Investments, EBRD, for their overall guidance.

Abbreviations and acronyms

EAEU	Eurasian Economic Union
EBRD	The European Bank for Reconstruction and Development
EFA	Economic and Financial Analysis
ENPV	Economic Net Present Value
Ex-ACT	EX Ante Carbon balance Tool
FAO	Food and Agriculture Organization of the United Nations
FINTECC	Finance and Technology Transfer Centre for Climate Change
GDP	gross domestic product
GET	Green Economy Transition
GHG	greenhouse gas
GLEAM	Global Livestock Environmental Assessment Model
IBP	International Best Practices
INDC	intended nationally determined contributions
IRR	internal rate of return
LIFDC	low-income food-deficit country
LU	Livestock unit
MACC	Marginal Abatement Cost Curve
MCA	Multi-Criteria Analysis
NC	National Communications
NPV	net present value
OECD	Organisation for Economic Co-operation and Development
TPES	total primary energy supply
UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division

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Introduction

Agrifood systems are important contributors to greenhouse gas (GHG) emissions and are therefore increasingly under pressure to become more resource-efficient and reduce their environmental footprint. At the same time, agrifood system performance is closely dependent on natural resources and faces major threats from climate change. It is thus urgent to increase the agrifood sector's resilience to climate change through targeted investments that reduce its vulnerability to extreme weather events. Accelerating the adoption of climate technologies is an essential step towards these objectives.

With this in mind, the European Bank for Reconstruction and Development (EBRD) and the Food and Agriculture Organization of the United Nations (FAO) developed a methodology to identify and prioritize climate technologies in the agrifood sector, based on their potential to mitigate GHG emissions and contribute to adaptation to climate change. The assessment and prioritization is based on multiple criteria, including technical and financial parameters, economy-wide impacts and sustainability, and institutional and regulatory aspects.

This report outlines the results of a rapid assessment of climate technologies in the Kyrgyz Republic's agrifood sector based on this methodology. A similar assessment was conducted in Kazakhstan and summarized in a companion publication. The results of both country assessments were presented to stakeholders in both countries during two workshops held in Bishkek and Astana on 2 November 2018 and 7 November 2018, respectively.

The report contains seven chapters. Following the introduction, the second chapter provides a brief overview on the five-step methodology used for the assessment. The subsequent chapters present the main results of each step of the methodology applied to the agrifood sector in Kyrgyz Republic. The final chapter presents the overall ranking of climate technologies vis-à-vis their mitigation and adaptation potential and highlights opportunities and challenges to foster the expansion of the most promising technologies to the required scale.

Due to time and resource constraints, the results presented in this report are derived from a rapid assessment. As such, the number of possible technologies has been limited to 12. These were selected based on available data and discussion with key in-country stakeholders and experts during field missions to the Kyrgyz Republic. Future assessments could add other technologies.

Methodology to assess climate technologies

BACKGROUND

The EBRD and FAO recognize that addressing climate change mitigation and adaptation challenges in the agrifood sector will require radical changes in food production systems. Greater adoption of climate technologies is a core element of this transition towards more sustainable food systems. Under the Finance and Technology Transfer Centre for Climate Change (FINTECC) programme, the EBRD and FAO developed a practical tool to inform policy-makers and to orient public and private institutions interested in investments that foster the greening of the agrifood sector. This methodology[1] was first tested in Morocco during 2015-2016 and results are detailed in the respective FAO/EBRD publication.[2] During 2017-2018, a revised methodology was used to assess climate technology potential in the Kyrgyz Republic and Kazakhstan.

OBJECTIVE AND KEY ELEMENTS

The objective of the methodology is to derive a prioritized list of climate technologies in a country's agrifood sector that contribute to mitigation (reduction of GHG emissions from the sector) and to adaptation (enhancement of climate change resilience) to climate change. The methodology consists of five steps and applies a Multi-Criteria Analysis (MCA) to assess climate technologies from various angles. It draws on various existing data sources including FAOSTAT, World Development Indicators, United Nations Statistics Division (UNSD), Nationally Determined Contributions (NDCs) and National Communications to the United Nations Framework Convention on Climate Change (UNFCCC), as well as studies and interviews with local stakeholders.

The methodology is implemented by a core team of international and national experts that consults key stakeholders during the various stages. It builds on other conceptual frameworks and tools that contribute to the assessment of mitigation and adaptation benefits – i.e. EX-Ante Carbon balance Tool (Ex-ACT); FAO's Water, Energy and Food Nexus; Global Livestock Environmental Assessment Model (GLEAM); FAO's Self-evaluation and Holistic Assessment of Climate Resilience of Farmers and Pastoralists (SHARP) tool and EBRD's Green Economy Transition (GET) approach.

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[1] Adoption of climate technologies in the agrifood sector. Methodology

[2] Morocco: Adoption of climate technologies in the agrifood sector

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The five steps are depicted in Figure 1. Step 1 identifies the main sources of GHG emissions in the agrifood sector and analyses the vulnerabilities of the sector to climate change. Based on these analyses, a list of climate technologies that contribute to GHG mitigation and climate change adaptation in the national context is identified through a combination of literature review, international best practices and local expert consultations. Steps 2 to 4 evaluate and score these technologies using MCA.

Figure 2 illustrates these criteria. Step 2: (1) performance compared to international best practices; (2) maturity of technical support services; (3) current technology adoption rate; (4) trends in gap between uptake and potential; and (5) final returns. Step 3: (6) potential to reduce annual GHG emissions; (7) contribution to adaptation; (8) mitigation cost; (9) negative externalities; (10) positive externalities. Step 4: (11) policy reform requirements. The ratings are based on a Likert Scale, scoring 1 (very low), 2 (low), 3 (neutral), 4 (high) and 5 (very high) for criteria that can only be assessed qualitatively (e.g. maturity of technical support service) and on absolute values for quantifiable criteria (e.g. current adoption rate or Internal Rate of Return - IRR).

In Step 5, overall ranking and conclusions are derived concerning the potential of the technologies to contribute to climate change mitigation and adaptation in the agrifood sector. The ranking is based on the normalization of scores and weights assigned to 11 dimensions further described below. Step 5 concludes with suggestions for policy measures to foster the uptake of the prioritized technologies.

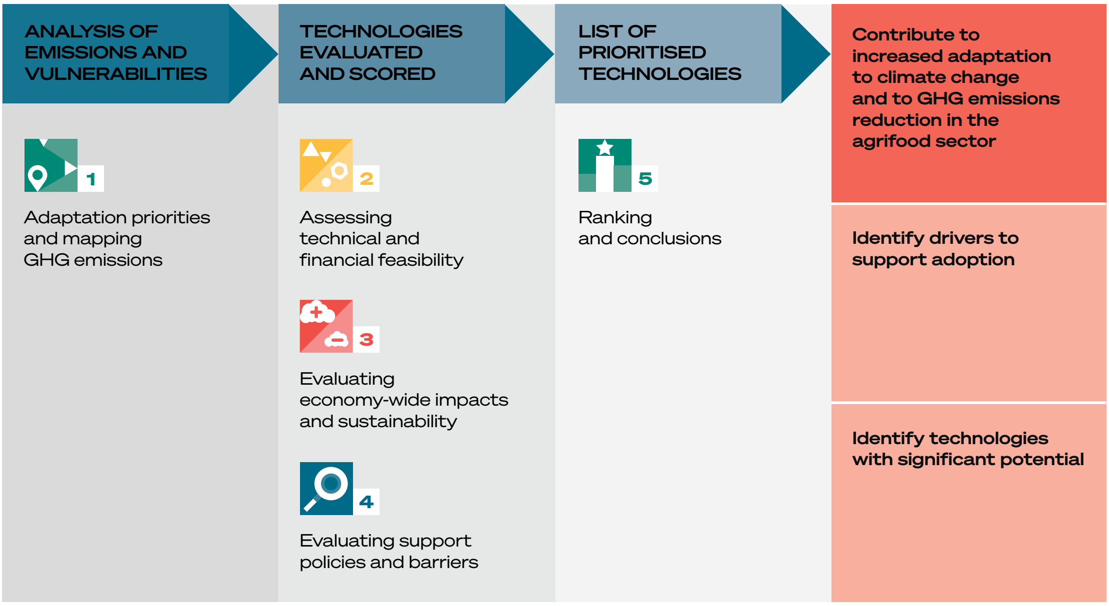
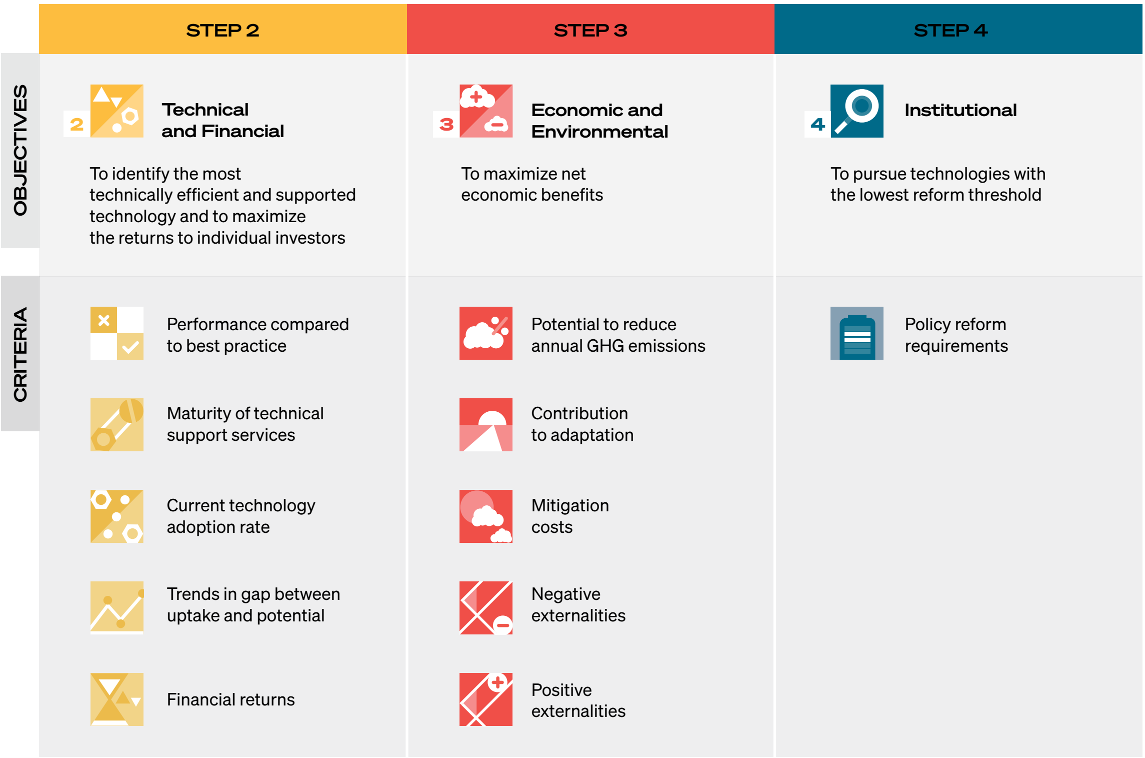


Figure 1
Summary of the five-step methodology

Source: Authors‘ compilation.



	STEP 2	STEP 3	STEP 4
OBJECTIVES	2 **Technical and Financial** To identify the most technically efficient and supported technology and to maximize the returns to individual investors	3 **Economic and Environmental** To maximize net economic benefits	4 **Institutional** To pursue technologies with the lowest reform threshold
CRITERIA	Performance compared to best practice	Potential to reduce annual GHG emissions	Policy reform requirements
	Maturity of technical support services	Contribution to adaptation	
	Current technology adoption rate	Mitigation costs	
	Trends in gap between uptake and potential	Negative externalities	
	Financial returns	Positive externalities	

Figure 2
Objectives and criteria – Steps 2 to 4

Source: Authors’ compilation.

Country context

The Kyrgyz Republic is a low-income, food-deficit country with a population of nearly 6 million, of which almost two-third live in rural area. Despite some strong progress in poverty reduction over the last years, the official poverty rate decreased from 38 percent in 2012 to 25 percent in 2016, rural areas are still lagging behind where 66 percent of the population is poor.

Amidst a steadily declining contribution to the country's total gross domestic products (GDP) from 27 percent in 2007 to 12 percent for 2018, agriculture remains an important sector for the economy of the Kyrgyz Republic. According to the last available estimate, the sector still provided employment to 30 percent of the economically active population (World Bank, 2018). In 2018, agriculture also accounted for 11 percent of total exports in value terms and 8 percent of total imports. Leading agricultural products for exports include vegetables, fruits, cotton, dairy products, tobacco and meat.

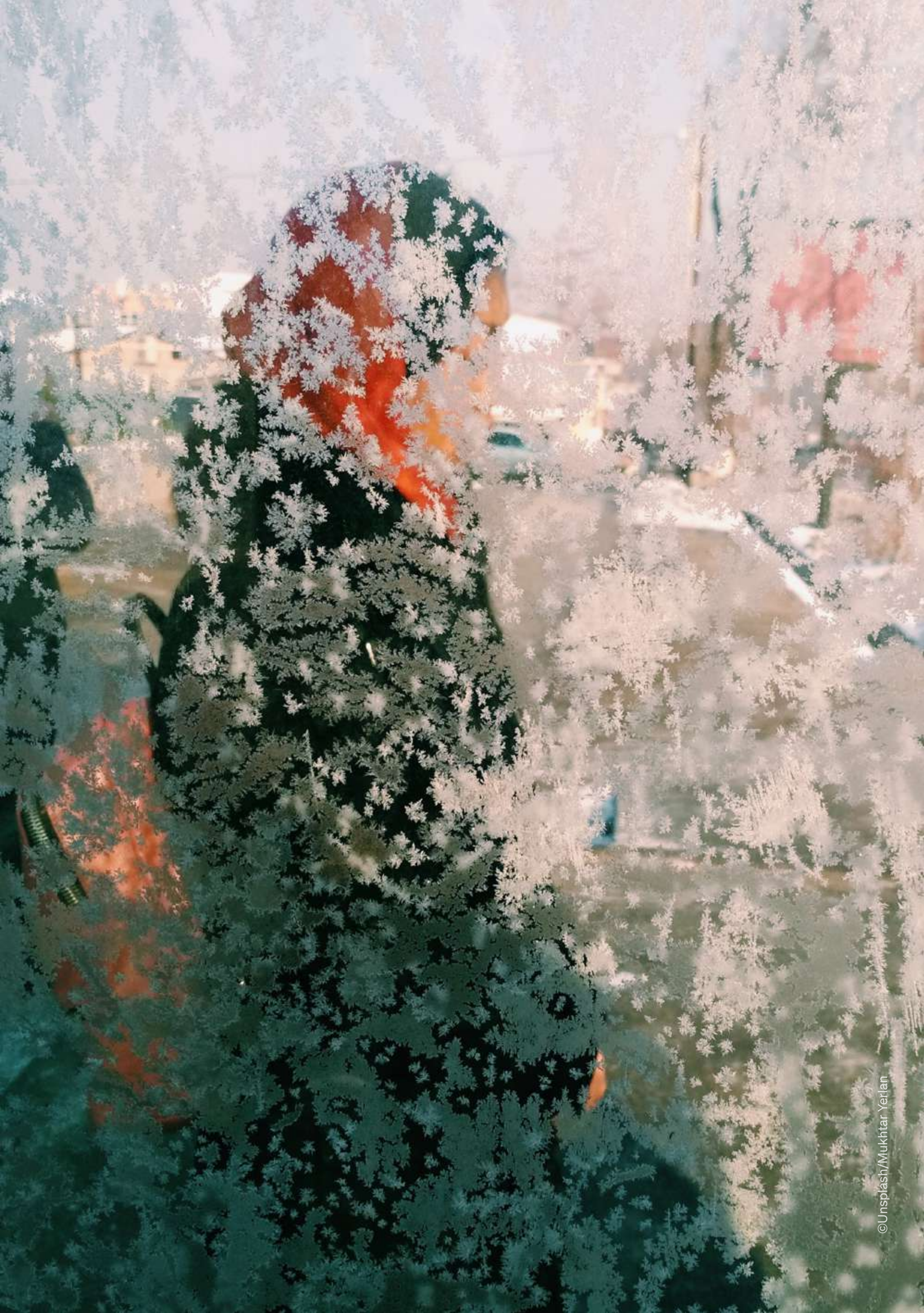
Land used for agricultural production 55 percent of the total land area in the Kyrgyz Republic, while 48 percent and 7 percent of that land accounts for permanent meadows and pastures and arable land respectively. Forestland represents 3 percent of total land but plays a strong social and environmental role despite this small share.

The agricultural sector has undergone a deep restructuration since the 1990s: through a land and agrarian reform, previously state-owned agricultural land was privatized. In 2012, the country had an estimated 535 716 privately owned farms, the vast majority of these categorized as small-scale of 3 hectares on average. These small-scale farms are characterized by are characterized by intercropped and mixed crop-livestock whose production is often consumed domestically. The middle and large-scale production systems are mostly privately owned and are characterized by commercial investment in large parcels of land used to cultivate wheat, barley, sugar beet, maize, and potato. These production systems however often suffer from unsustainable management practices, mainly poor pasture management practices, that can potentially trigger or accelerate land degradation and jeopardize income for small-scale farmers who still rely on livestock for living.

Climate-smart technology and practices present opportunities for addressing climate change challenges as well as for stimulating economic growth and promoting sustainable development within food and agricultural systems in the Kyrgyz Republic.

Figures indeed estimate that more than 40 percent of the agricultural land has seriously degraded, and over 85 percent of the total land is exposed to erosion.

The country is also highly vulnerable to shocks associated with climate change, primarily due to the sensitivity of its agricultural systems. Climate change impacts are projected to jeopardize agricultural livelihoods across the country. While climate change adaptation measures have been set as priorities, as expressed through the “Priority Directions for Adaptation to Climate Change in the Kyrgyz Republic until 2017”, climate-smart technology and practices present opportunities to address climate change challenges, stimulate economic growth and promote sustainable development within food and agricultural systems in the Kyrgyz Republic.



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Results of Step 1

Analysis of emissions and vulnerabilities

KEY FINDINGS FROM ANALYSIS OF GHG EMISSIONS

In 2010 total GHG annual emissions in the Kyrgyz Republic averaged 13 million metric tonnes CO2 equivalent (MtCO2 equivalent).[3] This included emissions from energy, transport, industrial processes, waste, residential uses and agriculture, and excludes emissions and sinks from land use. Agricultural emissions accounted for around 30 percent of total emissions in the country, whereas the energy sector contributed about 60 percent and industrial production contributes 6 percent. Agriculture's share in total GHG emissions is disproportionately high, compared with the sector's contribution to national GDP, which was 15 percent in 2010. These trends call for urgent actions to reduce the carbon footprint of the sector.

The value intensity of agriculture emissions is high – around 4.7 tonnes of CO2 equivalent per USD 1 000 of GDP in 2016, up from 4 tonnes/USD 1 000 in 2002. As shown in Figure 3, this is well above the regional average for Central Asia (3.5 tonnes/USD 1 000) and far above the average in Organisation for Economic Co-operation and Development (OECD) countries (1.6 tonnes/USD 1 000).

In absolute terms, agricultural GHG emissions increased by 1 528 thousand tCO2eq during 2000-2016, from 3.2 to 4.7 million metric tCO2eq, equivalent to an increase of +52 percent.

Approximately 95 percent of the increase in agriculture emissions over the past 15 years is due to livestock-related activities. The subsector contributes almost 90 percent of total emissions from agriculture at present. The main contributing factor is enteric fermentation, followed by manure-related emissions. The GHG footprint of the livestock subsector has been exacerbated by increased ruminant numbers (especially cattle, including dairy and non-dairy) along with increased livestock density (livestock units per hectare) combined with stagnant productivity levels resulting mostly from extensive production systems. For crop production, synthetic fertilizers are the main source of GHG (Figure 4).

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[3] FAOSTAT, using EDGAR Database (JRC/PBL, 2016). Emissions from land use are excluded from this figure.

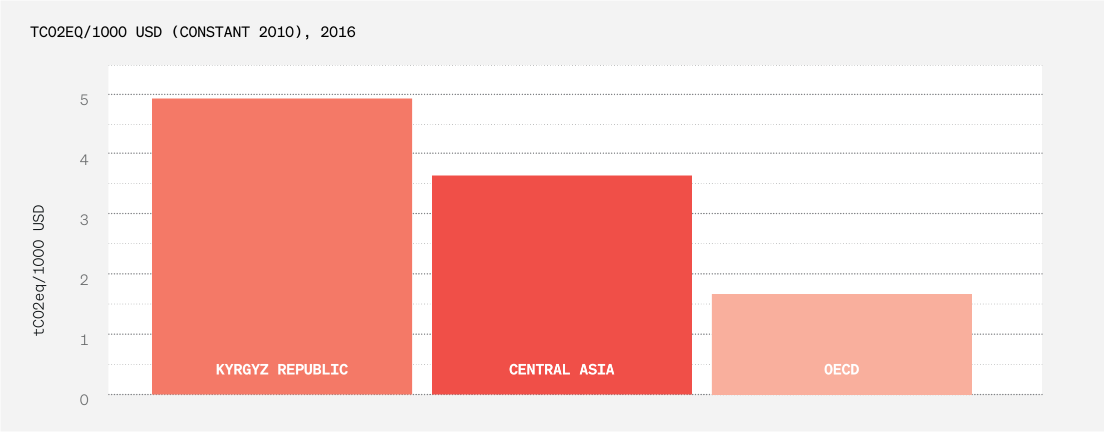

Figure 3
Agriculture emissions relative to agriculture GDP

Source: FAOSTAT and World Bank, 2018 (2016 data).

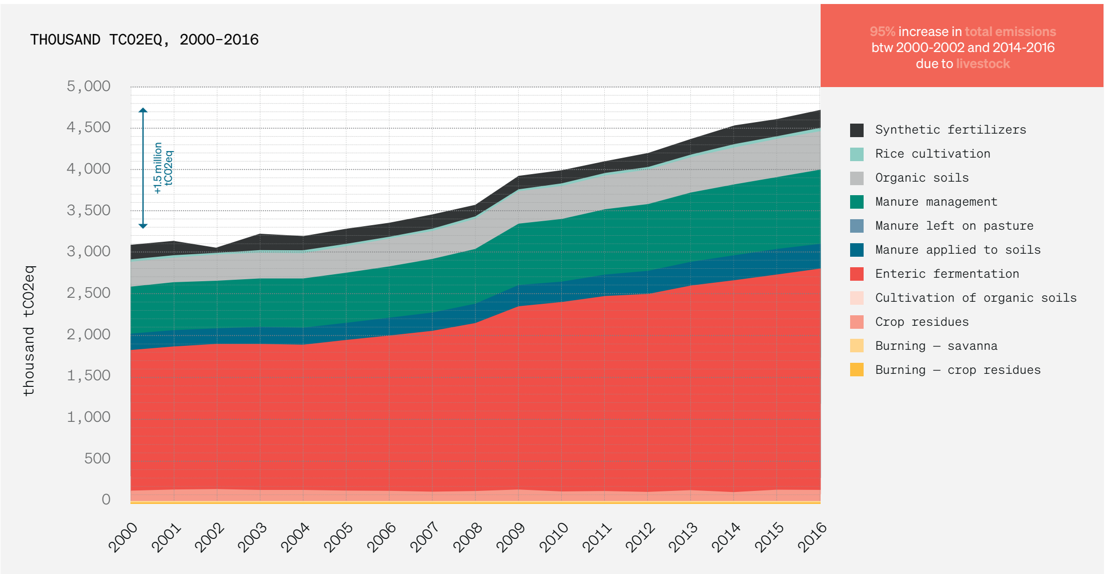

Figure 4
Emissions from agriculture activities between 2000-2016

Source: FAOSTAT, 2018.

The emissions from on-farm energy use have remained stable at relatively low levels (around 7 percent of total energy-related emissions). In turn, overall emissions from the electricity sector have declined by 90 percent since 2000, due to a shift towards hydropower.[4]

The INDC of the Kyrgyz Republic envisages a reduction of GHG emissions in the range of 11.49 - 13.75 percent below business as usual (BAU) in 2030, and by 12.67 - 15.69 percent below BAU in 2050. Although per capita emissions of 2.7 tC02eq in 2013 (WRI CAIT 2.0, 2017) are less than half of the global average (6.3 tCO2), the goal of the government is to reduce the per capita GHG emissions

[4] FAOSTAT and UNSD.

to 1.23 tCO2eq in 2030 or 1.58 tCO2eq in 2050. This reduction is needed to achieve the objective of less than 2°C global temperature increase, with a probability of 66 percent and 50 percent, respectively. The promotion and increased adoption of climate-smart technologies in the agrifood sector can make an important contribution to meeting these targets.

MAIN VULNERABILITIES OF AGRICULTURE SECTOR

The impact of climate change on agriculture and other sectors of the economy in the Kyrgyz Republic will intensify during the coming decades. According to the Third National Communication to the UNFCCC, the observed changes include: i) a significant increase in average annual temperatures by 0.0104°C/year over the 1885-2010 period; ii) increased variability of rainfall patterns in certain regions; and iii) a decrease in glacier volumes by 15 percent between mid-1970 to 2000. These trends are projected to continue throughout the twenty-first century.

The Kyrgyz Republic is the third most vulnerable country to the impact of climate change in Eastern Europe and Central Asia, primarily due to the dependency of its agricultural systems on water resources.[5] According to FAOSTAT and FAO-AQUASTAT, only 12 percent of the agricultural land is used for crop production, of which 75 percent depends on irrigation. The livestock subsector is highly dependent on precipitation levels. Overall, the agricultural sector already uses 93 percent[6] of the country's freshwater resources and changes in water availability will have important impacts on its performance. In addition to climate change, the agricultural sector is also vulnerable to growing pressure on natural resources resulting from overgrazing and other inadequate land and water management practices combined with low efficiency in the use of such resources.

Possible shortages in water resources may result from changes in surface water flows, as most rivers are fed by glaciers and/or snow melt. According to national and international sources,[7] surface water flow is expected to increase by 10 percent to 55 km3/year in the period 2020–2025 and then decrease by about 40 percent until 2100. As a result, water supply to agriculture is at risk. Other potential impacts include the following:

- Depletion of water resources and temperature increases may lead to an expansion of arid and semi-arid areas from 15 percent in 2000 to 23-50 percent in 2100. This may significantly reduce the size and productivity of highland pastures.
- Increase in frequency and intensity of extreme climate events may lead to reduced water availability for livestock and additional pressure on pastures, especially due to more frequent heat stress and droughts at low altitudes in summer months. Increased mudslides, flash floods and river floods will limit the accessibility of pastures. Increased droughts will also have a negative impact on crop yields.

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[5] Adapting to Climate Change in Eastern Europe and Central Asia, World Bank 2010.

[6] From FAOSTAT and WB - Latest data available from 2006.

[7] These include: Third National Communication to UNFCCC; Priority Adaptation to Climate Change in the Kyrgyz Republic; Climate Change Impact on Pasture and Livestock Systems in Kyrgyzstan (2013), IFAD; and INDCs 2015.

High economic losses are expected in the absence of timely adaptation in agriculture. These losses are estimated at USD 85 million per year by 2100 (in 2018 prices) according to the country's NDCs. In order to reduce these losses, very high adaptation investments are needed in all sectors, totalling USD 2.3 billion (according to INDC data adjusted for 2018 prices). For the agricultural sector, investments should focus on increasing the resilience of crop and livestock production and improving the provision of water resources to agriculture.

SELECTION OF CLIMATE TECHNOLOGIES AND PRACTICES TO BE ASSESSED

The emissions data analysis highlights the most critical agrifood activities in terms of GHG emissions (excluding land use), which in turn is the basis for identifying and selecting technologies and practices with potential to mitigate emissions from the sector.

Based on the assessment of the main trends in GHG emissions from agriculture and the vulnerabilities of the sector to climate change, the FAO identified 12 climate technologies and practices for further analysis and prioritization In addition, the decision on which technologies to assess was made based on national best practices evidenced by literature, expert consultations and discussions with key stakeholders and partners in the Kyrgyz Republic.

The technologies considered can be defined as “climate-smart” since they are expected to improve food systems while addressing at least one of three other objectives of EBRD’s GET approach: (i) reduction of GHG emissions (mitigation); (ii) enhancement of climate change resilience (adaptation); and (iii) other environmental benefits (including improved resource efficiency, improved resilience, and restoration of ecosystem).

Descriptions of these 12 technologies appear in Annex 1, Table 1, as well as their opportunities for addressing mitigation and adaptation. As indicated above, subsequent updates to this study by local or international stakeholders can easily add more technologies as required. For the presentation of the assessment results conducted from Step 2 to Step 4, the above technologies have been grouped as follows:

1. Crop-farming technologies: conservation agriculture; drip irrigation; field machinery; and improved greenhouses;
2. Livestock technologies: pasture improvement; manure management; and fattening units;
3. Renewable and energy-efficient technologies: production of biogas and biofertilizer; solar water pumps; wind water pumps; and steam boilers.

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Results of Step 2

Assessing technical and financial viability

TECHNOLOGY PERFORMANCE AND MATURITY OF TECHNICAL SUPPORT SERVICES

All four crop-farming technologies perform reasonably well in in the Kyrgyz Republic compared compared to international best practices (IBP), with scores between neutral and high (see Annex 2, Table 1). Efficiency is somewhat compromised by the fact that farmers mainly use regionally imported and locally produced technology, as more efficient machinery and equipment from western countries is costly. Technical support services exist for all four technologies but they are not country-wide and well-trained (scores from low to moderate). Conservation agriculture requires intensive extension services for proper application and these are currently not in place.

Livestock technologies perform well when compared to IBP. Pasture improvement and manure management scored very high, as relevant know-how and equipment are available in the country. Fattening units received an intermediate score, because best practices are only applied by few large and medium-sized farms. Technical support services exist for all technologies but are not widespread, and the technologies have not been widely adopted. In addition, qualified and experienced livestock/veterinary experts are in short supply.

Technical performance of renewable technologies under conditions in in the Kyrgyz Republic is poor compared to IBP, with scores ranging from very low for wind pumps to low for biogas and neutral for solar pumps. Except for wind pumps, best-practice technologies have been introduced in the country but accessibility is constrained by their high costs. Technical support services have limited outreach and there is a lack of qualified and experienced specialists.

MARKET POTENTIAL AND ADOPTION RATES

A. Potential adoption

The technologies are not suitable for every part of the country. Each technology has particular relevance for specific areas where it fits well into prevailing production systems. Moreover, some technologies are more attractive to smallholder farmers, whereas others are more suitable for larger farmers. While the full technical potential adoption for each technology was estimated, the assessment was conducted for a base case scenario of potential adoption using conservative assumptions. For example, in the case of conservation agriculture, the full technical potential adoption was estimated at 1.2 million of hectares (cultivated area of cereal, oil and leguminous crops in 2016). However, the potential adoption for conservation agricultural in the Kyrgyz Republic used in the assessment was 200 000 hectare, i.e. 20 percent of rain-fed/water scarce areas of cereal, oil and leguminous crops.

Table 1

Current and potential adoption levels of climate technologies

Climate technology	Current adoption (in 2018)	Base technical adoption potential	Full technical potential
Conservation agriculture	700 ha	200 000 ha	1.2 million
Drip irrigation (*)	1 000 ha	11 000 ha	15 000 ha
Field machinery	Tractors: 2 800 Harvesters: 300	Tractors: 14 000 Harvesters: 2 400	Tractors: 28 000 Harvesters: 4 800
Improved greenhouses	2 ha	100 ha	155 ha
Pasture improvement	500 000 ha	3 000 000 ha	9 900 000 ha
Manure management	15 000 LU/year	500 000 LU/year	1 010 000 LU/year
Fattening units	5 000 LU/year	58 000 LU/year	289 000 LU/year
Steam boilers	10 units	60 units	80 units
Biogas	25 plants	3 000 plants	10 000 plants (**)
Biogas (Biofertilizer)	1 plant	10 plants	30 plants
Solar water pumps (*)	1 unit	3 400 units	4 900 units
Wind water pumps (*)	1 unit	400 units	600 units

(*) with mitigation benefits and
(**) based on share of cattle in stables/mixed system from total herd estimated at 40%

Source: Authors' estimations.

B. Current adoption rate versus potential adoption

Estimated adoption rates of crop-farming technologies in the country are quite low – between 0 and 16 percent of potential – suggesting significant potential for expansion.[8] Improved field machinery has the largest outreach, while conservation agriculture is still at a very early stage, being practised only on 700 ha in 2013 (0.4 percent of base case technical adoption potential), according to FAOSTAT. All livestock technologies show considerable room for expansion, with current adoption rates ranging from 3 percent for manure management, to 9 percent for fattening units and 17 percent for pasture improvement.

The adoption rates of solar/wind pumps and biogas are very low (less than 1 percent), which leaves ample room for expansion. Moderate adoption rates are estimated for biogas (biofertilizer) and steam boilers, at 10 percent and 17 percent, respectively. While technology adoption rates were estimated against adoption potential under the base case scenarios, Figure 5 shows how adoption rates could differ if calculations were done with the full technical adoptions. The assessment and estimation of other criteria under Steps 2 to 3 have been done using the base case scenario of adoption.

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[8] Technologies with high adoption rates currently make a bigger contribution to GHG mitigation than those with very low adoption rates. However, the focus of the study is on identifying those technologies that have a high potential for increased GHG. Therefore, technologies with low current adoption rates are ranked higher as they offer greater scope for expansion.

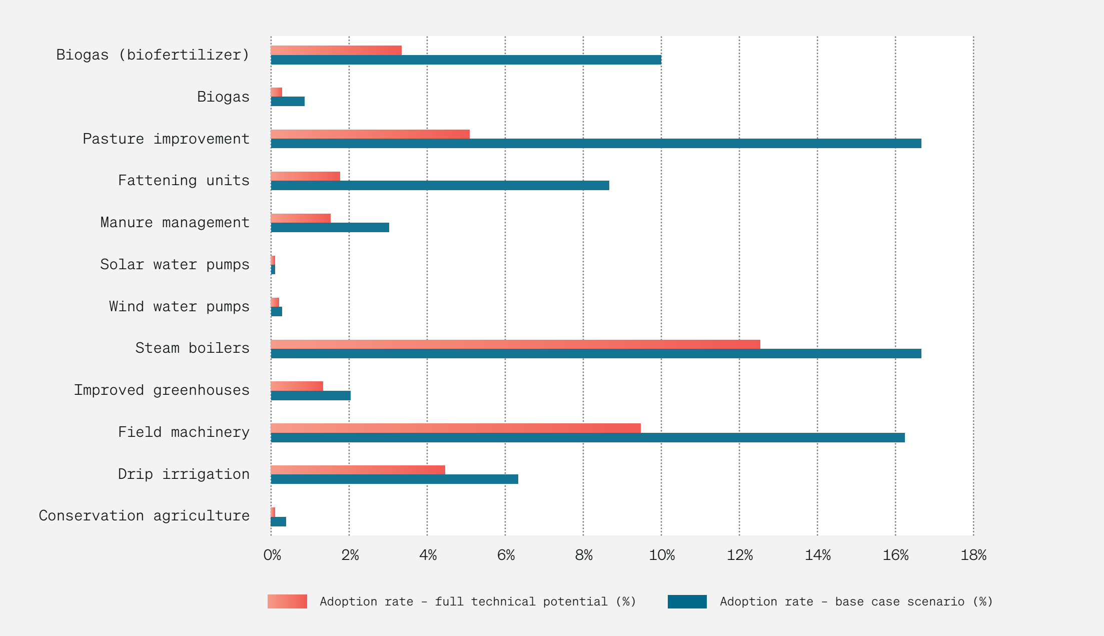

Figure 5
Adoption rates (against full technical adoption vs base case scenario)

Source: Authors' calculation.

C. Trends in gap between uptake and potential

Overall, gaps between current and potential uptake have remained large with little change for most technologies. This applies to conservation agriculture, cattle fattening and renewable energy technologies. In the cases of drip irrigation, field machinery, improved greenhouses and pasture management, the gap has been decreasing due to government support and donor programmes (for improved pastures and drip irrigation). For example, renovation of field machinery and investment in greenhouses have been supported through concessionary loans and leasing products in recent years, whereas pasture management and drip irrigation have received considerable donor support.

Following the same logic as above, decreasing adoption levels imply a larger potential for adoption and GHG reduction and therefore they receive higher scores than in cases when the gap has been narrowing.

Financial returns

For each technology, representative business models were built based on existing experience. Technical parameters and assumptions were validated with stakeholders and during expert consultations and financial analyses were conducted for ten-year periods using financial prices of 2017 to assess the financial viability of each technology. Table 2 summarizes the business models and investment analysis for each technology and Table 3 displays the results of the financial analysis. Investment costs and the net present value (NPV) were calculated at the latest phase of the analysis; the rounding off has been done at the highest decimal so to include the cost of the training necessary for the adoption of the technology. For each technology including two crops or farm models, financial parameters were averaged.

Table 2
Business models and investment costs

Technology	Crop/farm models	Investment cost	Financial benefits and costs
Conservation agriculture	1) 20 ha farm producing alfalfa, corn and barley shifting from conventional to conservation agriculture (plus rental income for no-till set for 80 ha annually) 2) 100 ha farm cultivating wheat, corn, barley and alfalfa.	USD 31 000 for equipment (No-till seeder and hydro pneumatic subsoiler) and training.	Compared with a conventional farming scenario, crop yields decrease by 10% over the first two years and then increase by up to 30%. Production costs such as labour and fuel consumption decrease as the number of field operations decreases. Herbicide costs increase during the first years.
Drip irrigation	1) 2 ha farm with tomato production. 2) 10 ha farm with apricot production. Both models analyse a switch of pump systems from surface to drip irrigation.	USD 6 000 and USD 17 000, respectively, for drip equipment, small reservoir of 10 m^3, pump and training.	Compared with surface irrigation scenario, water usage is more efficient and yields rise by 17 percent due to drip technology, improved seeds and fertilizer application.
Field machinery	Tractor model for 80 ha area and harvester model for 200 ha area.	Tractor: USD 20 000 Harvester: USD 60 000	Financial benefits are due to fuel savings, lower maintenance costs, and reduction of post-harvest losses.
Improved greenhouses	Greenhouse production of tomato and cucumber on 10 000 m2 investing in an energy-efficient heater and thermocover.	USD 100 000 for thermocover and heating.	Main financial benefits come from reduced heating consumption (500 tCO2e/ha/year).
Manure management	Biohumus production by small-scale farmers with 3 LU/farm (3 cattle or 30 sheep/goats), including regular collection and composting of manure into Biohumus for sale in local market.	USD 2 000, including facility construction costs, Californian worms and training.	The adoption of manure management can generate additional income from compost sales.
Pasture improvement	Pasture User Union with an average pasture area of 16 000 ha and 5 600 LU.	USD 210 000 for infrastructure improvement (bridges/waterpoints) tree and grass planting, equipment and training.	Compared with a conventional farming scenario, meat and milk productivities increase by 10. On the other hand, production costs such as leasing pasture (grazing) areas and artificial insemination.
Fattening units	Building a new fattening unit for 200 cattle - young bulls are purchased from households at 8 months old, fattened over 9-10 months, and then sold.	USD 115 000 for facility construction, tractor/implements, feed mixer and training to manage the facility.	Compared with a conventional scenario (small-scale households keep their bulls at pasture and in stables behind the house), bull's live weight increases (from 280 to 420 kg).
Biogas	60-head cattle farm investing in small biogas plant to produce electricity for the grid and digestate as a by-product.	USD 31 000	Opportunity costs of using of biogas instead of coal and digestate sales. Financial costs are manure purchase, water and labor.
Biogas (Biofertilizer)	Small-scale biogas plant for production of biofertilizer from digestate enriched with supplements as the main product.	USD 1 125 000 for biogas plant (1 000 m^3)	Revenue generated from biofertilizer sales and opportunity costs of using of biogas instead of coal consumption. Financial costs include manure and biosupplements, water and labor as well as other costs like packaging, marketing, utilities etc.
Steam boilers	An agrifood firm investing in energy-efficient boilers.	USD 22 000	Replacing an old gas-powered boiler could bring savings of around 15.7 thousand m3 of natural gas per boiler annually.
Wind water pumps	Farm-level investment in wind pump equipment to substitute existing electric pump for irrigation.	USD 15 000 per wind pump equipment.	Replacing electric pumps by wind pumps saves around 15 thousand kWh/year/wind pump. Maintenance of the wind pumps is the main financial cost.
Solar water pumps	Farm-level investment in solar pump equipment to substitute existing electric pump for irrigation.	USD 10 000 per solar pump equipment.	Financial benefits comes from savings on electricity consumption (9.0 thousand kWh/year/solar pump). Maintenance of the solar pump is main cost.

Source: Authors' compilation.

For most technologies, the estimated IRRs are higher than the cost of capital (10 percent). As shown in Table 4, among crop technologies, drip irrigation and improved greenhouses have the highest returns on investment (IRRs of 18 percent and 19 percent, respectively). Payback periods are relatively short (4 to 5 years), making these investments attractive from a financial point of view. These are followed by conservation agriculture, which scores moderately, with an IRR of 13 percent and a longer payback period. Field machinery has low returns because regionally produced machinery achieves only limited diesel savings and a modest reduction of harvest losses. While more efficient field machinery technology is available, it is more costly and difficult to maintain, which limits its uptake.

Within the livestock technologies and practices, fattening units have a high financial return on investment (26 percent) and a short payback period (4 years). In turn, pasture improvement and manure management have low estimated financial returns (below cost of capital) which, combined with the long payback periods, makes them less attractive to private investors. On the other hand, investment costs are also comparatively low, making them more accessible for small operators.

Solar and wind pumps, as well as biogas, have low financial returns (below the cost of capital). Given the current low electricity prices, by-products such as biofertilizer from digestate are more profitable than electricity production. This is reflected in the high IRR of the biogas factory producing biofertilizer. Hence, focusing on by-products such as biofertilizer rather than on energy production made the investment in a biogas plant financially viable. Efficient steam boiler technology generates moderate financial returns.

Table 3

Financial Analysis Results

Climate technology	Investment costs (USD)	NPV (USD)	IRR (%)	Payback period (years)
Conservation agriculture	USD 31 000	USD 7 000	13%	7
Drip irrigation	USD 12 000	USD 6 000	18%	5
Field machinery	USD 40 000	USD -3 000	10%	7
Improved greenhouses	USD 100 000	USD 37 000	19%	4
Pasture improvement	USD 210 000	USD -64 000	5%	8
Manure management	USD 2 000	USD -400	6%	9
Fattening units	USD 115 000	USD 93 500	26%	4
Steam boilers	USD 22 000	USD 1 500	12%	6
Biogas	USD 31 000	USD -22 000	-6%	11
Biogas (Biofertilizer)	USD 1 125 000	USD 463 000	20%	4
Solar water pumps	USD 10 000	USD -3 700	2%	10
Wind water pumps	USD 15 000	USD -5 000	2%	10

Source: Authors' compilation.

Results of Step 3

Evaluating economic and environmental benefits, economy-wide impacts and sustainability

MITIGATION POTENTIAL AND INVESTMENT NEEDS

The total mitigation potential for each technology was calculated by multiplying the mitigation potential per unit (e.g. ha, head) with the total incremental adoption potential in the Kyrgyz Republic, as discussed in the previous section. Aggregated over all technologies, 2.9 million tCO2eq, or almost 60 percent of total agrifood sector emissions in the country, could be mitigated at an aggregated investment of approximately USD 1 billion across various climate technologies. Figure 6 shows the share of each technology in the total investment portfolio.

Figure 7 plots the investment requirements of each technology against the respective mitigation potential. It shows that pasture improvement has by far the largest mitigation impact (80 percent of total) while only accounting for 3 percent of total investment costs. This is followed by manure management, biogas and conservation agriculture, contributing to 16 percent of the total mitigation potential but accounting for 50 percent of total investment costs. Field machinery only makes a small contribution to GHG reduction, at high cost.

Overall, livestock technologies, especially pasture improvement and manure management, can make by far the largest contribution to climate change mitigation (86 percent), at comparatively low investment costs (39 percent).[9] In turn, crop technologies represent 45 percent of the total investment costs (USD 450 million) but only contribute to 7 percent of the total carbon mitigation potential (or 205 KtC02eq). Within the group, conservation agriculture has the largest mitigation potential due to lower fuel consumption and soil carbon sequestration, and the considerable scope for expansion. Renewable technologies (except for biogas) present low mitigation potential, cumulatively accounting for only 7 percent of total estimated mitigation potential at 16 percent of overall investment costs.

[9] The bulk of the costs of livestock technologies apply to fattening units, which make the smallest contribution to climate change mitigation.

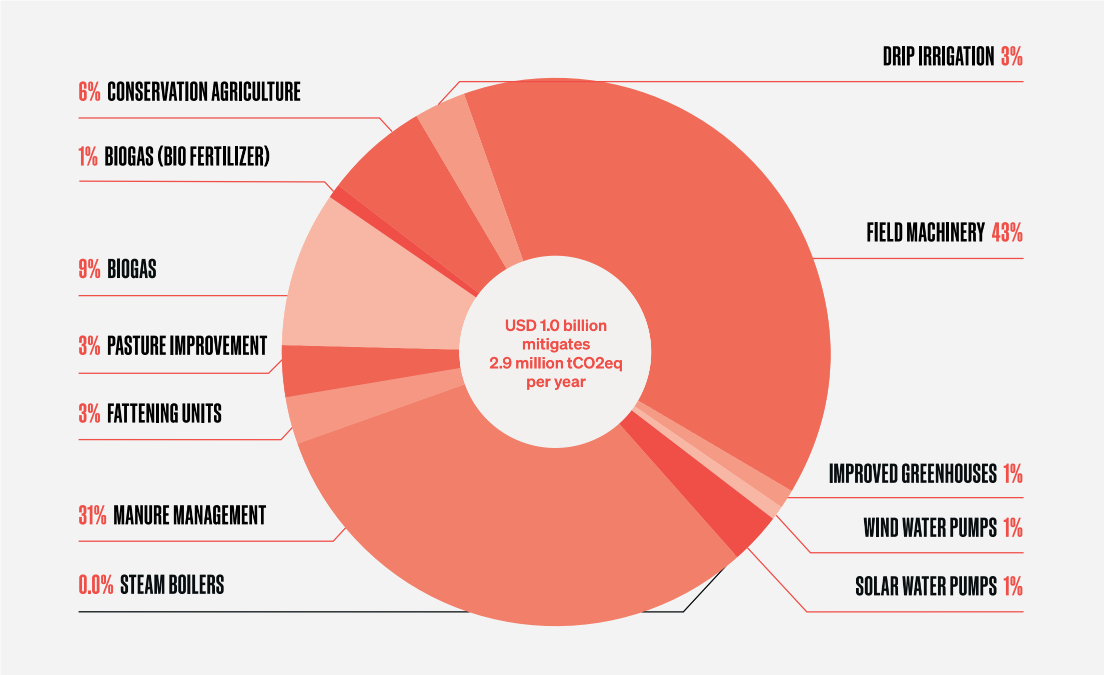

Figure 6
Total estimated investment size and share of each technology

Source: Authors' calculation.

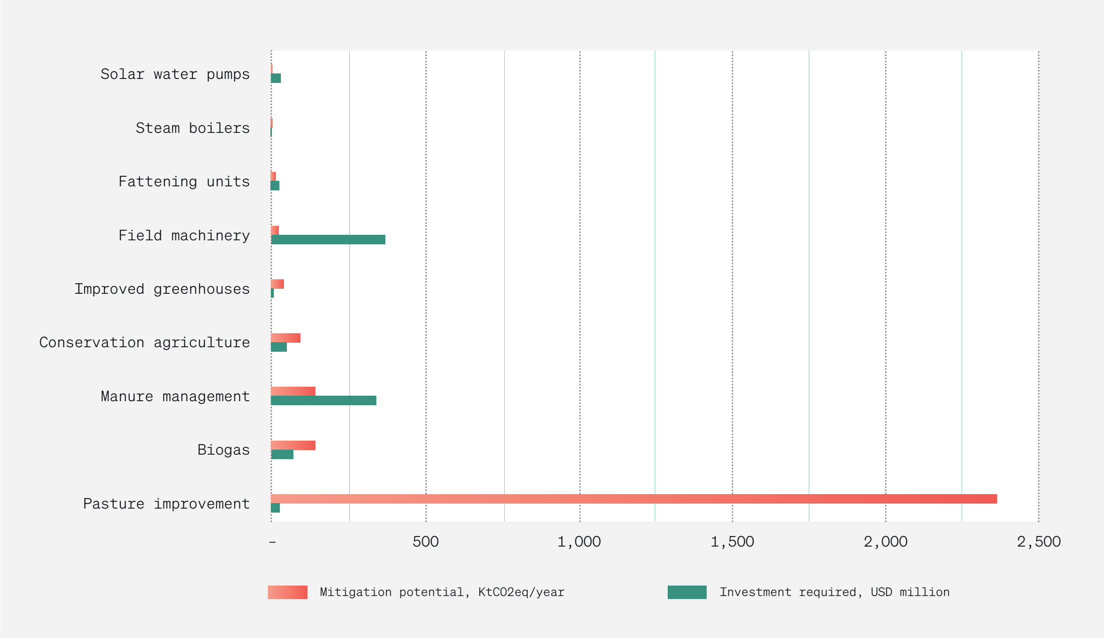

Figure 7
Mitigation potential and investment by technology

Source: Author's calculation.

CONTRIBUTION TO CLIMATE CHANGE ADAPTATION

The contribution of the selected technologies or practices to climate change adaptation was first assessed based on qualitative information and scored using the Likert scale. Where possible, adaptation benefits were also quantified in economic terms. The incremental benefits were compared to a reference scenario without investments in climate technologies and include: (1) increased agricultural production; (2) increased water availability; and (3) increased energy availability. The scoring for each of the technologies is available in Annex 2.

Drip irrigation scored highest (5 points) in this criterion and also generated the highest monetary adaptation benefits, at USD 109 million (see Table 4). The latter is due to the large increases in water use efficiency, freeing water for other economic purposes including incremental agricultural production. The economic price of water[10] can be high in areas with water scarcity.

Other technologies with considerable adaptation potential are conservation agriculture, improved greenhouses, pasture improvement, manure management and solar/wind water pump technologies. For conservation agriculture, the main adaptation benefits are related to increased agricultural production due to long-term improved soil nutrient management and water retention. The economic value of the annual additional production due to adoption of conservation agriculture at incremental technical potential (assuming rotation of wheat, corn, barley and alfalfa crops) was estimated at USD 35.3 million (9 percent of the total economic value of agricultural production in 2016). Benefits from reduced soil degradation as a result of conservation agriculture were included qualitatively but were not quantified due to the lack of information on declining yield trends without technology.

Improved greenhouses allow additional food production and increase the resilience of agricultural production to climate change impacts. The aggregate economic value of the additional annual production of tomato and cucumber (produced by current greenhouses adopting the thermocover) is estimated at USD 1 million. If potential investments in new greenhouses (“greenhouse as a package”) are included, the aggregated economic value of additional food production adds up to USD 226 million. In addition, improved greenhouses may increase energy availability by reducing aggregated coal consumption (if improvements are installed in current greenhouses).

The economic value of the annual additional production due to pasture improvement was estimated at USD 6.7 million/year (of which USD 5 million/year corresponds to climate change adaptation benefits from more resilient pastures). These benefits are derived from incremental meat and milk production under improved pasture management at full adoption level compared to a base scenario under current management practices.

Solar/wind water technologies increase energy (electricity) and water availability and can stabilize or increase agricultural production in areas without access to water and energy sources (so that remote areas can be used for agricultural production).

By using compost from manure, farmers may recover degraded areas affected by climate change and maintain soil fertility and an agricultural production system resilient to climate change. This may lead to increased agricultural potential. In addition, it may lead to increased energy availability due to energy saved from the replacement of synthetic fertilizer production and transportation by vermicompost.

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[10] The opportunity cost of water was estimated by EBRD at USD 1.3 (adjusted to 2017 prices).

Table 4

Quantification of adaptation benefits

Climate technology	Annual USD using economic prices (2017)			
	Additional agriculture production	**Increased water availability**	**Increased energy availability**	**Total estimated USD/year**
Conservation agriculture	USD 35.3 million	n/a	USD 3.5 million	USD 38.8 million
Drip irrigation	USD 6 million	USD 102 million	USD 1 million	USD 109 million
Field machinery	USD 34 million	n/a	USD 5 million	USD 39 million
Improved greenhouses	USD 1 million	n/a	USD 1 million	USD 2 million
Pasture improvement	USD 7 million	n/a	n/a	USD 7 million
Wind pumps	USD 3.2 million	USD 0.01 million	USD 0.2million	USD 3.5 million
Solar pumps	USD 21 million	USD 0.04 million	USD 1.1 milion	USD 22.1 million
Steam boilers	n/a	n/a	USD 0.2 million	USD 0.2 million
Biogas	n/a	n/a	USD 5.3 million	USD 5.3 million
Biofertilizer	n/a	n/a	USD 0.5 million	USD 0.5 million

(*) Benefits from Manure Management and Fattening Units were not quantified

Source: Authors' compilation.

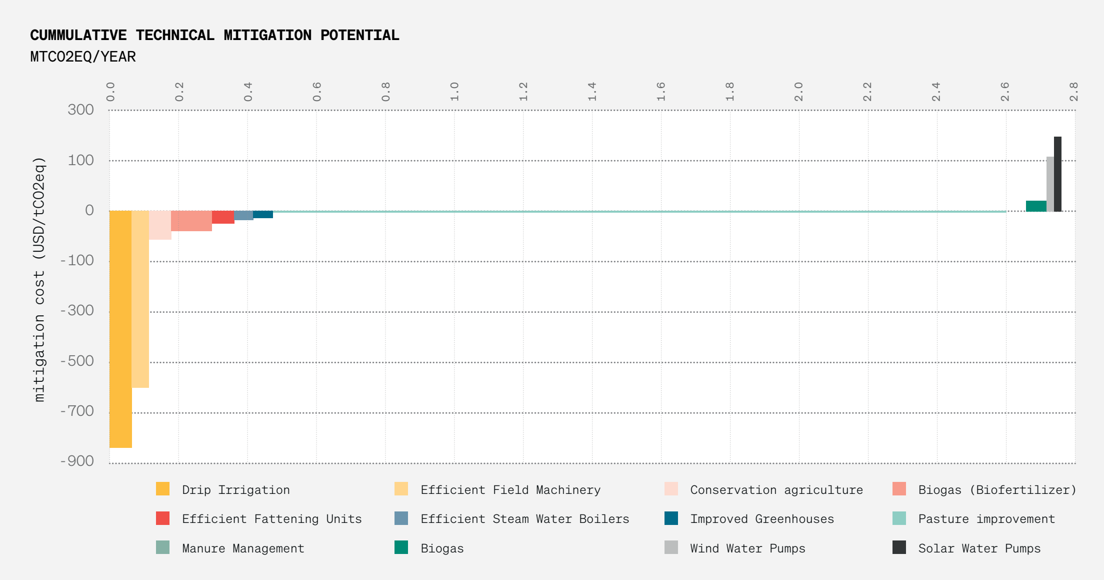

Figure 8

Estimated simplified MACC

Source: Authors' own elaboration.

Field machinery and biogas received a neutral score. The introduction of new, efficient machinery leads to an increase of agricultural production through a reduction of harvest losses by 13 percent (equivalent to about USD 34 million). Efficient machinery reduces diesel consumption by 440 l/tractor/year and 1120 l/harvester/year and thus leads to increased energy availability, valued at USD 5 million using economic prices.

Digestate and biofertilizer as part of soil improvement practices can be used to rehabilitate degraded lands. Digestate improves water retention in the soil and provides an effective source of organic matter to be applied to soils most severely affected by climate change (thereby preventing erosion, increasing water retention, etc.) It therefore contributes to stabilizing yields and preventing production losses due to droughts. Steam boilers and fattening units score low.

Mitigation costs

The mitigation cost of a technology is the ratio between the estimated economic net present value (NPV) and its GHG emission reduction potential.[11] Based on the analysis in Steps 2 and 3, it was possible to draw marginal abatement cost curves (MACCs) plotting: (i) the estimated cost of mitigation by technology; and (ii) the technical GHG mitigation potential. Figure 8 provides an indication of the mitigation that would be technically achievable (x axis), with the area underlying the curve indicating the associated total cost (y axis). Technologies are ordered left to right from lowest to highest cost. Those technologies below the horizontal axis offer the potential for economic savings, or positive Economic Net Present Value (ENPV), whereas technologies above the axis come at a net cost. The width of each bar represents the emission reduction potential of the technology.

This analysis shows that drip irrigation and efficient field machinery are the most profitable per tonne of CO2 equivalent mitigated but have a relatively low technical mitigation potential. They are followed by conservation agriculture, biogas (biofertilizer), fattening units, steam boilers and improved greenhouses, all of which have a mildly positive ENPV but only modest mitigation potential. In turn, pasture improvement has huge mitigation potential but its ENPV is very low if discounted at the social discount rate (6 percent). Manure management and biogas have the second and third largest mitigation potential of all technologies analysed but their adoption comes with small economic cost and therefore requires some level of public support. In turn, wind/solar water pumps would come at high economic cost while offering only small mitigation potential.

OTHER EXTERNALITIES

This section provides a brief overview of the externalities and co-benefits generated by the climate technologies. In addition to their contribution to climate change mitigation and adaptation, other environmental and social impacts related to the scaling up of the technologies need to be considered. A comprehensive assessment of externalities is beyond the scope of this study. Nevertheless, some key externalities – positive and negative – are briefly highlighted below. Further information on the scoring for each technology is available in Annex 2.

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[11] A negative mitigation cost means that the NPV is positive, and vice versa. Hence, the technologies on the left spectrum of Figure 8 are profitable at economic costs whereas the technologies on the right (with positive mitigation costs) have a negative NPV.

Crop-farming technologies. The main negative externalities are as follows: Conservation agriculture may lead to an increase in herbicide use in the short term until the production system consolidates. New field machinery have an environmental impact related to the manufacturing process and related resource and energy use. The environmental balance of drip irrigation can turn negative if the incremental energy required to pressurize the system outweighs the energy savings from reduced water consumption. The carbon balance of additional tubing also needs to be factored in. Hence, careful choice of technology is required to mitigate such negative externalities. On the positive side, conservation agriculture, greenhouses and drip irrigation contribute to food security at the household level and food self-sufficiency at the national level. Drip irrigation can lead to aggregate savings in water use if an appropriate regulatory and institutional setting is in place. Increased uptake of field machinery and other equipment may induce increased domestic presence and investment of manufacturers and suppliers, generating employment and tax income.

Livestock technologies. While manure management has no negative externalities (score of 5), pasture improvement could lead to pollution of water resources around waterpoints; still, its impact is assessed to be mild (score of 4). Fattening units might have a stronger negative environmental footprint in terms of pollution of surface and groundwater and an aggregate increase in water consumption for feed production and fattening (score of 1). Hence, the expansion of such technologies needs to be managed carefully. In terms of positive externalities, manure management reduces water pollution (leaching of nitrogen) and dependence on chemical fertilizers (score of 4), whereas pasture improvement enhances food security, increases biodiversity and provides the basis for value chain development (score of 5). The expansion of fattening units has similar benefits and may enable more structured meat value chains targeting export markets.

Renewable and other technologies. The main negative externalities relate to possible water pollution by effluents of biogas and overexploitation of underground water, which need to be managed through adequate regulatory and institutional frameworks. On the positive side, the proposed technologies would contribute to the diversification of energy sources beyond hydropower. Moreover, due to their decentralized nature, they would enable additional agricultural production in remote areas.

Overall, the analysis suggests that no significant negative externalities exist that would seriously undermine the expansion of climate technologies. Care needs to be taken when monitoring herbicide use in conservation agriculture and water pollution in improved livestock technologies.

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Results of Step 4
Institutional assessment

ADDRESSING POLICY BARRIERS HINDERING UPTAKE

Step 4 analyses relevant policy, institutional and other barriers and support mechanisms that influence the potential deployment of climate technologies for GHG reduction and climate adaptation in the agrifood sector. Table 5 summarizes the typology of barriers analysed for each technology while further details on the scoring obtained by each technology is available in Annex 2.

Based on the analysis of the above barriers and support mechanisms, an aggregate score has been calculated that is labelled “policy reform requirement.” A low score on this aggregate criterion indicates a substantial need for reforms and supporting instruments in order to speed up technology uptake, and vice versa.

In terms of **crop technologies**, conservation agriculture and drip irrigation score very low (1) and low (2), respectively, on this criterion, meaning that major policy reforms are needed for their scaling up. In turn, field machinery and greenhouses score neutral (3) and moderately high (4), respectively, as they require less policy attention and support measures. Overall, the principal obstacles to the adoption of the crop-farming technologies are limited knowledge and information, regulatory and institutional issues, and access to credit and cost of capital.

Expanding adoption of conservation agriculture would require greater knowledge dissemination, pilots with lead farmers and further development of support services. Drip irrigation deployment would benefit from improved institutional arrangements for efficient water governance and greater awareness about the technology and its benefits. Adoption of greenhouse technologies such as thermocovers and efficient heating systems could be supported through sensitization campaigns and capacity development. Use of more efficient field machinery could be stimulated by enhancing farmers’ knowledge about practices to reduce fuel consumption, providing technical support services and incentives, and improving access to capital (for small-scale farmers).

Table 5
Typology of barriers analysed

Knowledge and information	Organizational / social	Regulations / institutions	Support services / structures	Financial returns	Access/cost of capital
◆ Information asymmetries ◆ Lack of awareness about the technology ◆ Not enough technical expertise to use the technology adequately	◆ Collective action needed for technology to take off ◆ Social norms can hinder adoption ◆ Focus on private/ non-governmental issues	◆ Laws, regulations and other aspects that may prevent adoption ◆ Technology specifications are not well defined ◆ Focus on government/ public domain	◆ Existence of research institutes ◆ Efficiency and coverage of supplier networks ◆ Efficiency and coverage of maintenance companies	◆ Low returns ◆ IRR below the cost of capital	◆ Credit market failures ◆ High upfront investment cost ◆ Too high cost of capital ◆ High risks in relation to returns

Source: Author's compilation.

For **livestock technologies**, pasture improvement and fattening units score low (2) whereas manure management scores neutral (3) based on this criterion. Overall, the main barriers hindering uptake are linked to poor awareness and knowledge, organizational weaknesses and limited support services. Supporting pasture improvement would therefore require organizational strengthening of, and substantial financial support to, pasture committees in order to enable them to manage pastures in a sustainable way. Investing in fattening units would benefit from clear national targets, secured access to markets such as the Eurasian Economic Union (EAEU), pilot programmes to illustrate practice benefits, local value chain organization, tailored support for small farmers, and technical expertise on improved feeding and veterinary care. More widespread manure management would benefit from awareness and knowledge creation among farmers, environmental norms and regulations, and some level of public financial support. The latter should be linked to effective implementation and adherence to environmental regulations.

Finally, **renewable technologies** in the Kyrgyz Republic score very low in terms of policy reform requirements as major policy reforms are needed. Legislative efforts have been concentrating on hydropower with little attention to other types of renewable energy.

Biogas, wind and solar energy have been introduced through a few demonstration projects across the country but there is generally low awareness and no systematic promotion of the use of small-scale renewable energy systems. A major barrier to investment in these technologies is the very low price of electricity mandated by the government. Further constraints include: limited local expertise and support services; high upfront investments, combined with high interest rates; absence of risk capital for early development stages; and lack of pilot programmes.

Further policy reforms, with clear implementation and financial mechanisms, seem to be required. The introduction of solar and wind pumps can be supported in areas with available pumping water and lack of access to the electric grid, through provision of concessional financial resources, awareness and capacity development, as well as qualified support services. A shortage of areas with appropriate wind capacity can limit the adoption of wind technologies.

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Organizational, logistical and regulatory support for collecting feedstock by small-scale farmers, financial incentives and market development for biogas, digestate and biofertilizer can encourage the adoption of biogas technology.

Development of the market for efficient steam boilers seems constrained by the size and growth of the country's food industry (downstream industries) and lack of binding GHG emission regulations.

Results of Step 5
Final ranking and conclusions

Figure 9 provides an index measuring the performance of each technology based on all the criteria assessed under Steps 2 to 4 (except mitigation cost and potential to reduce GHG emissions, which are illustrated in the diagram). Mitigation costs are displayed on the Y axis, while the X axis includes the aggregate final score based on the normalized scores of each MCA criterion for each technology. Moreover, the Figure indicates the technical mitigation potential of each technology through the size of the bubbles.

Figure 10 displays the overall ranking of each technology on a normalized scale. The first scenario, which is mitigation-oriented, ranks the climate technologies applying a greater weight to the criteria "potential to reduce annual GHG" (30 percent) and "mitigation costs" (15 percent). The results of the MCA suggest that pasture improvement in the Kyrgyz Republich has by far the greatest potential, not only in terms of its mitigation potential (bubble size) but also after factoring in other key determinants for its successful rollout. It is followed by manure management, drip irrigation and improved greenhouses. Renewable technologies rank very low in the analysis due to weak financial results (cheaper alternatives are available) and low mitigation potential (except for biogas) – only 7 percent of total estimated mitigation potential. In the case of biogas technologies, their proliferation is hindered by: (i) scattered production of livestock manure due to small-scale livestock farming prevailing in the country; and (ii) underdeveloped markets for biogas plant products (biogas and digestate). Moreover, since biogas energy is very difficult to transport or store, there is a high risk of wasted energy. Hence, the size of a village is a critical parameter for the viability of biogas plants.

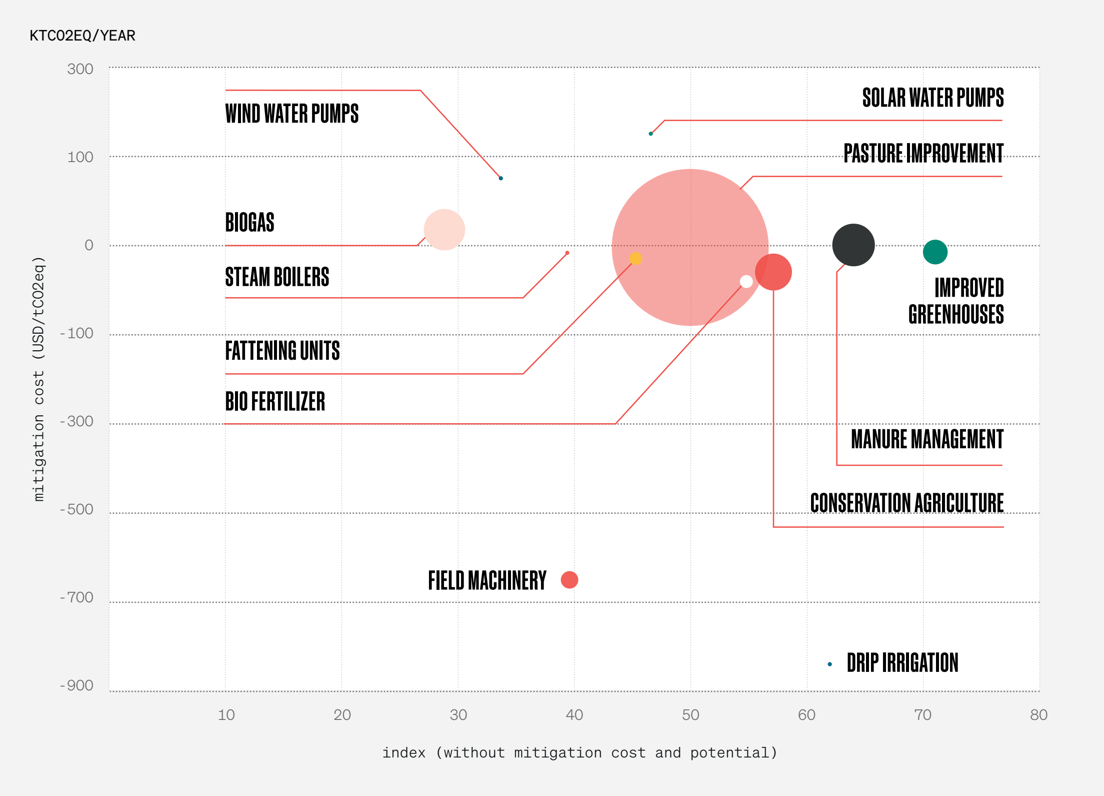

Figure 9

Mitigation costs, potential and weighted scores

Source: Authors' own elaboration.

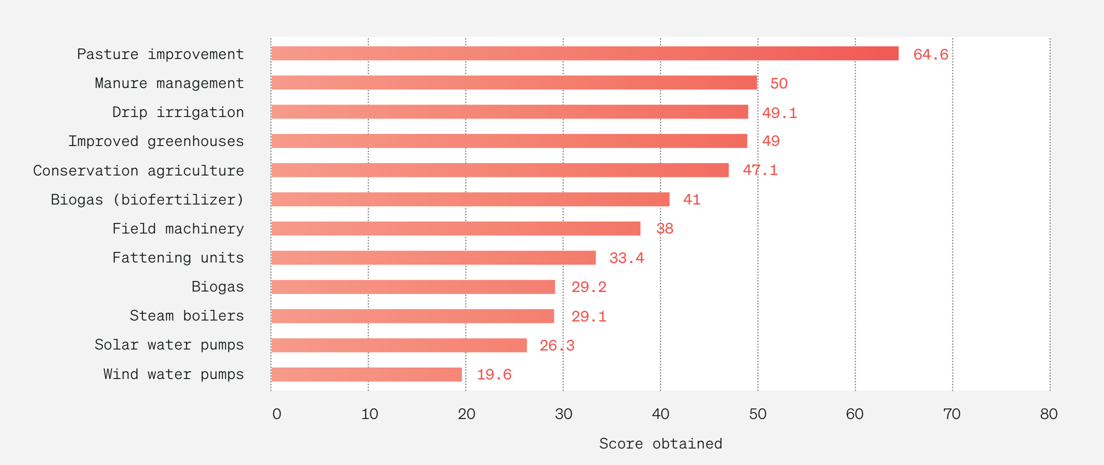

Figure 10

Technology ranking – mitigation-oriented

Source: Authors' calculations.

The second scenario (Figure 11) ranks the climate technologies applying a greater weight to climate change adaptation (30 percent). The MCA suggests that drip irrigation is the most promising technology given its potential to increase water availability (especially in areas with water scarcity) and agricultural production. It is followed by pasture improvement, manure management, improved greenhouses and conservation agriculture, as they contribute to improved long-term soil health, and higher yields and aggregate production in drought years.

The top five climate technologies are the same for both climate change mitigation and adaptation, notwithstanding some differences in their relative positioning. This is also visualized in the technology tree (Figure 13). Hence, policy attention and investments should focus on these technologies first.

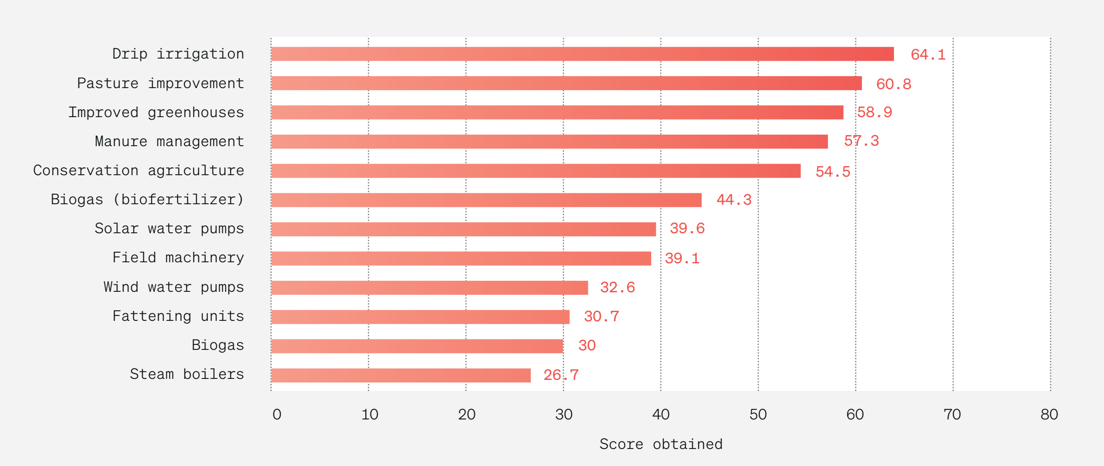

Figure 11
Technology ranking – adaptation- oriented

Source: Authors' calculations.

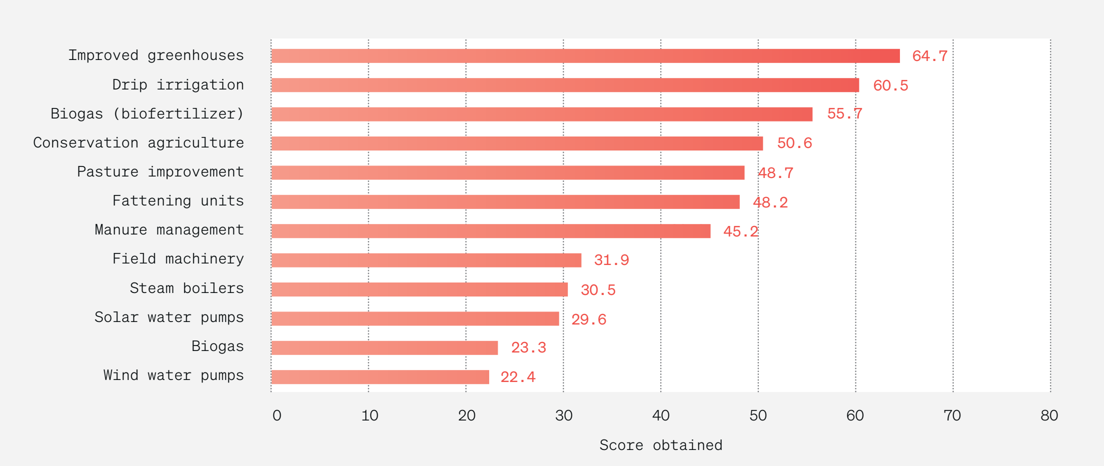

Figure 12
Technology ranking – financial return- oriented

Source: Authors' calculations.

RESULTS OF THE FIVE-STEP ASSESSMENT

BIOGAS FROM MANURE

Very high potential but insufficient goverment support for a rapid development

- Inefficient use of existing tech; premium for electricity generation is not enough to cover investment
- Servicing companies and manure management are prerequisites for technology deployment

WIND WATER PUMPS

High potential in remote areas with adaptation benefits

- Very good financial returns due to public support measures
- Only interesting in areas where electicity is not available

DRIP IRRIGATION

Only a mitigation technology in specific situations

- Significant adaptation benefits if water scarcity and with appropiate governance
- Water/groundwater regulations, clear targets and incentives for water-saving

FIELD MACHINERY

Good potential for fleet renovation

- Moderately good mitigation benefits through diesel savings
- Access to capital and availability of best technology concerns

CONSERVATION AGRICULTURE

Very high potential for mitigation and also adaptation

- Good financial returns; best practices dissemination and widespread support services needed
- Despite initial boom, policy reform and financial support needed to foster adoption

STEAM BOILERS

Promising but adoption linked to agrifood sector transition

- Good returns and moderate mitigation benefits
- Limited number of food enterprises

SMALL DAMS

High demand to prevent floods and irrigate, but requires long-term view

- Negative financial returns due to high up-front investment and low level of water tariffs
- Development of fisheries, tourism, recreational services, biodiversity improvements

IMPROVED GREENHOUSES

Limited market potential but interesting greening benefits

- Financially attractive for industrial greenhouses that operate for the entire year
- Government support and incentives may lead to new investment opportunities

EFFICIENT FATTENING UNITS

Tackling livestock productivity issues

- Good financial returns; can support sector modernization
- Capacity utilization is crucial for financial profitability

PRECISION AGRICULTURE

Good potential area served by field machinery equipped with tech

- Excellent financial returns due to less wasted seed, fertilizer, fuel and time
- Demonstration farms and activities on promotion of technology are needed

PASTURE IMPROVEMENT

Very high potential for carbon sequestration

- High priority for the sustainable development of the livestock sector
- Setting national targets towards the recovery of degraded pastures can help

Figure 13

Results of the five-step assessment

Source: Authors' compilation


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As described in Chapter 4, dissemination and awareness campaigns, training, and technical support services should be strengthened for all five technologies. Drip irrigation, manure management and pasture improvement will also require strengthening of regulatory frameworks concerning land and water governance (groundwater extraction and livestock densities). Financial support – e.g. in the form of matching grants or concessionary lending – should focus on those technologies (among the top five) that are less attractive from a purely private sector perspective, despite their large mitigation and adaptation benefits.

Figure 12 ranks the climate technologies applying a greater weight to their financial returns (30 percent). As discussed in Chapter 3, it shows that improved greenhouses and drip irrigation are quite attractive to private investors given their high rates of return and shorter payback periods. In turn, pasture improvement and manure management score considerably lower given their lower returns on investment and payback periods of 7-8 years. Given their large potential impact on GHG reduction and their high overall rankings, these technologies should be prime targets for financial incentives. Direct investment support to renewable energy technologies should only be considered in tandem with policy reforms addressing the price disincentives that currently render them less attractive for investors.


TAKE-3

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Annex 1
Climate technologies

Table 1.1

Selected climate technologies and their contribution to climate change mitigation and adaptation

Climate technology	Description and rational for selection	Contribution to climate change adaptation and mitigation
Conservation agriculture	Farming system defined by: (i) minimum mechanical soil disturbance (no-till); (ii) permanent organic soil cover; and (iii) crop rotation. Conservation agriculture can increase yields/crop productivity and reduce production costs such as fuel, labour costs, machinery maintenance costs, herbicides and pesticides in the long term. In the Kyrgyz Republic, few farmers implement conservation agriculture through no-till (direct seeding) and crop rotation. They are mainly applied on large-scale farms in the north of the country (Chui oblast). Organic soil cover is not applied since crop residues are used for grazing or removed from the fields. Small-scale farms are reluctant to adopt conservation agriculture practices due to the initial losses in yields during the first years.	**Mitigation benefits:** Conservation agriculture reduces on-farm fuel consumption (by lessening field operations) leading to lower GHG. Also fewer mineral fertilizers and pesticides are used, due to permanent soil cover and crop rotation. It also contributes to carbon sequestration by agricultural soils. **Adaptation benefits**: (i) Increased agricultural production as a result of soil quality improvements – crop yields become more resilient during drought years; and (ii) increased energy availability.
Drip irrigation	Applies water to each plant in small and frequent quantities, allowing more rational water use, if adequate water governance systems are in place. In Kyrgyz Republic, drip irrigation application is steadily growing in all oblasts (except Talas oblast). Only high-income crops are financially suitable for drip irrigation technology in the country.	**Mitigation benefits**: Drip irrigation can have mitigation benefits in situations when the energy saved from pumping less water to irrigate the same area offsets the extra energy that is required to pressurize the system. **Adaptation benefits:** (i) Increased water availability because of more efficient water usage when compared with surface irrigation; (ii) increased agricultural production, especially in situations of water scarcity; and (iii) increased energy availability, when drip irrigation is introduced in areas with pumped water and electricity is saved.
Field machinery	Eighty-seven percent of the current fleet of machinery is old (over 20 years) and the country faces a lack of tractors and harvesters. Investing in new tractors and harvesters, with regular and proper maintenance combined with training to drivers to improve machinery management, would allow savings in fuel consumption and maintenance costs and reduction in food losses.	**Mitigation benefits:** New tractors and harvesters under right management would save fuel consumption (up to 20 percent), leading to decreased GHG emissions. **Adaptation benefits:** (i) Increased agricultural production due to reduction in harvest losses (up to 13 percent); and (ii) increased energy availability due to reduction in diesel consumption.
Improved greenhouses	The analysis looks at existing greenhouses that operate six months a year. Improving a greenhouse means investing in an energy-efficient heater and a thermocover. The promotion of improved greenhouses is possible in all oblasts of Kyrgyz Republic, especially in the southern part of the country where more than 80 percent of the greenhouses operate.	**Mitigation benefits:** Use of thermocovers and energy-efficient heaters reduces coal consumption and therefore GHG emissions. **Adaptation benefits:** (i) Increased agricultural production (optimal heating can lead to increased yields); and (ii) increased energy availability due to energy savings in coal consumption

Source: Authors' compilation.

Pasture improvement	Degraded pastures have potential for rehabilitation through application of rotational grazing. This requires a package of investments in: (i) integrated pasture management (including capacity development); (ii) infrastructure rehabilitation and maintenance; (iii) pasture vegetation; and (iv) livestock breeds and health.	**Mitigation benefits:** Improved pastures could significantly increase soil carbon sequestration and improve resistance to climate change impacts.
		Adaptation benefits: (i) Higher pasture and livestock production (average milk and meat productivity raised by 5 percent to 15 percent from grazing); and (ii) improved resilience to climate change impacts (temperature and water stress, soil erosion).
Manure management	Requires practices such as frequent manure removal from livestock housing, reduced storage time, dedicated storage infrastructure and adequate practices for composting. Compost production is mainly practiced in the south of the Kyrgyz Republic among small-scale farmers, but few farmers produce it for their own fields and for sales.	**Mitigation benefits:** Frequent removal and prevention of leaching and volatilization from manure may directly reduce emissions from manure, while the compost produced can displace synthetic fertilizer and reduce emissions associated with its production.
		Adaptation benefits: (i) Increased agriculture production, as compost can recover degraded areas and maintain soil fertility; and (ii) increased energy availability, as compost can substitute for synthetic fertilizer and save energy consumed for its production
Fattening units	The facility is used for intensive animal farming and finished livestock – a balanced and nutritious diet is provided to produce beef of a consistent quality and quantity. In the Kyrgyz Republic livestock management is heavily based on grazing on pastures, while old and inefficient fattening practices (especially in cold periods) are all over the country. Few large-scale farms (100-1000 cattle heads), operating almost all year in Chui oblast, fat cattle efficiently.	**Mitigation benefits**: Methane emission reduction (in the process of digesting feed) is estimated per kg of meat in intensive fattening units vs extensive production systems.
		Adaptation benefits: Efficient fattening leads to increased food (beef) production.
Steam boilers	This technology focuses on energy-efficient boilers (including a set of economizers), which use natural gas for steam production, and require training for their proper operation. The agrifood industry uses steam for a wide variety of purposes, of which the most important are heating, drying, and distillation.	**Mitigation benefits:** More efficient energy consumption (natural gas or fossil fuel oil boilers) leads to GHG emission reduction.
		Adaptation benefits: Increased energy availability resulting in natural gas savings.
Biogas / Biofertilizer	Biogas is a type of biofuel that is naturally produced from the decomposition of organic waste. In the Kyrgyz Republic, relatively small-scale biogas plants (average 50 m3 reactors) were introduced which produce biogas and digestate from livestock manure at the farm level. The biogas produced is used for heating and cooking purposes, while produced digestate is utilized on farmers' own fields as fertilizers. There is no biogas plant that generates electricity from biogas in Kyrgyz Republic..	**Mitigation benefits**: By operating biogas plants, it is possible to save coal used for on-farm cooking and heating and thus reduce GHG emissions.
		Adaptation benefits: (i) Reduced pressure on energy sources; (ii) increased agriculture production, as digestate improves water retention in the soil, provides an effective source of organic matter to soils and improves long-term soil nutrient management.
Solar / wind water pumps[11]	Solar water pumps can be used an alternative to grid electricity- powered water pumps in irrigated areas. Wind pumps (mechanical water pumping without electricity production) may be used in irrigated areas by substituting for current electricity-powered pumps. In the Kyrgyz Republic, there is almost no use of wind pumps (only one wind pump is installed in Issyk-Kul oblast) with technically relevant wind capacity.	**Mitigation benefits:** The substitution of electricity-powered water pumps by solar/wind pumps can provide limited mitigation benefits since electricity is mainly produced by hydropower plants (> 90 percent of electricity production) with a very low emissions coefficient.
		Adaptation benefits: (i) Reduced pressure on conventional energy resources; and (ii) good potential in remote areas (with difficult access to electricity grid) to provide farmers with access to irrigation (increased water availability) and additional production (increased agricultural production).

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[11] There are three scenarios for the application of this technology: (i) wind/solar pump is installed to substitute for existing pump stations (mitigation benefits); (ii) wind pump is set in remote area with no access to electric grid (adaptation benefits); and (iii) wind pump is installed in area with potential access to the electric grid (connection to electric grid is considered an opportunity cost).

Annex 2

Score of selected technologies

Table 2.1

Scoring selected technologies

Tech/ Criterion	Performance compared to best practice	Maturity of technical support services	Current technology adoption rate (%)	Trends in gap between uptake and potential	Financial returns (%)	Potential to reduce annual GHG (KtCO2eq/ year)	Contribution to adaptation	Mitigation cost (USD/ tCO2eq)	Negative externalities	Positive externalities	Policy reform intensity
Units	Likert	Likert	%	Likert	%	KtCO2eq/ year	Likert	USD/ tCO2eq	Likert	Likert	Likert
Preferred value	High	High	Low	High	High	High	High	Low	High	High	High
Conservation agriculture	3	2	0.4%	4	13.4%	125	4	-51	4	5	1
Drip irrigation	4	3	6.3%	2	17.9%	2	5	-849	3	3	2
Field machinery	3	3	16.3%	3	9.7%	29	3	-640	3	4	3
Improved greenhouses	4	3	2%	3	18.8%	49	4	-12	2	4	4
Steam boilers	4	2	16.7%	3	11.7%	2	2	-13	5	4	3
Wind water pumps	1	1	0.3%	4	2.3%	0.37	4	131	2	4	1
Solar water pumps	3	3	0%	5	1.6%	2	4	215	2	4	1
Manure management	5	3	3%	5	6.1%	161	4	2.3	5	3	3
Fattening units	3	2	8.6%	4	25.6%	16.8	2	-21	1	4	2
Pasture improvement	5	4	16.7%	2	4.6%	2 300	4	-0.1	4	5	2
Biogas	2	2	0.8%	4	-6.1%	167	3	30	2	3	1
Biogas (biofertilizer)	4	2	10%	4	19.7%	17	3	-69	3	3	3

Source: Authors' compilation.

Table 2.2

Score normalization and final ranking of the technologies

Criteria	**Performance compared to best practice**	**Maturity of technical support services**	**Current technology adoption rate (%)**	**Trends in gap between uptake and potential**	**Financial returns (%)**	**Potential to reduce annual GHG (KtCO2eq/ year)**	**Contri-bution to adaptation**	**Mitigation cost (USD/ tCO2eq)**	**Negative extern-alities**	**Positive extern-alities**	**Policy reform intensity**	**Weighted scores of each option**	**Rank**
Units	Likert	Likert	%	Likert	%	KtCO2eq/ year	Likert	USD/ tCO2eq	Likert	Likert	Likert		
Preferred value	High	High	Low	High	High	High	High	Low	High	High	High		
Weight	5%	5%	5%	5%	10%	30%	10%	15%	5%	5%	5%		
Conservation agriculture	50	33	100	67	45	20	67	57	75	100	0	47.1	5
Drip irrigation	75	67	91	0	82	0	100	100	50	0	33	49.1	3
Field machinery	50	67	25	33	14	4	33	100	50	50	67	38	7
Improved greenhouses	75	67	100	33	90	7	67	46	25	50	100	47.3	4
Steam boilers	75	33	22	33	31	0	0	46	100	50	67	29.1	10
Wind water pumps	0	0	100	67	0	0	67	5	25	50	0	19.6	12
Solar water pumps	50	67	100	100	0	0	67	0	25	50	0	26.3	11
Manure management	100	67	100	100	0	26	67	42	100	50	67	50	2
Fattening units	50	33	76	67	100	0	0	49	0	50	33	33.4	8
Pasture improvement	100	100	22	0	0	100	67	43	75	100	33	64.6	1
Biogas	25	33	100	67	0	27	33	34	25	0	0	29.2	9
Biogas (biofertilizer)	75	33	67	67	98	2	33	63	50	0	67	41	6

Source: Authors' compilation.

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Agrifood systems are major contributors to greenhouse gas emissions and increasingly under pressure to become more resource-efficient. The sector also faces threats from climate change, due to its dependence on natural resources. The Food and Agriculture Organization of the United Nations (FAO) and the European Bank for Reconstruction and Development (EBRD), collaborating within the Finance and Technology Transfer Centre for Climate Change (FINTECC) programme, developed a rapid assessment methodology to identify and prioritize climate technologies and practices in the agrifood sector, based on their potential to mitigate greenhouse gas emissions, support climate change adaptation and contribute to economic development. This report presents findings from the methodology's application in the Kyrgyz Republic to guide policy-makers and inform public and private investments towards greening the country's agrifood sector.

ISBN 978-92-5-134954-0

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CB6812EN/1/03.22