UNIVERSITY OF CENTRAL ASIA
GRADUATE SCHOOL OF DEVELOPMENT
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Climate Change in Afghanistan, Kyrgyzstan and Tajikistan: Trends and Adaptation Policies Conducive to Innovation

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WORKING PAPER #55, 2019

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Abstract: Afghanistan, Kyrgyzstan, and Tajikistan are among the world's most vulnerable countries to climate change with weak adaptive capacities. This analysis summarises adaptation technologies for agricultural, water, transport and health sectors, as well as disaster risks management technologies, that contribute to the climate resilience of the population and sectors of the economy. The technological solutions proposed are assumed to cope with and limit the negative impacts of climate change on the people and sectors of the economy against the expected impacts and hazards but also contribute to productivity and economic growth, and the overall welfare of the populations. Most of the technological solutions proposed in this analysis are also applicable in other neighbouring Central Asian countries. This policy-oriented research urges the governments of these three countries to take respective actions to ensure environmental sustainability and sustainable economic growth, as well as to improve the welfare of these countries' populations and to avoid the negative consequences of climate change.

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Keywords: climate change adaptation, technological solutions, agricultural, water, health, transport sectors

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Contents

Abbreviations

ADB	Asian Development Bank
AKT	Afghanistan, Kyrgyzstan and Tajikistan
AKUH	Aga Khan University Hospital
CCA	Climate Change Activity
CIF	Climate Investment Fund
DRR	Disaster Risk Reduction
EBRD	European Bank of Reconstruction and Development
ECC	Engineered Cementous Composite
ECTAP	Enhanced Competitiveness of Tajik Agribusiness Project
EECCA	Eastern Europe, Caucasus and Central Asian
EU	European Union
FEWS-NET	Famine Early Warning Systems Network
FMICs	French Medical Institute for Mothers and Children
GDP	Gross Domestic Product
GEF	Global Environment Facility
HMA	Hot-mix asphalt
IAEA	International Atomic Energy Agency
ICIMOD	International Centre for Integrated Mountain Development
IDFC	International Development Finance Club
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
ITS	Intelligent transportation system
IWMI	International Water Management Institute
JICA	Japan International Cooperation Agency
LIDAR	Light Detection and ranging
LLINs	Long-lasting insecticidal bed nets
LLL	Laser Land Levelling
MDB	Multilateral Development Bank
MEWS	Monitoring and Early Warning System
MSRI	Mountain Societies Research Institute of University of Central Asia
NCCARF	National Climate Change Adaptation Research Facility
ND-GAIN	Notre Dame Global Adaptation Initiative
NEPA	National Environmental Policy Act
OECD	Organization for Economic Co-operation and Development
PEACE	Pastoral Engagement, Adaptation, and Capacity Enhancement Project
RDTs	Rapid Diagnostic Tests
SPCR	Strategic Programme for Climate Resilience
UNFCCC	United Nations Framework Convention on Climate Change
UK	United Kingdom
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UMMB	Urea-molasses multi-nutrient blocks
US	United States of America
USAID	United States Agency for International Development
WB	World Bank
WHO	World Health Organization
WMA	Warm-mix asphalt
WUAs	Water User Associations

Executive Summary

This analysis was conducted within the "Pathways to Innovation: Strengthening Mathematics, Science, and Economic Policy Capacity in Afghanistan and Central Asia (P2i)" project led by the Aga Khan Foundation Canada (AKFC) and the University of Central Asia (UCA). This P2i project explores the question of how to foster healthy innovation within the context of developing countries in Central Asia and Afghanistan, and in turn to support economic growth or, at a minimum, mitigate negative economic shocks associated with the current global economic crises. This project seeks to help the region respond to these challenges by strengthening individual and organizational skills in mathematics, environmental science and economic policymaking in Afghanistan, Kyrgyzstan and Tajikistan (AKT). The application of innovative technology and knowledge to existing economic sectors will drive economic growth, improve productivity and competitiveness, and generate employment.

The objective of this analysis is to explore climate change adaptation policies in AKT countries that are assumed to cope with and limit the negative impacts of climate change on the people and sectors of the economy against the expected impacts and hazards, through exploring advanced climate adaptation technologies that not only reduce vulnerability but are also conducive to innovation.

One of the main challenges for the sustainable development of Afghanistan, Kyrgyzstan, and Tajikistan (AKT) is climate change. An increase of temperature and fall of precipitation are key climate change risks and vulnerabilities that lead to the melting of glaciers, deforestation, desertification, natural disasters, drought reducing the agriculture yield, the increase of agriculture diseases, and the maladaptation of some plants and animals, etc. The climate change adaptation policies in these countries are project-based and predominantly financed and tracked by development partners, while there is no evidence of financing climate change activities within the state budget of each country under review. However, some clauses in the sectoral budget can be found and classified as relating to climate adaptation, e.g., building structural barriers in riverine districts, the desalination of soil, the lowering of groundwater, and the restoration of irrigation systems and canals, etc.

This analysis has revealed that some technology solutions are available in the region, while most such solutions tested in other regions are not available yet. This analysis summarises adaptation technologies that contribute to the climate resilience of the population and sectors of the economy in AKT countries. The technologies assessed in this analysis cover six types of technologies in agriculture, three group of technologies in the water sector, three in transportation and two in human health sectors, as well as five disaster risk management technologies.

Agricultural sector. Laser land levelling is a technology that can be widely used in AKT countries to flatten or level agriculture fields in an effort to conserve irrigated water. This is due to the low relative cost, co-benefits, and co-cost of this technology, which are assessed as more desirable from effectiveness, relative cost, co-benefits and co-cost perspectives (an example provided in Annex 3), except for rice agriculture either planted in LLL or in an unlevelled plot. Groningen et al. (2013) pointed out an increase of emissions of CH_4 from rice agriculture and provided several options to reduce CH_4 emissions, such as mid-year drainage and using alternative fertilizers, switching to more heat-tolerant rice seeds and by adjusting sowing dates. Therefore, yield decline due to temperature increase will be prevented, thus, reducing the effect of warming on CH_4 emissions per yield. Notice that the laser land levelling technology is not applicable in salinized soil, as for such land it is preferable to have a slope that allows for the washing of the salt from it. This technology can be used in such soil too, in combination with salt tolerance plants.

Symbiont fungi as climate adaptation technologies specifically refer to several classes of fungal organisms with the potential to alter the host plants' response to stresses brought on by climate (ADB, 2014). This technology is prominent and upon further development and tests should be considered as a climate adaptation technology and employed in the region.

Pressurized irrigation technologies are highly recommended due to their water-saving feature, as well as prerequisite of yield increase; however, higher relative costs make it less desirable. Nonetheless, a solution can be found as preferential long-term loans can be provided to farmers, where the interest rate for the implementation of drip irrigation technologies can be covered either by the government or climate adaptation projects that provide grants equivalent to the cost of the interest rate.

Floating agriculture involves planting crops on soil-less floating rafts. Due to the intermediate relative costs, *floating agriculture* technology can be tested in riverine coastal districts of AKT countries, where flooding occurs often, and in case of positive effects this can then be spread across to relevant areas.

Adoption of best practices on *livestock feeding* is crucial for an increase of dairy products and meat in AKT countries, as livestock productivity is low, and this technology is climate resilient.

Temperature regulation for livestock is important so as to increase livestock productivity. Employing either water- or electricity-based technologies is dependent on the context and milieu, thus, those which are available and inexpensive should be used. Potential marketing and financing can be done by the private sector and relevant government institutions. Meanwhile genetic breeding to ensure livestock heat resilience needs institutional support.

Water sector. In this sector three groups of technologies were assessed, i.e. water quantity[1], water quality and inland flooding.

The relative cost of each *water quantity* technology is classified from more to less desirable depending on the scale of implementation and cost per unit. However, relative cost should not be a barrier for the implementation and adoption of any technology and must be adopted in the case of the prevailing of benefits over costs.

Wastewater treatment technology should certainly be used, while the choice between a centralized or decentralized system of wastewater treatment in each case should depend on the prevalence of benefits over cost.

Non-structural barriers to flooding are preferable over a structural technology that allows the negative effects of flooding to be minimized and can be implemented in the riverine districts of Kyrgyzstan and Tajikistan. However, note that for this to be more effective a significant amount of land resources need to be devoted.

Accommodation of flooding technology, due to relatively lower costs, is an applicable technique and highly recommended in Kyrgyzstan and Tajikistan, especially for newly-planned infrastructure and buildings.

1 Water quantity technologies are: (1) rainwater harvesting; (2) surface-water storage; (3) inter-basin water transfer; (4) aquifer recharge; (5) water loss reduction technologies; (6) water demand reduction technologies; (7) desalination; (8) point-of-use water treatment.

Transportation sector. In this sector, three relevant technology solutions, i.e. warm-mix asphalt, engineered cementitious composite and intelligent transportation system are assessed.

Warm-mix asphalt is a relatively new technology that requires a mixing temperature of 0.5°C – 49°C versus 132°C – 163°C of traditional hot-mix asphalt (HMA) and is ideal for both warmer and colder climates (Chowdhury and Button 2008; US FHWA 2013). In warmer temperatures, there is less heat strain on workers, and in cooler temperatures, less energy is needed to heat the mix to the appropriate temperature. The *warm-mix asphalt* (WMA) technology was experimentally tested in Iran (Fazaeli et al. 2012), South Korea (Kim et al., 2011), India (Khan and Chandra 2012) and has went through a field trial in China (Zhu et al., 2013). The results of the latter indicate that the Sasobit-modified WMA had better workability and rutting resistance than traditional HMA. The literature on WMA indicates that no such practice is in place in AKT countries. However, warm-mix asphalt (WMA) technology has been presented to Tajik representatives from the Ministry of Transport during a study tour to Japan organized by JICA[2]. Thus, further field tests need to be monitored and should be replicated in the case of AKT countries, regardless of the comparatively higher costs for the rehabilitation of roads and the construction of new ones.

Engineered Cementitious Composite (ECC) is a new technology proposed for bridge construction as a replacement for traditional concrete. Fly ash and ground granulated blast furnace slag (GGFBS), waste foundry sands and carbon residue can be used for ECC concrete (Lepech et al. 2008, cited in ADB, 2014). ECC technology is still not widely used across the world, though it has great potential, thus, its development should be tracked and implemented in AKT countries.

Intelligent Transportation System. For the well-functioning of ITS, information from meteorological services on weather events will be useful to develop early warning systems for travellers. For example, collaboration of the Safe City Project in Dushanbe[3] with the meteorological services under the Government of Tajikistan and the Emergency Committee under the Government of Tajikistan on the functioning of ITS in Dushanbe and later after expanding Safe City across the country, will play a crucial role in addressing the challenges in real time. Innovative Road Solution Company that maintains the road between the country's capital and the south part with north part of the country can be an important player in the development of a well-functioning ITS for the northern part of the country. The Safe City Project can serve as a basis for the development of the ITS system, first in Dushanbe, and then across the country. This experience can be expanded further to other neighbouring countries.

Human Health Sector. Two out of the five technologies solutions – E-Health and Rapid Diagnostic Tests (RDTs) are evaluated, as a relevant and applicable technology in the human health sector.

E-Health technology. Despite the existent barriers to implementing E-Health technology in remote areas with limited numbers of trained staff it should be used to provide at least primary health care through existing and available technologies.

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2 Японский опыт обслуживания дорог обсужден на семинаре в Душанбе. http://avesta.tj/2018/02/15/yaponskij-opyt-obsluzhivaniya-dorog-obsuzhden-na-seminare-v-dushanbe/ . Выпускники учебных курсов JICA поделились опытом, полученным в ходе тренингов. https://news.tj/ru/news/tajikistan/society/20180215/vipuskniki-uchebnih-kursov-jica-podelilis-opitom-poluchennim-v-hode-treningov

3 Safe City Project in Dushanbe was introduced on October 31, 2014 and cover 870 cameras. The total cost of the Project is $22.0 million. For more detail see: Safe City Improves Traffic, Cuts Crime. http://e.huawei.com/en/case-studies/global/2015/201504031050

Rapid Diagnostic Tests (RDTs) is an affordable technology for the quick diagnosis of illnesses such as malaria, tuberculosis, AIDS, syphilis, and visceral leishmaniasis. It is an indispensable technology in remote areas of AKT countries, especially in Afghanistan due to the lack of well-trained staff and laboratories, with an acceptable price per unit. RDTs are already available and used in Afghanistan to improve the treatment of malaria (Leslie et al., June 2014).

Disaster Risk Management Technologies. *Light Detection and Ranging* (LIDAR) technology can be used in AKT countries, at least in vulnerable areas, if financial assistance is provided by the international community or through providing concessional loans.

The main barriers to using *artificial lowering of glacial lakes* include the extreme level of elevation in the high mountainous region that makes access difficult. Even so, effectiveness, relative direct and indirect costs, as well the co-benefit and co-cost, are assessed from more desirable to intermediate. Typically, international aid partners can support the countries to implement and use such technology, where glacial lake outburst floods occur in AKT countries.

The effectiveness of a *monitoring system* is very high and more desirable allowing farmers and people to prepare for hazards, thus, minimizing potential negative effects. Therefore, to employ such technology each country should have well-trained staff/researchers and adequate financing needs to ensure a high internal rate of return.

Early warning system. The cost of early warning system technologies varies, depending on the type used (ADB, 2014); however, they are invaluable, as they can save people's lives and reduce negative consequences for infrastructure and population dwellings. Co-cost and co-benefits of such technology are assessed as intermediate and barriers to implementation are similar to those as mentioned with regard monitoring system technologies. Thus, having such a system is important; however, without well-trained human and financial resources introducing such a system is meaningless. Developing partners and financial institutions that finance climate adaptation related activities can support the most vulnerable countries to develop and utilize such systems, through providing grants or concessional loans and conducting training for personnel.

Social media technology, like Facebook, Twitter, etc. can help raise additional awareness on disasters at a comparatively lower cost.

In sum, the analysis reveals that not all climate change adaptation technologies are available in the region, and even those that are in use have not spread across the region as perhaps had been hoped. The policy, institutional and governance gaps, economic and financial gaps, education and capacity building gaps, knowledge sharing gaps, technologies, methodologies, practice, and infrastructure gaps, and science-based information and data gaps (for more detail see MSRI, January 2018) are the main barriers facing the spread of climate resilience technologies in the AKT countries.

1. Introduction

"I'll pay to send climate change deniers to Venus" – said physicist Stephen Hawking[4]. Climate change is one of the main challenges for the development of any economy in the XXI century. It can influence human health, agriculture and water sectors due to changes in the amount of precipitation and temperature. Moreover, it is a challenge for food security and now affects the livelihood of populations across the world, especially in rural areas (Khakimov & Aliev, 2018, IFPRI study, forthcoming). The Sustainable Development Agenda accentuates the attention of governments on the necessity to take urgent action to combat climate change and its impacts on people and the ecosystem (Sustainable Development Knowledge Platform, Goal 13). Climate change heightens poverty: one of the challenges that the development goals wish to address (NHDR, 2012, Tajikistan: Poverty in the Context of Climate Change).

Nonetheless aspects such as integrating climate change risks into relevant national policies, plans, and programmes, the evaluation and mainstreaming of climate change adaptation measures, the strengthening of inter-ministerial coordination on climate change, and integrating climate adaptation options into sectoral policies in Kyrgyzstan and Tajikistan, can be assessed as unsatisfactory thus far due to the aforementioned existing gaps (for more details on the existing gaps see Annex 2)[5] (Mountain Societies Research Institute (MSRI) of University of Central Asia, Jan' 2018).

The scarcity of financial resources within the national budgets and financing climate change related activities on a residual basis make AKT countries more vulnerable to the ongoing process of climate change. Climate change in AKT countries is an inevitable process, so, relevant policy and technological solutions need to be proposed, not only to minimize the losses but also to ensure sustainable and inclusive socio-economic growth.

In Kyrgyzstan climate-related development finance is five times less than the average for Eastern Europe, the Caucasus and Central Asian (EECCA) countries. For instance, in Kyrgyzstan the per capita committed finance in 2013 was $10 versus $27 for the EECCA region in 2014. According to a climate-related development finance report of the OECD (2016, Kyrgyzstan Country Study) in 2014, more than 80% of financial resources was directed to mitigation measures, nearly 11% to adaptation measures, while the rest to aspects regarding mitigation and adaptation. In Kyrgyzstan, domestic funding is limited: only 2.5% to 10% of total investments between 2006 and 2012 were provided by local sources and the rest was financed by international funding sources, most to the energy sector, i.e. generation and supply of energy (OECD, November 2016, Kyrgyzstan Country Study). In Tajikistan, according to ADB (May 2016) study, "…climate change adaptation is evident in the national budget but only in peripheral and informal ways. It is left to the singular judgment of sectors rather than prioritized from the central and highest levels of government as a matter of national environmental security. Ministries and agencies need a systematic foundation for deciding how to incorporate climate resilience into their budgets in

4 "Professor Stephen Hawking, from Oxford, has predicted our planet will one day look like Venus with surface temperatures of 460°C (860°F) if global warming continues. The planet was habitable for around 2 billion years, with water at its surface and mild temperatures similar to Earth's. A build-up of greenhouse gases in Venus's atmosphere burned off its oceans and turned it into the scorching hot planet seen today, with winds of up to 180mph (300km/h)". Read more: *http://www.dailymail.co.uk/sciencetech/article-5253705/Stephen-Hawking-Earth-burn-thanks-climate-change.html#ixzz59n1z3eXU*

5 The gaps as: (1) Policy, institution and governance gap; (2) Economic and financial gaps; (3) Education and capacity building gaps; (4) Knowledge sharing gaps; (5) Technologies, methodologies, practice, and infrastructure gaps; (6) Science-based information and data gaps. for more details see Mountain Societies Research Institute (MSRI) of University of Central Asia, Jan' 2018.

optimal ways that can have a multiplying effect rather than a one-off benefit from a single project or activity". A review of open-access sources indicates that no evidence on climate adaptation activities within the national budget was identified, in Afghanistan, though it may be a case but not publicly available.

More broadly, climate change activities can be divided into two groups: climate change mitigation and adaptation to climate change. The United Nations Environment Programme (UNEP) defines climate change mitigation as efforts directed to reducing or preventing the emission of greenhouse gases through employing new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour (UNEP). Climate change adaptation has been defined in different ways. The United Nations Framework on Climate Change Convention (UNFCCC) describes it as help to communities and the ecosystem to cope with changing conditions. The Intergovernmental Panel on Climate Change (IPCC) defines it as "…adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". The United Nations Development Programme (UNDP) describes it as a "…process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented". The United Kingdom (UK) Climate Impact Programme defines it as "…process or outcome of a process that leads to a reduction in harm or risk of harm, or realisation of benefits associated with climate variability and climate change". The National Climate Change Adaptation Research Facility (NCCARF) describes it as consisting of actions undertaken to reduce the adverse consequences of climate change, as well as to harness any beneficial opportunities. Nonetheless of the different definitions available and used to describe climate adaptation policy, all refer to the reduction of harm, risks and adverse consequences on communities and ecosystems through moderate harms, the exploitation of beneficial opportunities– by taking advantages and coping with changing conditions.

One of the impacts of climate change is human migration in (Khakimov and Mahmadbekov, 2009) examined the linkages between climate change and migration in Tajikistan and found that not all forced migration is related with climate change and that some forced migration is related to the degradation of the environment due to human activity, i.e. man-made disasters. "An increased frequency of landslides is largely the result of the low educational level of population in ecology and incorrect use of the land and the construction of dwellings in the places at high risk of mudflows (Khakimov and Mahmadbekov (2009).". Moreover, "… environmental degradation, such as soil degradation, desertification, and the increase of the level of subsoil water and so on, is not the main reason for migration, whereas reduction of the incomes of the people who are employed in agriculture was an accelerator of external labour migration, i.e. degradation of the environment was one of the several factors leading to migration for individuals, but not households" (Khakimov & Mahmadbekov, 2009). Kyrgyzstan's country case study within the EACH-FOR (Synthesis Report, 2009) Project indicate that "Migration processes in Kyrgyzstan have a strong environmental flavour and environmental problems causing migration and displacement of large groups of people bring only negative, deteriorating impacts on the life of communities… Environmental factors are interconnected with economic, social and cultural factors affecting the migration flows of people".

Climate change is an urgent issue in most sensitive-to-climate-change[6] countries with a relatively low adaptive capacity[7] (Fay et al., 2010). On the one hand, an adaptive capacity or readiness indices are important to assess the capacity of each country to cope with ongoing processes of climate change. On the other hand, the sensitivity or vulnerability to climate change indices allow for the assessing of the degree of vulnerability of each society. Two conceptual frameworks – outcome and contextual vulnerabilities – produce different rankings and strategies to reduce vulnerability (O'Brien et al., 2007). Contextual vulnerability is a wider framework than outcome vulnerability, and is rooted to the political economy. In a contextual vulnerability framework climate change and responses are two-way linked with contextual conditions[8], while at the same time the latter is two-way linked with political, socio-economic, institutional structures and changes. Within this framework, the responses should be linked with political, socio-economic, and institutional structures and changes (for more details see: Füssel, 2009). In a background analysis to a World Development Report (2010) Füssel (2009) concludes: "All existing indices of vulnerability to climate change show substantial conceptual, methodological and empirical weaknesses including lack of focus, lack of a sound conceptual framework, methodological flaws, large sensitivity to alternative methods for data aggregation, limited data availability, and hiding of legitimate normative controversies". As revealed, most climate vulnerability indices are outcome vulnerability orientated with a focus on exposure unit and responses. This analysis refers to vulnerability and readiness indicators of the University of Notre Dame (For more details on the explanation of GAIN Index see Annex 1) that almost fit the requirements of the contextual vulnerability framework and provide up-to-date figures for 191 countries. The vulnerability indicator measures exposure, sensitivity and adaptive capacity in six life-supporting sectors – food, water, health, ecosystem services, human habitat, and infrastructure. Meanwhile, the readiness indicator measures economic[9], governance[10] and social readiness[11] aspects to cope with climate change.

Afghanistan in terms of vulnerability is ranked 171st out of 181 countries, with a score 0.596, while in terms of readiness it is ranked 179th out of 191 countries, with a score of 0.222. Kyrgyzstan is ranked 65th with a score of 0.390 in terms of vulnerability and is ranked 104th with a score of 0.391 in term of readiness. Tajikistan is placed at 101st with a score of 0.438 in terms of vulnerability and 142nd with a score of 0.296 in terms of readiness. As seen, all three countries are among of the most vulnerable and is not ready to cope with climate challenges.

6 Climate change sensitivity index are based on physical indicators (available renewable water resources per capita and the extent of air pollution), economic indicators (share of employment and value of assets), overall quality of infrastructure, share of population over age 65 (as a most sensitive group of population) and economic indicators capturing the importance of agriculture in the economy (share of employment and value of assets). For more details see Fay et al. (2010).

7 Adaptive capacity index comprises social (income inequality), economic (gross domestic product [GDP] per capita), and institutional measures. For more details see Fay et al. (2010).

8 Institutional, biophysical, socio-economic and technological.

9 Doing business sub-indicators – starting a business, getting credit, enforcing contracts, dealing with construction permits, protecting investors, getting electricity, paying taxes, registering prosperity, trading across the borders, resolving insolvency.

10 Political stability and non-violence, control of corruption, rule of law, regulatory quality.

11 Social inequality, ICT infrastructure, education and innovation.

A combination of these two indicators is the GAIN Index. Thirty-six indicators contribute to ND-GAIN's measure of vulnerability and nine indicators contribute to the measure of readiness[12]. In 2016, out of 181 countries, Afghanistan, Kyrgyzstan and Tajikistan were ranked 174; 113 and 81 respectively, and when not adjusted for GDP, 31.3, 42.9 and 50.0, while when adjusted by GDP[13] these countries were ranked as 163; 23 and 83, with respective scores - 10.5, 7.5 and 0.6[14].

As the review of different climate-related indicators and indices shows, all three countries are among the most vulnerable in the world with low adaptive capacity: a prerequisite for introducing climate adaptation technologies to ensure their resilience.

This paper consists of six parts. Following the introductory part, where the importance of the study is outlined, and the objectives of the analysis are presented, in the second section, a general overview of the current and future trends of climate change is provided. The third section provides a preliminary assessment of Tajikistan's progress made so far within the Strategic Programme for Climate Resilience in the framework of the First Joint Multilateral Development Bank (MDB). The next section is devoted to reviewing the current literature on climate change adaptation measures and applicable technological solutions. The fifth section deals with a review of the available climate change adaptation technologies in AKT countries. The last section is devoted to conclusions and sets out recommendations regarding institutions and policy tools that are relevant and effective for each country to define tailor-made political solutions.

2. Overview of the Current and Future Climate Situation

2.1. Afghanistan

Overview and future. Since the 1960s, in Afghanistan, the mean annual temperature has increased by 0.6° C, while it is projected to increase between 1.4 and 4°C by 2060 and between 2 and 6.2°C by 2090. For the same observed period, the average annual precipitation has decreased by 0.5 mm per month per each decade and the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) indicates that there will be little or no change in precipitation throughout the 21st century. At the same time, the frequency of 'hot' days will increase, respectively by 25 and 26 days and a further increase is expected by 14-25% in the 2060s and by 16-32% in the 2090s. The number of cold days and nights decreased by 12 days and this is projected to decrease in frequency and become exceedingly uncommon, with projections 0-6% in the 2090s. (World Bank, Climate Change Knowledge Portal, 2017). Vulnerability to changes in precipitation is high in Afghanistan, where rainfed crops comprise up to 80% of cultivated land (UNEP, NEPA, and GEF 2009).

The main climate challenges and the largest economic damages in Afghanistan are due to: change in precipitation patterns; floods, especially flash floods from heavy rainfall and snowmelt; and droughts (duration and strength) that adversely affect a population and a country's economy (International Centre for Integrated Mountain Development, ICIMOD).

According to ICIMOD, key climate changes challenges include:

12 For an explanation of each indicator see: University of Notre Dame, ND GAIN. *https://gain.nd.edu/our-work/country-index/methodology/*

13 Value close to 100 is better

14 Higher scores are better.

- Inadequate supplies of potable water, shortage of potable and irrigation water;
- Drought, soil degradation, overgrazing, deforestation, desertification, water and air polution, and deteriorated irrigiation system;
- Forest, rangeland and biodiversity climate change, which can impact enormously on forests and rangeland with temperature change.

An increase in temperature and a fall of precipitation are key climate change risks and vulnerabilities that can lead to:

- Natural disasters;
- Drought reducing the agriculture yield;
- An increase in agriculture disease;
- Maladaptation of some plants and animals.

2.2. Kyrgyzstan

Overview of current and future climate development. For the period 1880-2010 the average temperature has increased by 0.0104°C annually; during 1960-2010 the speed of this increase more than doubled at 0.0248°C per annum; in 1990-2010 the temperature increased annually on average by 0.0701°C. The increase in temperature was observed in all climatic zones and regions of Kyrgyzstan and all changes are statistically significant (Iliasov et al., 2013).

Estimated precipitation trends show a slight increase in average annual precipitation for the period 1880-2010 (0.847 mm per annum), but in 1960-2010 growth slowed down significantly (0.363 mm per annum), and in 1990-2010 there was already a declining precipitation trend (-1.868 mm per annum) (Iliasov et al., 2013).

These drops due to natural hazards according to WB estimates are the equivalent of 0.5-1.3% of GDP. Unless appropriate adaptation measures to climate change are adopted, an increase in temperatures, changing hydrology conditions and a greater frequency of extreme weather events associated with climate change will exacerbate the Kyrgyz Republic's vulnerability and reduce its ability to manage these events (WB, Climate Change Knowledge Portal).

2.3. Tajikistan

The change in temperature and precipitation in Tajikistan can be clearly observed. In the valleys, the average annual temperature over the last 65 years has increased by 0.3-1.2^{0} C, in mountainous and highlands areas by 0.1-0.7^{0} C, and in the cities by 1.2-1.9^{0} C (Water for Life Conference, Dushanbe, 8-10 June 2015). The mean annual temperatures are projected to increase by 2^{o}C by 2050, especially during the December-August period (WB, Climate Change Knowledge Portal).

In 1990-2012, the precipitation level in January-February exceeded the same period for 1960-1990, while the inverse case can be observed during March-May. From August onward the precipitation pattern for these two observed points remains more or less on the same level (World Bank, World Development Indicators, 2015). In 2050, the mean annual precipitation is projected to decrease by 5 percent. In addition, the number of dry 'days' is to increase by three days and the number of 'cold' days is to decrease by 35 days. Winters are projected to be drier and summers wetter, which could result in both increased floods and droughts (WB, Climate Change Knowledge Portal).

The main types of natural hazards are landslides, droughts, earthquakes, floods, and epidemics. The county's worst drought was in 2000, which affected about 3 million people. About 36 percent of Tajikistan is at risk of landslides and mudslides; in 2006, about 13,000 people were affected by flooding and landslides (WB, Climate Change Knowledge Portal). In 2017, 157 houses, 604.4 hectares of sown areas, 16 bridges and about 1,200 km of roads were affected due to 720 snow avalanches, 41 mudflows, 32 emergencies associated with rising water levels in rivers, 23 landslides, 33 earthquakes, 21 rockfalls and 13 heavy winds. Total losses are estimated at $400-$500 million (Committee for Emergency Situations and Civil Defense under the Government of Tajikistan).

Due to the impacts of climate change, the country's glaciers have changed and according to some estimates, they have lost 20 percent of their volume and 30 percent of their area mass over the past 50-60 years (Water for Life Conference, Dushanbe, 8-10 June 2015). This development might increase the risk of sudden floods from glacier lake outburst floods. In the long run, glacier retreats and more severe and frequent droughts are likely to cause severe water shortages, posing threats to food security and the environment (WB, Climate Change Knowledge Portal).

3. Strategic Programme for Climate Resilience: Experience From the Region

Prior to the review of available climate adaptation technologies in the following section and the available technological solutions in AKT countries in section five, this section deals with the progress made so far in the region to ensure the climate resilience of its people and sectors of the economy.

The European Bank for Reconstruction and Development, the Asian Development Bank, and the World Bank, under the framework of First Joint Multilateral Development Bank (MDB), jointly with the Government of the Kyrgyz Republic and the Government of the Republic of Tajikistan developed the Strategic Programme for Climate Resilience (SPCR), respectively in 2016 and 2011. Despite higher vulnerabilities to climate change and less adaptive capacities Afghanistan out of the list of beneficiaries of this Programme(see Climate Investment Fund). Using a two-phase programmatic approach, the SPCR assists national governments in integrating climate resilience into development planning across sectors and stakeholder groups. It also provides additional funding to put plans into action and pilots innovative public and private sector solutions to pressing climate-related risks (CIF). As the SPCR for Kyrgyzstan was developed recently and the investment fund is still under development, this section will preliminary assess the progress made so far in Tajikistan within the Climate Resilience Financing Facility developed by the EBRD and CIF.

The table below provides a short summary of active projects on climate change that are financed within the Pilot Programme for Climate Resilience in Tajikistan.

Table 1. Projects financed within the Pilot Programme for Climate Resilience in Tajikistan

Fund	Project title	Thematic focus	Sector	MDB	Funding (US$M)	Co-financing (US$M)
Pilot Program for Climate Resilience	Building Capacity for Climate Resilience	Climate Information Systems and Disaster Risk Management	Public	ADB	6.0	0.0
	Improvement of Weather, Climate and Hydrological Service Delivery	Climate Information Systems and Disaster Risk Management	Public	IBRD	7.0	12.0
	Enhancing the Climate Resilience of the Energy Sector	Infrastructure	Private	EBRD	11.0	65.0
	Environmental Land and Management and Rural Livelihoods	Agriculture and Landscape Management	Public	IBRD	9.5	7.4
	Building Climate Resilience in the Pyanj River Basin	Water Resources Management	Public	ADB	22.3	0.0
	Small Business Climate Resilience Financing Facility	Enabling Environment	Private	EBRD	5.0	0.0
	Enhancing the Climate Resilience of the Energy Sector. Part of: Private Sector Set-Asides	Enabling Environment	Private	EBRD	10.0	0.0

Source: Climate Investment Fund.
https://www.climateinvestmentfunds.org/projects/building-capacity-climate-resilience

For instance, the ADB Project "Building Capacity for Climate Resilience" focuses on:

- Access to information-related activities, including training personnel, impact assessments for priority sectors, developing climate-science modules for university curricula;
- Integrating climate change risk into development programme/projects, including reviewing national, sector programmes and national budget, supporting adaptations plans, designing and implementing training programmes, and offering technical support to the government;
- Knowledge management system, including a national communication strategy, climate change public awareness campaigns, publications, and disseminations;
- Assessing baseline and identifying indicators and facilitating independent M&Es;
- Applying for adaptation fund accreditation.

The EBRD and the Climate Investment Fund, financed Tajikistan Climate Resilience Financing Facility Project so-called CLIMADAPT, that dedicated to investing in the improvement of climate resilience technologies to help the country's residents, agriculture and businesses become more resilient to climate change. CLIMADAPT supports existing and pilot climate adaptation technologies through recommending a list of suppliers and installers[15] to the improve efficiency in water and energy use, as well to reduce soil erosion. Technical assistance and advice for the client are available and free of charge. (For more details see CLIMADAPT Finance Technology Innovation).

15 The developed list is not a final one and new suppliers and installers can be included on the recommended list by contacting the Project.

The *Eskhata* Bank, *Humo* Micro Lending Organization, *Imon* and *Arvand* Micro Deposit Organization are those financial institutions in Tajikistan that were selected to be partners of CLIMADAPT to provide loans for businesses, agriculture and the country's residents. The eligibility criteria, eligible projects, application procedure and technical assistance are listed for each aforementioned sector.

The technology originates from Tajikistan, Kyrgyzstan, Kazakhstan, China, Czech Republic, Uzbekistan, South Korea, Turkey, Germany, Japan, USA, Russia, Serbia, Italy, Latvia, UK, Switzerland.

The technological solutions provided include: insulation; windows; biomass boilers; solar water heaters; energy saver lamps; comprehensive facility and monitoring control systems; compressed air system; construction; rehabilitation; renovation of equipment; efficient greenhouses; efficient solid fuel stoves; electrical water heaters; installation of pump; pipes; sprinklers; micro sprinklers and other fittings; pressured system (drip irrigation); refurbishment of water distribution systems; solar PV and solar water heater; sustainable land management technology (minimum or zero tillage); water intake, capture and storage.

Notice that not all of the abovementioned technological solutions offered within CLIMADAPT can be regarded as climate adaptation technology, i.e. they represent a mix of climate mitigation, climate adaptation and household support to reduce non-monetary poverty. For instance, in rural areas where coal and wood are the main sources of heat supply, the provided list of technological solutions minimise greenhouse gas emission on the environment and can be considered as climate mitigation strategies. Moreover, minimising households' spending can contribute to reducing non-monetary poverty. Meanwhile for businesses, the use of energy-saving technologies minimizes the production price and ensures competitiveness in domestic and foreign markets. The building of cold storage in rural areas allows farmers and businesses to maximize benefits. However, this cannot be included on the list of climate change adaptation technologies. The building of greenhouses with the implication of drip irrigation can be counted as climate change adaptation technologies. In the residential sector, rainwater harvesting and its use for agriculture and daily life can be considered as a climate resilience technology.

The next section deals with a review of the existing climate change adaptation technological solutions with the aim of defining those applicable for AKT countries.

4. Climate Change Adaptation Measures and Technological Solutions in Low/Lower-Middle Income Countries

Climate resilience technologies aim to minimize the effects of the negative consequences of climate change on the population's health and sectors of the economy. At the same time, the new technology hopes to minimize the adverse consequences of climate change and is a prerequisite for sustainable economic growth through increased effectiveness.

Several analyses have proposed climate change adaptation technologies. For instance, Christiansen et al. (2011) classified types of intervention as hardware[16], software[17] and orgware[18].

16 Hardware technologies refers to the 'hard' technologies, i.e. physical infrastructure and technical equipment on the ground.

17 Software technologies refers to 'soft technologies', i.e. approaches, processes and methodologies, including planning and decision support systems, models, knowledge transfer and building skills necessary for adaptation.

18 Orgware technologies are organisational technologies, i.e. the organizational, ownership and institutional arrangements necessary for successful implementation and sustainability of adaptation solutions

An analysis of UNEP (Zhu et al. 2011) provides 22 adaptation technologies in the agricultural sector grouped into seven categories: (i) planning for climate variability and change; (ii) sustainable water use and management; (iii) soil management; (iv) sustainable crop management; (v) sustainable livestock management; (vi) sustainable farming systems; and (vii) capacity building and stakeholder organisation. Elliot et al. (2011, UNEP) and UNEP (August 2017) provide a technological solution for the water sector. The latter's analysis provides 102 water adaptation technologies grouped depending on the challenges that need to be addressed and type of responses: (i) too little water; (ii) too much water; (iii) water pollution; (iv) sea level rises; (v) disaster preparedness; and (vi) unknown climate risk. Meanwhile, the former analysis proposed 11 concrete adaptation technologies and practices.

In contrast to the abovementioned analysis, a recent analysis by ADB (2014) alongside solutions for agriculture and water sectors also provides technological solutions for human health and transportation sectors, as well disaster risk management. In addition, this analysis only focusses on Asian countries, including those countries that have similar climatic conditions with AKT countries and face similar climatic challenges. Moreover, this analysis provides concrete examples of the co-benefits and co-costs, relative costs, obstacles to implementation, the scale of applicability, as well as potential marketing and financial mechanisms (See Box 1). Therefore, this section of the analysis mainly refers to the ADB (2014) analysis, unless otherwise indicated.

Box 1. Criteria for the selection of climate resilience technology

- According to ADB (2014) each climate resilience technology should meet the following criteria:
- **Effectiveness** to reduce vulnerability or increase resilience;
- **Relative cost** score[19] (high, middle, low);
- **Co-benefits**, such as increasing ecosystem services or creating jobs;
- **Co-costs**, in contrast to co-benefits, measure the negative consequences of using the technology, such as ecosystem destruction or job loss;
- **Barriers to implementation** score measures the difficulties standing in the way of technology implementation, such as the need for infrastructure investment or a specialized set of skills;
- **Feasibility of implementation**, e.g. internet availability, whether the technology is adopted elsewhere and is appropriate for different conditions;
- Scale of implementation: micro, meso and macro;
- **Applicable locations and conditions**: technologies to minimise the drought risk are less relevant where an increase of precipitation is expetected, and vice versa;
- **Potential financing and marketing:** availability of technology from private, academic institutionss, international organizations, cofinancing or public-private partnerships.

In Annexes 3 and 4, two examples of a technology assessment, following the criteria provided by ADB are presented. In the subsections below those technology solutions that meet the criteria defined for each sector are presented.

19 Score for each case defined based on the research done, as well subjective judgement.

4.1. Technology Solutions for the Agricultural Sector

Climate resilience investment in the agricultural sector aims to rationalise water and energy use and promote sustainable land management. In the agricultural sector, this can include drip irrigation and zero tillage (EBRD, Sustainable Energy Initiative in Tajikistan).

The impact of climate change on the agricultural sector can be reflected in the decline in crop yields resulting from higher temperatures, less precipitation, reduced availability of irrigation water, saltwater intrusion, an increase of waterlogging and flooding, increased incidence of crop pest and diseases, and the loss of crops due to extreme weather events. The adverse effects of climate change can be reduced through: (i) introducing new heat tolerance crops, lowering the amount of water required, increasing moisture tolerance, and introducing crops that have greater levels of salinity tolerance; (ii) improving water collection, storage and distribution techniques, and improving irrigation techniques, water management and efficiency of use (e.g. soil moisture and evapotranspiration); (iii) barriers to saltwater intrusions, aquifer recharge; (iv) improving drainage or flood control techniques; (v) improving pest and disease management techniques; (vi) improving extreme weather event prediction; (vii) increasing resilience of crops to extreme weather event.

This subsection summarizes the available technology solutions for an agricultural sector that allow for adaption to climate change, while at the same time are conducive for innovation.

Six of out seven climate resilience technologies assessed for the agricultural sector are[20]:

- Laser land levelling
- Fungal symbionts
- Pressurized irrigation technologies
- Floating agriculture
- Improved livestock feed
- Temperature regulation for livestock.

For laser land levelling, pressurized irrigation, and floating agriculture technologies, an evaluation scoring method revealed that if a cost of less than $100 per hectare is more desirable, an intermediate is a cost between $100-500 and less desirable is a cost of over $500. For the other technology categories above, estimates are more subjective and are based on the prices quoted.

4.1.1. Laser Land Levelling

Precision laser land levelling (LLL) is a technology solution that allows reducing water use and water waste in agriculture due to unnecessary runoff water from the field. LLL ensures water conservation and efficiency, an increase in crop yield, better utilization of variable rainfall and the reduction of groundwater depletion (Singh et al. 2009; Lybbert and Sumner 2012; Akhtar 2006; Naresh et al., 2011; Kahlon and Lal, 2011 cited in ADB, 2014).

The relatively low cost of LLL technology makes it more desirable: $6-13 per hour for used services (Lybbert et al. 2012; Ahmad, Khokhar & Badar, 2001 cited in ADB, 2014).

20 Crop breeding technology is not assessed in this analysis, as compare to other agricultural technologies will face more barriers, not only due to consumer perception of genetic engineering crop, but also limited knowledge, access to the resources, tools and infrastructure, expensive regulatory process, etc.

Co-benefits of introducing such technology can include an increase in ecosystem services or creating new jobs in rural areas (Jat et al., 2006 cited in ADB, 2014). Naresh et al. (2011 cited in ADB, 2014) found that the co-benefits of LLL include zero tillage and bed planting. Meanwhile, Singh et al. (2009 cited in ADB, 2014) consider that one particular co-benefit is the reduction in irrigation time by 2-5 hours per hectare. Lybbert and Sumner (2012 cited in ADB, 2014) and Lybbert et al. (2012 cited in ADB, 2014) note that fertilizer efficiency and a lessening of reliance on diesel pumps are co-benefits of such technology. Jat et al. (2006 cited in ADB, 2014) found that the introduction of laser land levelling technology will save 1.5 million hectare/meters of irrigation water and up to 200 million litres (equal to US$140 million) of diesel and improve crop yields by up to US$500 million in three years and reduce greenhouse gas emissions by up to 500 million kilograms.

Lybbert et al. (2012 cited in ADB, 2014) measured the negative consequences of using the technology, such as ecosystem destruction and job loss and found that as an ideal technology with minimal negative impact on ecosystem and job places. At the same time, they note the usefulness of LLL in flood irrigation areas.

Feasibility of implementation can be scored as intermediate as laser land levelling can be done on a contractual basis; in other words, individual farmers will not have to purchase their own equipment to benefit from the technology.

The scale of the implementation of such technology widened after 7 years introducing the technology in the Uttar Pradesh region of India, where the number of levellers increased since it introducing to 925 and 200,000 hectares of land had been levelled with the help of the technology (Lybbert et al. 2012 cited in ADB, 2014).

4.1.2. Fungal Symbiont

Fungal symbiont is a new climate adaptation technology that will make crops more heat tolerant, effective, and reduce the amount of water required. Fungal symbionts refer to fungi that live in a mutually beneficial symbiotic relationship with plants. Still, this technology is in its infancy, and many opportunities for further growth exist, although limited research and knowledge is available on this at the moment. The scale of implementation of this technology at the laboratory stage, i.e. relatively undeveloped stage, can be considered a barrier for its further expansion. Therefore, the feasibility of implementation is still less desirable since replicating the results from the laboratory to the field is extremely difficult. Thus, the relative cost has not been defined yet. Nonetheless, co-costs and co-benefits are desirable as the technology ensures greater food securities of the countries and increases water use efficiency of crops that afford farmers benefits also with regard reduced irrigation costs, in addition to an increase in crop yields (ADB, 2014).

The laboratory tested watermelon and tomato seeds exposed to fungi and saw an improvement in heat resilience. Their roots, which under normal conditions would die at any exposure above 38°C, survived at 50°C; they were then left to cool off at night, and some of the plants survived in temperatures of up to 70°C during the day. The laboratory tested wheat exposed to fungi that showed drought resistance compared to uninfected one: 18 days dry tolerance versus 10 days (Pennisi, 2003 cited in ADB, 2014).

4.1.3. Pressurized Irrigation Technologies

Pressurized irrigation technologies such as sprinklers, drips, mini-sprinklers, or high-efficiency drip systems are highly efficient technologies that can be used to reduce water waste and the amount of water used to produce one unit of crops. This technology ensures more efficient water delivery to the plant roots and provides ideal moisture, as well as reduces evaporative loss. Buyukangaz et al. (2007 cited in ADB, 2014) found that low- to medium-pressure sprinklers are 75% effective in applying water directly, drip sprinklers are 80%–90% effective, and micro- and mini-sprinklers are 75%–85% effective. Meanwhile traditional sprinklers and surface canals are efficient in water delivery by 50%–60% and 30%–35%, respectively (Ackermann, 2012 cited in ADB, 2014). Research findings in India, Israel, Jordan, Spain, and the US indicate that drip irrigation reduces water use by 30% to 70% and crop yield increases by 20% to 90% (Buyukangaz et al., 2007 cited in ADB, 2014). Thus, due to high levels of efficiency, it is a more desirable technology. However, this technology is less desirable due to the high relative cost, $1,500-$3,000 per ha (Buyukangaz et al., 2007 cited in ADB, 2014). Although the relative cost has declined since 2007, it still remains high and it can be regarded as an intermediate barrier for the spread of such technologies.

According to Ackermann (2012 cited in ADB, 2014), employing buried pipelines can save over 100,000 ha of land with a market value of $ 3.24 billion that make this technology is suitable. Co-cost is desirable too, as the reduction of water usage will increase the supply of water to downstream users (Young et al., 2010 cited in ADB, 2014) thus there is less demand for surface water abstraction, which reduces the downstream flow from run-off or excess supply (Young et al, 2010; Molden et al., 2010 cited in ADB, 2014).

4.1.4. Floating Agriculture

Floating agriculture assumes planting crops on soil-less floating rafts that are made from a composted organic material, including water hyacinth, algae, waterwort, straw, and herbs. Floating agriculture technology can be implemented in regions prone to flooding, e.g., in riverine coastal districts. As a strengthening strategy adapting to flooding floating agriculture is an applicable technology for areas that experience heavy monsoons or are prone to flooding, especially in coastal and riverine areas. For instance, this technology is widely used in coastal areas of Bangladesh for many reasons (for more details see Islam & Atkins, 2007 cited in ADB, 2014).

4.1.5. Improved Livestock Feed

Improving nutrients of livestock through the use of feed supplements, such as urea molasses multi-nutrient blocks (UMMB), low bypass protein, lipids calcium hydroxide and its digestibility ensures the effectiveness of feed and the resilience of livestock to climate change (cited in ADB, 2014. For more details see: Kapur, Khosla, and Mehtal 2009; Wanapat et al. 2009; Shibata and Terada 2010; Thornton and Herrero 2010; Henry et al. 2012). The productivity of animals facing heat stress will fall and additives nutrient diet that includes minerals, vitamins, electrolytes, amino acids ensure meat or milk productivity (Renaudeau et al. 2010 cited in ADB, 2014).

The International Atomic Energy Agency (IAEA, 2006 cited in ADB, 2014) cited the effectiveness of UMMB on the feed of ruminants. Moreover, the relative cost is low. For instance, UMMB per kilogram is e $0.10 in Bangladesh, $0.18 in China, $0.03 in Myanmar and $0.04 in Pakistan (IAEA, 2006 cited in ADB, 2014). Cost-benefit and income changes analyses of this study indicate an increase of dairy farmers' income by 38% per cow per day and for beef cattle and small ruminant farmers' income increased by up to 30% per animal. A study by IFAD (n.d.) indicates farmers' savings in Iraq due to switching to additional supplements of up to 50% and a reduction on reliance of imports.

The co-benefits of improving livestock feed include a reduction in methane (CH_4) emission. More efficient absorption of nutrients ensures a consequent reduction in gaseous losses and the ability to produce a comparable amount of dairy and meat with fewer animals required (Kapur, Khosla, and Mehtal 2009; Wanapat et al. 2009; Mapato, Wanapat, and Cherdthong 2010; Thornton and Herrero 2010 cited in ADB, 2014).

Reduction in demand for feed might lead to a decline in prices that make this technology more desirable and unrelated to co-cost.

There are only few associated barriers with the implementation of this feeding technology, as farmers have a choice either to reduce the size of their herd due to productivity increase or to increase their numbers due to saved feed resources, i.e. efficiency gain.

Low productivity of livestock in many developing countries can help make the implementation of this technology feasible.

4.1.6. Temperature Regulation for Livestock

Temperature regulation for livestock technology is employed to minimize economic losses in the livestock sector, as temperature rises have a harmful effect on the quantity and quality of dairy, meat, and eggs (Nardone et al. 2010; Henry et al. 2012 cited in ADB, 2014). In response to heat stress, it is recommended to keep livestock under a tree or structured shades, and/or use misters, drips, fans, pads, floors, room cooling systems, sprinkler systems, to evaporate water into warm air, evaporative pad systems, and air-conditioning systems (Nardone et al. 2010; Renaudeau et al. 2010; Henry et al. 2012 cited in ADB, 2014).

Olson et al. (2006, cited by Padgham, 2009) found that cattle breeds with short and dense hairs crossed with highly productive dairy cow breeds will reduce body temperature by 0.5°C and increase of milk production by 1,000 kg. West (2003 cited in ADB, 2014) proposed a simple measure to reduce total heat by 30-50% through a well-designed shade system and sufficient cooling during the night so that cattle can tolerate the hot daytime.

The relative cost of employing the aforementioned technologies vary from low to high, depending on the region and the simplicity or complexity of the technology. Co-benefits, co-cost and barriers can be assessed as intermediate. Barriers to implementation may relate to the availability of electricity or water for such technologies.

4.2. Technology Solution in the Water Sector

Either a decrease of precipitation (cause of drought) or an increase of precipitation (prerequisite of flooding), melting glaciers, as well a shift of precipitation pattern and it amount are consequences of climate change and main challenges in the water sector. Flooding, inundation and water quality are three challenges that need to be addressed, as an adaptation strategy to climate change in the water sector. The construction and rehabilitation of water resource infrastructure, as well as the adoption of water saving technology and practices is crucial for a stable supply of water, especially for the agricultural sector. Adaptation technologies to climate change in the water sector can be divided into three main groups (ADB, 2014):

- water quantity (rainwater harvesting, surface-water storage, inter-basin water transfer, aquifer recharge, water loss reduction technologies, water demand reduction technologies, desalination, point-of-use water treatment) technologies;
- water quality (wastewater treatment) technologies;
- inland flooding (storm-water management & bios-wales, structural and non-structural barriers to flooding, accommodation of flooding) technologies.

All the above three groups of technologies are applicable and crucial for AKT countries. The literature survey above indicates that Tajikistan faces medium-term water reductions. An adaptive infrastructure can comprise early warning systems for extreme events; multipurpose dams for water storage and power generation; upgraded provincial waterways; flood control and drainage systems; and systems for storing, diverting, and sharing water during a period of scarcity (Tajikistan MONC 2003 cited in ADB, 2014).

In this sector, technology can be considered as more desirable, if it costs less than $10 per unit, intermediate within $10–$10,000 per unit and less desirable if it costs more than $10,000 per unit.

4.2.1. Water Auantity Technologies

The effectiveness of almost all water quantity technologies scored as more desirable, except surface water storage that scored as intermediate. Co-benefits of these technologies are more desirable too, except salination and inter-basin water transfer technology that scored as less desirable and intermediate, respectively.

The co-costs of these technologies are more desirable also, except salination and rainwater harvesting (e.g. vector disease) (Arunachalam et al. 2010 cited in ADB, 2014) technologies that scored as intermediate and inter-basin water transfer as less desirable (e.g., environmental damage, due to project construction and ecosystem change, see: Zhang 2009; Liu et al. 2013 cited in ADB, 2014) and surface water storage (e.g., vector disease, negative effects in riverine ecosystems, displacement of population, etc. see: WCD 2000; IWMI 2009 cited in ADB, 2014).

There are several barriers to the implementation of water quantity technologies. The barriers to point-of-use water treatment[21] and rainwater harvesting[22] are assessed as intermediate. Meanwhile, significant barriers to desalination[23], inter-basin water transfer[24] and surface water storage[25] technologies will make them less desirable. For other water quantity technologies, no barriers have been identified.

21 Due to limited funding for water purifying.

22 Due to continually needs to maintain and monitor to prevent potential contamination and water losses due to leakage and evaporation.

23 E.g. high energy cost

24 Due to the necessity of displacement of people, significant engineering, planning, design, and construction inputs.

25 Due to continually maintained and monitored to avoid contamination of supply, needs for political and community support in the regional-level system, a necessity for safety and construction inspections and permits, water rights, abstraction licenses, environmental regulations, concessions, tenure systems, and other legal factors (FAO 2010)

Feasibility of the implementation of these technologies by different studies is assessed as more desirable, except inter-basin water transfer (Yevjevich 2001 cited in ADB, 2014) and desalination (due to high energy costs this is a less attractive option in developing countries, IEA-ETSAP and IRENA 2012 cited in ADB, 2014) that scored as less desirable.

4.2.2. Water Quality Technologies

Wastewater treatment technologies, either centralized or decentralized, allow for the improvement of water quality, where potable water is scare and for industrial uses. Per unit cost of wastewater centralized treatment may be low, while capital or operating costs are high. On the other hand, decentralized treatment has a high per unit cost, but does not involve any additional costs for infrastructure development and operation costs. Thus, it is scored as intermediate to less desirable. However, co-benefits, co-cost, and feasibility if implemented is scored as more desirable, as safe high-quality water is crucial for a better quality of life and the reduction of diseases and has no related co-cost.

4.2.3. Inland Flooding Technologies

Three out of five inland flooding technologies are applicable in the case of AKT countries, which are:

- Structural barriers to flooding;
- Non-structural barriers to flooding;
- Accommodation of flooding.

Structural and Non-Structural Barriers Technologies. Structural and non-structural barriers to flooding protect vulnerable lands, people, infrastructure, and resources from the destruction caused by increased flooding and inundation. In contrast to structural technologies (often referred to as a hard option) that require the construction of artificial barriers such as dams, dikes, locks, and levees, non-structural barriers (often referred to as a soft option) do so by restoring natural protective functions of coastal ecosystems and landforms (ADB, 2014).

The effectiveness of non-structural barriers is scored as more desirable, while structural barriers are scored as intermediate to less desirable, depending on the type. Advantages of non-structural barriers prevail over structural ones. Due to higher costs structural barriers is classified as less desirable, while the lower cost of non-structural barriers make them more desirable. There are several co-benefits of non-structural barriers to flooding[26] and co-cost, while the main barrier is limited land resources and due to the time needed for maintenance this technology scored as intermediate.

Accommodation of flooding technology. Floods can be accommodated through: (i) elevating buildings and infrastructure; (ii) designing structures to move with the water level; and (iii) slowing the rate of the water flow to reduce downstream flooding. These technologies are applicable in countries and regions at coastal sea or riverine areas below or at sea level and are least effective in protecting existing infrastructure, thus the level of effectiveness is assessed as intermediate. Accommodative approaches require less investment than structural barriers. Rel-

26 Such as protection of wildlife habitat, maintenance of water quality, water storage, groundwater recharge, pollution abatement, nutrient retention and cycling, and establishment of highly productive areas for fisheries (ADB, 2014).

ative cost, co-benefits, and barriers to implement are assessed as intermediate, while co-cost is assessed as more desirable as it encourages development in areas prone to floods (ADB, 2014).

4.3. Technology Solutions in the Transportation Sector

The changes in the pattern of precipitation and temperatures can affect transport infrastructure beyond the designed capacity. The literature review indicates that transportation infrastructure prompted by climate change is in place in Afghanistan and Tajikistan. For instance, in Afghanistan, severe floods can cause as much as $300 million in infrastructure damage (UNEP, NEPA, and GEF 2009). Meanwhile, in Tajikistan, the considerable effects of climate change are evident in damaged road surfaces and bridges. Infrastructure has been washed away by mudflows and avalanches, and more than 300 kilometres of mountain roads are vulnerable to dangerous geological and hydro-meteorological phenomena (Tajikistan MONC 2003 cited in ADB, 2014).

An improved weather prediction system and an early warning system, improved construction techniques to accommodate heat and flooding, improved disaster management, and integrated contingency planning can all help to minimize damages to bridges, roads and rail networks (ADB, 2014).

The following four climate adaptation technologies are often used to reduce vulnerability to climate change:

- Warm-mix asphalt (WMA)
- Engineered cementitious composite (ECC)
- Active motion-dampening systems
- Intelligent transportation systems (ITSs).

Three out of four adaptation technologies in the transport sector will be assessed in this section, as active motion-dampening systems technology is irrelevant in the case of AKT countries.

4.3.1. Warm-Mix Asphalt

The usage of warm-mix asphalt (WMA) instead of hot-mix asphalt (HMA) improves the durability of road surface material. WMA technology is ideal for both warmer and colder climates. An additive is included in the asphalt to make it heat resistant, and thus, to ensure a longer lifespan at a higher temperature (ADB, 2014). A study by Fazaeli et al. (2012 cited in ADB, 2014) indicate that an increase of FT-paraffin (Sasobit) content in bitumen samples reveals a significant increase in heat tolerance. The WMA additives Sasobit, Asphaltan-B and Licomont BS 100 "increase the stiffness of the asphalt binding agents, thus reduce rutting and cracking" (US FHWA 2007; OSU 2012 cited in ADB, 2014).

Additional additives will increase the cost of asphalt per unit. For instance, water injection systems have high up-front costs; however, they do not require a continual application of additives. Meanwhile, organic additives can cost $2-4 per ton of mix (Duwey, 2012, cited in ADB, 2014). One of the main benefits of WMA is reducing the cost of fuels for heating by 20% to 75% depending on the approach used (Chowdhury and Button 2008; US FHWA 2013, cited in ADB, 2014).

The decline of CO_2 emission by 30% (Fazaeli et al. 2012 cited in ADB, 2014) reduces fumes and odours (Fazaeli et al. 2012; NYC DOT, 2013 cited in ADB, 2014) and greater distance transportation than HMA make WMA a more desirable technology (US FHWA 2007; Chowdhury and Button 2008; Fazaeli et al. 2012 cited in ADB, 2014).

On the other hand, co-cost scored as intermediate, because the production of synthetic additives will increase CO_2 emission, while the lower heating requirement for WMA lessens this emission (van Vliet, Faaij, and Turkenburg 2009 cited in ADB, 2014).

Barriers and feasibility of implementation scored as intermediate, as new equipment is required for this technology (Prowell, 2007 cited in ADB, 2014); however, there is no need for infrastructure investment.

4.3.2. Engineered Cementitious Composite

Engineered Cementitious Composite (ECC) is a new technology proposed for the use of bridge construction and as a replacement for traditional concrete. Fly ash ground granulated blast furnace slag, and waste foundry sands and carbon residue can be used for ECC concrete (Lepech et al. 2008, cited in ADB, 2014). It is applicable for repairing roadways, bridge decks, and in constructing bridge piers (Li et al. 2004 cited in ADB, 2014).

Due to a comparatively higher cost this technology it is not widely used yet. However, ECC has several advantages over normal concrete. The ECC can recover 76-100% of its initial strength thanks to self-healing properties (Yang et al. 2009 cited in ADB, 2014). According to Sahmaran and Li (2010 cited in ADB, 2014), the strain capacity of EEC is 300-500 times higher than normal concrete. The Mihara Bridge in Hokkaido, Japan is 40% lighter than traditional ones and its projected lifespan is 100 years (Li, 2003). Moreover, Keoleian et al. (2005 cited in ADB, 2014) assessed the life cycle of ECC and found that tit consumes 40% less energy, 50% less solid waste generation and 38% less raw material consumption than traditional concrete bridges.

4.3.3. Intelligent Transportation System

A study of ADB (2014) state that "…climate change brings more extreme temperatures, which increase wear and tear on roads, it will be increasingly important to monitor road conditions, address hazards in real time, and maximize road maintenance resources". Intelligent Transportation System (ITS) is a technology that can be used for minimizing the risks and maintenance of roads through the monitoring of it conditions in real time.

Due to the higher cost of the ITS system and barriers, such as privacy, reliable energy supplies and access to the internet, only a few examples can be found in the literature review, e.g. Hyderabad, India (ITS International 2013 cited in ADB, 2014), Singapore (City Climate Leadership Awards, 2013 cited in ADB, 2014), Japan (Martinez et al. 2010 cited in ADB, 2014) and Bangkok, Thailand (Yokota, 2004 cited in ADB, 2014). Nonetheless, co-benefits, co-cost and feasibility of implementation of such a system scored as more desirable.

4.4. Technology Solutions in the Human Health Sector

Many countries are likely to experience public health problems as temperatures rise and precipitation decreases. Tajikistan could face a more prevalence of diseases transmitted through contaminated food or water, or by disease-carrying organisms (Tajikistan MONC 2003 cited in ADB, 2014).

An increase of waterborne diseases in turn increases malnutrition and heat stress, a rise in respiratory illnesses due to heat and local air pollution, and an increase in injuries from extreme weather events are among the projected impacts of climate change on human health. The technology needs to achieve: (i) improved water treatment and distribution; (ii) improved surveillance of diseases out-brakes; (iii) improved health care access, diagnosis and treatment; (iv) improved integrated pest management; (v) improved early warning systems for food emergencies and emergency food distribution systems; (vi) improved disaster management; (vii) improved heat management techniques, e.g., cooling centre and building cooling; (viii) improved prediction and early warning systems for extreme weather and air pollution events; (ix) improved technologies to reduce heat island effect (e.g., green or white roofs); (x) reduced local air pollution (ADB, 2014).

ADB (2014) proposed six climate resilience technologies in the health sector:

- Long-lasting insecticidal bed nets (LLINs)
- Rapid diagnostic tests (RDTs)
- Disease surveillance systems
- E-Health
- Food-proof sanitary latrines
- Food-proof drinking water wells

This study evaluates 41 technologies. However, only five (12%) meet the needs in the human health sector and intersect with Disaster Risk Management. There are two technologies – E-Health and Early Warning Systems (EWS) or rapid diagnostic tests (RDTs) described in this subsection as a relevant and with the widest applicability in AKT countries.

In the human health sector to define the desirability of the proposed technologies the following scores are used: more desirable – less than $10 per unit; intermediate - $10-$500 per unit; less desirable – over $500 per unit.

4.4.1. E-Health

E-Health is a technology that improves the surveillance of pest and disease outbreaks, health care access, diagnosis and treatment, or in other words, it is an early warning system for food emergencies and disaster management. This technology intersects, i.e. meet more than one need, with other human health-related technologies – rapid diagnostic tests, and technologies of early warning and monitoring systems within the sphere of disaster risk management.

E-Health may include advanced computing by health service providers[27], distance spanning communication technology[28], support and communication with patients via phone, tablets, and laptops, which is comprehensive, digitally-enabled, and rapidly deployable through mobile E-Health centres (ADB, 2014).

E-Health technologies can be regarded as cost-efficient as they provide unprecedented access to health care systems in remote areas, treat patients, minimise the spread of diseases, reduce un-

27 Examples: electronic medical records such as the Indian Health Service's Vista system, digital prescriptions, inventory monitoring systems, laboratory information management, pharmacy information systems, patient registration or scheduling systems, monitoring and evaluation and patient tracking systems, clinical decision support, research and data collection

28 Examples: telemedicine, virtual office visits or specialist consultations, remote diagnostics, automated telephone monitoring and self-care support calls.

necessary medical tests and treatments, and ensure public health awareness and preparedness (Holmner et al. 2012 cited in ADB, 2014).

The literature review indicates that several barriers to implementing this technology, even in developed countries, exist including a lack of infrastructure and transparency in operation, a long lag time, unverified installation, a scarcity of onsite medical manpower, and quality of health care that is difficult to assess (Agrawal et al. 2013), and technological capacity and political will (Holmner et al. 2012 cited in ADB, 2014). The technology requires a high degree of organizational skills and administrative systems for trainings and the supervision of health-care professional (Piette et al., 2012 cited in ADB, 2014).

4.4.2. Rapid Diagnostic Tests

Rapid Diagnostic Tests (RDTs) known also as "dipsticks" are simple kits that allow, through various methods, the quick diagnosis of illnesses such as malaria, tuberculosis, AIDS, syphilis, and visceral leishmaniasis (ADB, 2014). Compared with traditional laboratory microscopy for diagnosis, RDTs require less time (with results available in 5–20 minutes), less training, no equipment, and no consumables, but they have a relatively high unit cost and are designed for one-time use (Wongsrichanalai 2001; Moody 2002; Mabey et al. 2004; Mayxay et al. 2004; Bell and Peeling 2006; Murray et al. 2008 cited in ADB, 2014).

RDTs technology also meets more than one need and its introduction as an early warning system and monitoring system will improve the surveillance of pest and diseases outbreaks.

Even though RDTs are not ideal, they are indispensable in remote areas, where there is an unreliable supply of electricity for equipment and refrigerators, and a lack of well-trained staff, which make near impossible the use of traditional methods (ADB, 2014).

Due to lower relative cost, RDTs is a more desirable technology, at least, in remote areas. Meanwhile, RDTs are vulnerable to high temperatures and windy conditions, humidity or exposure to moisture, an inability to detect missed infections, failure to detect infection with a low concentration of parasites, and inaccurate results in some conditions (Wongsrichanalai 2001; Bell and Peeling 2006; Murray et al. 2008 cited in ADB, 2014).

It is feasible to implement this technology in remote areas and to make its use even more desirable, as mentioned above, it does not require highly trained personnel or a lot of time to interpret the results (Murray et al. 2008, Wongsrichanalai 2001; Moody 2002 cited in ADB, 2014).

4.5. Disaster Risk Management Technologies

An increase of flooding due to extreme weather events that cause infrastructure damage, injuries, and transport interruption, as well infrastructure degradation due to an increase of precipitation and heat are among the climate change impacts that require adequate disaster risk management technologies. The technology needs for AKT countries to adequately respond and adapt including: (i) improved prediction of extreme weather events and more reliable early warning systems; (ii) improved construction techniques to accommodate flooding; (iii) improved disaster management; (iv) heat- and water-resistant construction materials and techniques (ADB, 2014).

More than one third of disaster risk management technologies assessed by ADB (2014) meet more than one need. Emergency Shelters and Light Detection and Ranging (LIDAR) meet three needs, while Artificial Lowering Glacial Lakes, Early-Warning system, Monitoring System and Social Media in Disaster Response are technologies that meet two needs.

The five Disaster Risk Management (DRM) technologies assessed in this chapter are:

- Light detection and ranging (LIDAR);
- Artificial lowering of glacial lakes;
- Monitoring systems;
- Early-warning systems;
- Social media in disaster response.

The DRM technology can be assessed as more desirable if it costs less than $1.0 million per unit, intermediate if $1-$10 million per unit and less desirable if over $10 million per unit.

4.5.1. Light Detection and Ranging (LIDAR) and Artificial Lowering of Glacial Lakes

LIDAR is an inundation layer combined with other layers, such as land use and land cover or transportation infrastructure that can be used to identify the population at risk and to plan an evacuation route accordingly (Sanyal and Lu 2009; Khailani and Perera 2013 cited in ADB, 2014). Nonetheless, despite the importance of such technology the effectiveness and relative cost means that it is assessed as intermediate and many small and developing countries, such as AKT cannot employ it due to the high cost. Albert et al. (2013) indicate that the cost for 10 to 100 kilometres ranges between $468 and $936,000.

Artificial lowering of glacial lakes is a technology that is fully applicable to AKT countries, where glaciers are melting rapidly. As a result, glacial lakes are filling quickly that essentially increases the probability of glacial lake outburst floods.

There are two types of monitoring technologies – one for the seasonal and long run and an early-warning system used for monitoring climate-related hazards. The next two subsections are devoted to the long and short monitoring systems.

4.5.2. Monitoring System

"Monitoring system for seasonal and long run include, among others, remote sensing, numerical modelling, GISs, satellite-based vegetation indices, satellite rainfall estimates, gridded rainfall time series to provide historical context, and flood monitoring" (ADB, 2014). For these types of systems it is important to define vulnerability, for communication with individuals and communities. Moreover, the collected information can be fed into ad hoc models for crop yield forecasting (Balaghi et al. 2010 cited in ADB, 2014), used for flood mapping and forage conditions (UNEP, NEPA, and GEP 2009 cited in ADB, 2014).

The relative cost is high, at over $10 million according to Sachs et al. (2010 cited in ADB, 2014), excluding annual monitoring costs and the cost for personnel. There is potential savings, however, as employing monitoring system will allow to avoid disaster that cost much higher than developing of such system. Rogers and Tsirkunov (2011 cited in ADB, 2014) assessed the internal rate of return of such a system as 30%. Nonetheless, co-benefits and co-cost were assessed as intermediate and more desirable, respectively, and included barriers to implement such technologies as: (i) financing; (ii) technological knowledge to utilize them; (iii) professional interpretation of output by experts, as the results might be affected by many socio-economic and environmental variables (Verdin et al., 2005 cited in ADB, 2014); (iv) using output without neglecting the probabilistic nature of forecast (Ziervogel & Downing, 2004 cited in ADB, 2014).

4.5.3. Early-Warning System

The early-warning system is a combination of weather forecasting technologies, the system generating warnings and communication-oriented technologies that are used to inform people about a forthcoming threat. The implementation of such technology is more desirable as it can significantly reduce the loss of material and human life.

4.5.4. Social Media in Disaster Response

Social media, such as Twitter, Facebook, VK, Odnoklassniki, etc. can be used for sending alert messages to improve disaster responses (earthquakes, floods, tsunamis, typhoons, etc.). The main barriers to use social media in this regard can be a lack of access of the population to the internet and lack of knowledge of the equipment and technology used (Huang, Chan, and Hyder, 2010 cited in ADB, 2014). Alternatively, or interchangeably cell phones can be used for disaster responses, depending on the prevalence of these technologies. Social media is regarded as a more desirable technology in disaster management and responses by Li and Rao (2010 cited in ADB, 2014) in China (i.e. earthquakes) and in Japan according to Akar and Muraki (2011 cited in ADB, 2014) (i.e. earthquakes and subsequent tsunamis), while authorities have found social media chaotic during disasters (for more details see Goolsby, 2010, cited in ADB, 2014).

The next section will review the availability of such technologies in AKT countries for each sector described in this section.

5. Climate Change Adaptation Technologies Solutions Available in AKT Countries

5.1. Afghanistan

5.1.1. Agriculture Sector: Lazer Land Levelling

The literature review indicated that LLL techniques were tested in the eastern part of Afghanistan, in subtropical, semi-arid, and Mediterranean-type conditions, with frost during the winter at an elevation level of 572 m. The implication of LLL techniques reduces labour requirements, and water demand fell by 21%, 27% and 17%, respectively, for wheat, corn and eggplant. At the same time, yields increased by 21%, 40% and 38%, correspondingly. Moreover, water productivity increased by 39%, 53% and 37%, respectively (Hashimi et al., February 2017).

5.1.2. Water Sector: Water Loss Reduction Technology

An example from the region indicates that some water quantity technologies are in place, e.g., the rehabilitation of the Nahre Karim canal in Afghanistan, supported by the United States Agency for International Development (USAID) and reduced water loss by building a 2,910-meter retaining wall, installing 24 small and three large water distributors, building three culverts to facilitate the transportation of farm products, and improving four older passages to avoid flood damage to the canal. By preventing water loss, the project was also able to provide irrigation to an additional 100 hectares of land in Ahmadzai village (USAID/Afghanistan 2011).

5.1.3. Human Health Sector: E-Health

E-Health AKDN Programme in the Region: the Case of Afghanistan and Tajikistan. In 2007, French Medical Institute for Mothers and Children (FMICs) introduced an E-Health programme, as part of the larger AKDN programme to expand population access to high-quality healthcare and the use of information and communication technologies in the health sector of Afghanistan and Tajikistan, covering a population of about 25,000.

The E-Health programme connects six hospitals in the region: FMIC, the Bamyam and Faizabad Provincial hospitals, Mirwais Regional Hospital Kandahar in Afghanistan, Khorog Oblast General Hospital in Tajikistan and Aga Khan University Hospital (AKUH) in Karachi and one hospital in Paris.

E-Health services includes teleconsultations in a variety of specialities, including teleradiology (interpreting CT scans, mammograms and MRI images), telepathology (working together to study and diagnose diseases) and conducting live teleconsultations in specialities such as cardiology, obstetrics/gynaecology and paediatrics, adult neurology and paediatric neurology. As well, e-learning is also being developed and since 2008 to date, 7,000 cases have been attended to this way in participating hospitals. There are also plans to expand such services to the Kyrgyz Republic (FMICs)[29].

5.1.4. Disaster Risk Management: Monitoring System and Famine Early Warning System

Monitoring System. One example comes from Afghanistan, where the six-year Pastoral Engagement, Adaptation, and Capacity Enhancement (PEACE) Project implemented by the University of California–Davis and Texas A&M University, and was funded by USAID (UNEP, NEPA, and GEF 2009) once again confirmed that any efforts to build such a system without trained local staff and further stable financing will stop by the end of the Project. "This Project provided vulnerability monitoring data on emerging forage conditions to livestock producers, among other technologies intended to promote livestock development in the country. The forecasts, based on satellite imagery, plant growth modelling, and ground monitoring, took the form of maps and bulletins and were given to herders and rangeland decision makers in 90-day increments at the national level" (ADB, 2014).

Famine Early Warning Systems Network (FEWS-NET) consists of five US government agencies and two private contractors[30]. FEWS-NET provides early warning and analysis on acute food insecurity with a focus on two Central Asia countries: Afghanistan and Tajikistan. FEWS-NET produces: (i) monthly reports and maps detailing current and projected food insecurity; (ii) timely

29 For more details see: French Medical Institute for Mothers and Children *https://www.fmic.org.af/AboutUs/eHealth/Pages/default.aspx*; Telehealth in post conflict zones: Six year findings from a cross border eHealth program. *https://www.medetel.eu/download/2013/parallel_sessions/presentation/day2/Telehealth_in_post_conflict.pdf*; How E-Health is changing lives in Afghanistan. *http://www.akdn.org/news/how-e-health-changing-lives-afghanistan*

30 Lead by USAID, FEWS NET also draw on the expertise of: the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), US Department of Agriculture (USDA), and US Geological Survey (USGS).

alerts on emerging or likely crises and; (iii) specialized reports on weather and climate, markets and trade, agricultural production, livelihoods, nutrition, and food assistance. As of March 2016, FEWS-NET shifted from regular monthly reporting to special reporting in the case of Tajikistan, while for Afghanistan reporting is still done on a monthly basis[31].

The main limitation of this source of information for both countries is that the provided information is in English, thus, this language barrier presents the main obstacle for the local authorities.

5.2. Kyrgyzstan

5.2.1. Agriculture and Water Sectors: Drip Irrigation

The introduction of drip irrigation technology in the dry-continental climate of Osh Oblast, Kyrgyzstan in field-tomato cultivation yielded an increase of farmers' income by 7.5 times, an increase of tomato yields by two times, and water saving by 3 times, i.e. 33.8 m^3 vs. 100.3 m^3 per 100 m^2 of land plots compared to furrow irrigation (Transforming Smallholder Irrigation, September 2017).

5.2.2. Human Health Sector: E-Health

An electronic health care programme of the Kyrgyz Republic for 2016-2020 was approved by the Kyrgyz government in 2015. In 2017, within the pilot project, an E-Health system was introduced in Issyk-Kul regional hospital, Osh children's hospital, Nookat hospital, Ala-Buka and Aksy territorial hospital announced the country's Health Minister Talantbek Batyraliev[32]. E-Health is in its infancy and the development of an E-Health programme depends on well-trained personnel. E-Health should be part of the development of the notion of digital government.

5.2.3. Disaster Risk Management: Early-Warning System

Early-warning system is in place in Kyrgyzstan and study of Stucker et al. (2012) state that "… when heavy rains start, transboundary early warning calls are made from water managers to colleagues, mayors, farm managers, and/or friends downstream. The early warning calls give downstream Water User Associations (WUAs) approximately 2–4 hours to prepare by opening side or parallel canals and by opening the Plotina Dam. The early warning calls allow disaster support groups, especially in the upstream Khozho–Bakyrgan WUA to warn households near the river. The local governments have provided some phones for this purpose" (cited in ADB, 2014).

5.3. Tajikistan

5.3.1. Agriculture Sector: Laser Land Levelling

Abdullaev et al. (November 2007) study indicates that, in Tajikistan, LLL reduces the water application rate by 333 m^3 per ha in comparison with an unlevelled field and the average annual net income of farmers from the laser field is 22% higher than those unlevelled .

31 Famine Early Warning Systems Network. *http://www.fews.net/about-us*

32 E-Health starts working in several hospitals of Kyrgyzstan. http://kabar.kg/eng/news/e-health-starts-working-in-several-hospitals-of-kyrgyzstan/

An interview with the executive director of the cooperative *Sarob* indicates that some technology solutions in the agricultural sector are now available in Tajikistan (See Box 2).

Box 2. Available Technological Solutions in the Agricultural sector: Tajikistan

From potential financing and market perspectives, a climate adaptation technology can be made available from private financing, academic institutions, international organizations, co-financing or public-private partnerships.

An interview with the executive director of the cooperative *Sarob* indicates that some technologies are available too in Tajikistan, and they are already being provided to some farmers. Such technology is already in place in the other two neighbouring countries under review – Afghanistan and Kyrgyzstan.

Zero tillage technology in Tajikistan is widely used. Currently, *Sarob* by delivering such technology to the Tajik market provides such services to farmers and covers almost 1000 ha. The cost of these services ranges between 250-300 somoni (national currency of Tajikistan), which is the equivalent to $28-34 per ha, including fuel. The introduced zero tillage technology has increased wheat yield in rainfed areas by 40%. The combined effect, i.e. introducing the new variety of seeds and zero tillage technology has increased the yield by 100%. In irrigated land the introduced zero technology has reduced the amount of water used, increased yield, and reduced the salinization of land. These are just some of the positive effects of introducing of such technology. In addition, time has also been saved due to conventional tillage requiring almost one month, which allows maize to be planted immediately after wheat this receiving two yields from the same area, while at the same time ensuring crop rotation within the year.

Laser land levelling technology has not been delivered yet, but they plan to introduce it in a few years. The cost of the service provided to farmers per ha will be the same as the services of zero tillage technology. The technology cost ranges between $7,000 and $15,000 depending on the producer.

Due to time and staff constraints Sarob devotes less time on the assessment of effects of each technology on yield change, the amount of water use per ha, the salinization level, groundwater, saved time and labour inputs, as well fuel used. The cooperative has already approached Tajik Agrarian University and Academy of Agrarian Science with an initiative to support their Ph.D. students in research by providing all facilities and covering all related cost.

There is room for further growth, but due to limits with regard to financial resources and trained personnel/staffs some technologies have not been delivered yet.

Source: Interview with the executive director of the cooperative *Sarob*, Mr. Muminov Muhammadi.

5.3.2. Water Sector: Drip Irrigation Technology

Pressurized drip irrigation technology is also available in the market and costs between $2000 and $4,000 depending on the land slopes and is mainly used in rainfed areas that are used to develop horticulture. The development of horticulture per the decision of the Government of Tajikistan is allowed only in rainfed areas. Drip irrigation technology is not widely used by Sarob on irrigated land and due to the financial constraints of farmers, thus, an assessment of the amount of water saved due to shifting from flood to drip irrigation has been as of yet impossible (Interview with the executive director of the cooperative *Sarob).*

5.3.3. Human Health Sector: E-Health

In 2011, an E-Health policy/strategy was adopted in Tajikistan and a special fund was allocated for it implementation, however, it was only partially implemented. The E-Health policy strategy only deals with women's and children's health and monitors their health by tracking several indicators on an annual basis. Tertiary institutions offer ICT training for students of health sciences. Government intervention can be summarised as: (i) laws, regulations, quality directives and guidelines; (ii) certification, accreditation, seals of approval, or quality seals; (iii) dedicated website; (iv) online safety for children; (v) and privacy laws to protect citizens' personal identifiable data irrespective of format (paper or digital). However, social media, as Facebook, Twitter and YouTube are not used (WHO, 2013).

5.3.4. Disaster Risk Management: Monitoring and Early Warning Systems

The Monitoring and Early Warning System (MEWS) in Tajikistan were introduced in May 2007 at the Ministry of Economic Development and Trade. Monthly monitoring risk reports, through summarizing data from different sources, provide regular information and succinct analysis on the evaluation of natural, economic, floods, and energy-related and other risk factors. Initially it was supported by the UNDP country office in Tajikistan and since August 2014 it has been financed by USAID. The report has provided a hazards overview by type since 2000 on a monthly basis and weather forecasts for the upcoming month[33].

6. Conclusions and Recommendations

6.1. Conclusions

This analysis aimed to define those climate change adaptation policies and technologies, in each vulnerable sector of the economy, to mitigate the consequences of climate change, and at the same time, to be conducive for innovation. According to ADB (2014), each technology solution applicable to the region was assessed against the efficiency, relative cost, co-benefits, and co-cost, as well as feasibility and scale of implementation. To achieve the defined goal the current and future climate development and policies were reviewed, the relevant technological solutions assessed, as well as the availability of such technology in AKT countries.

An overview of current and future climate situations reveals that in all three countries climate change is the ongoing process, and that they are among the most vulnerable countries in the world in this regard.

A review of available technological solutions in Tajikistan, as part of the CLIMADAPT project, reveals that they are cover only the agricultural and water sectors (irrigation technologies, i.e. water conservation technologies and processing of agriculture products), as well as population dwellings, while, human health and transportation sectors and disaster risk management technologies are not on the list. However, some proposed technological solutions are related to climate change mitigation and directed to reduce non-monetary poverty, rather than address climate adaption policies.

33 Monitoring and Early Warning in Tajikistan. https://reliefweb.int/sites/reliefweb.int/files/resources/TJK_Monitoring_and_Early_Warning_Report_April_2012_ENG.pdf; http://untj.net/files/Publications/DRMP/Monitoring_and_Early_Warning_Report/TJK_Monitoring_and_Early_Warning_Report_March_2015_ENG.pdf

The ongoing climate change adaptation policy in each country is mainly financed by development partners and multi-development donors, almost with a lack of systemized approaches, even within the international community, with the exception of the Strategic Programme for Climate Resilience that was recently developed for vulnerable countries by the European Bank for Reconstruction and Development, the Asian Development Bank and the World Bank, under the framework of First Joint Multilateral Development Bank (MDB). Meanwhile, financing climate adaptation activities within the state budget is limited, either due to budgetary constraints or a misunderstanding of the overall consequences of climate change on the economy and on people's health. However, based on the review of a sectoral budget it is possible to find some clauses that are directed to save soil due to flooding in the river basin (coastal river protection), e.g. in the budget of the Ministry of Energy and Water Resources of Tajikistan. These climate adaptation activities can be considered as disaster risk management and should be classified as measures taken to minimize the risks of climate change. Another example is the return of degraded soil into cultivation through measures taken to minimize salinization, which decreases the level of groundwater. Such an example can also be found in the two other countries.

The melting of glaciers is one of the consequences of climate change and is one of the main challenges for AKT countries, where predominantly energy is produced by small-, medium- and huge hydro power stations (HPS). Though AKT countries will face energy scarcity in the long term, as a result of a decline of the volume of glaciers, less energy is generated from HPSs. Thus, today steps need to be taken to adapt wind and solar energy generated technologies.

6.2. Recommendations

As climate change is an ongoing process and climate mitigation through reduction of greenhouse gases emission is a long and time-consuming process, preparing societies to adapt to climate change should be on the agenda of each and every country.

Note that the common principles and guidelines for Climate Change Adaptation Finance Tracking that have been agreed upon between Multilateral Development Banks (MDB) and International Development Finance Club (IDFC)[34] should be used for tracking risks and stating the intent to address the identified risks in the project document, vulnerabilities and impacts related to climate variability, as well as indicating a direct link between the identified risks, vulnerabilities and impacts, and the related financed activities (for more details see MDB & IDFC Climate Change Adaptation Common Principles, March 2015).

The findings in section 4 of this report from other Asian countries on the adaptation of climate change technologies based on defined criteria should be adopted too and the list of service providers and technologies need updated as well. A review of the best practices from other parts of Asia shows some sectors in AKT countries have abandoned climate resilience activities.

The specific recommendations are:

1. **Addressing Existed Gaps**
   - Six groups of gaps on climate changes activities are as follows: (1) Policy, institution and governance gap; (2) Economic and financial gaps; (3) Education and capacity building gaps; (4) Knowledge sharing gaps; (5) Technologies, methodologies, practice, and infra-

34 IDFC, a network of 23 national and regional development banks from the North and the South. IDFC Members have a proven track record of outstanding successes, innovation and competence in the area of development finance.

structure gaps; (6) Science-based information and data gaps, identified in the climate change policy of Kyrgyzstan and Tajikistan[35] by Mountain Societies Research Institute of University of Central Asia (Jan' 2018). These should be addressed, through systematic approaches and inclusive processes, close cooperation and collaboration between the relevant governmental bodies and development partners to ensure the successful implementation of climate adaptation programmes and projects.

2. Monitoring & Evaluation

- An assessment of the efficiency of implementing climate adaptation projects should be tracked through the whole life cycle of the projects by independent evaluators, with relevant monitoring and evaluation tools, means of verification, with defined baseline and targeted indicators.

3. Financing Mechanism

- Climate change adaptation technologies can/should be financed within the budget, by the private sector, and development partners, within the framework of a multilateral development fund, co-financing or public-private partnership;
- National funds can be established and used to introduce climate adaptation technologies;
- All climate change adaptation activities and investments in AKT countries need to be aligned with the formulation of central government budget planning processes to ensure the effective implementation of undertaken activities;
- A use of climate change adaptation technologies will be widen if interest rate for loans targeted for purchase of these technologies will be consessional and offered to the client for longer period. A high interest rate (22-24% per annum)[36] for climate change related loans serve as a barrier to expand climate adaptation technologies. The donor community should also consider the option of providing concessional loans to the governments of countries that are particularly vulnerable to climate change to enforce climate adaptation activities.
- In addition, along with success stories that provided in CLIMADAPT portal and local financial institutions that involved to provide loans for climate adaption technologies, it might be useful to reflect also the feedback of borrowers on their experience. However it should be assessed by independent institutions. Steps should be taken to predict how to implement climate change adaptation financing, taking into account the obstacles, what steps need to be taken to facilitate and expand the best practices that serve an incentive for further climate change adaption policy conducive for innovation and to ensure further sustainable growth. These practices can be replicated in other neighbouring countries with similar climatic conditions.

35 Though, are in place laws, strategies, programs, plans, and documents; signed a variety of conventions; and implemented various programs and projects to support climate change activity, such as mitigation, disaster risk reduction, and environmental protection.

36 Though, lower than the other credit line in these financial institutions for other loan lines.

- It will be useful to learn more about the mechanisms of financing the European Commission Project "Enhanced Competitiveness of Tajik Agribusiness Project (ECTAP)" [37]. This project alongside the provided loans offers to lenders 20 percent of grants that almost compensate the interest rate to be paid later. Such a scheme allows borrowers to minimise the cost of interest rate whereby the saved amount can be additionally invested to ensure their competitiveness and expand production.

4. Incentives and Technology Promotion

To facilitate the process of climate adaptation technologies the governments of AKT countries can provide incentives, such as:

- Exemption of imported climate adaptation technologies from customs duties, value added taxes and other related taxes;
- Local producers and service providers can be exempt from income taxes in cases of employing climate resilience technologies;
- Allocation from the sectoral budget on climate adaptation technologies;
- Interest rates can be covered by the governments of those who plan to introduce climate resilience technology.

5. Sectoral Coverage

- Climate change adaptation policy should cover the agriculture and transportation sectors, water resources, human health and disaster risk management. Some measures will have synergy effects, i.e. an improvement or measures taken in one sector will lead to improvements in other sectors.

6. Knowledge Sharing

- Each country of the region should learn from each other and from other regions the best climate resilience practices. For instance, the climate change centre of Kyrgyzstan, provides almost all climate-related activities and documents, including legislation, while the same centre in Tajikistan has very limited information. On the other hand, CLIMADAPT facility devoted to Tajikistan summarises all climate change adaptation activities and can be replicated in Kyrgyzstan.

7. Use of Information Technology

- Development of apps for Android, Windows and IoS platforms on climate resilience has been facilitated by relevant institutions in common platforms that include all climate adaptation information and resources. This might be a useful tool especially when in the local language. Alternatively, or interchangeably the messages can be sent by the mobile company to people on expected climate hazards.

37 This project implemented by Frankfurt School of Finance and Management that contributes to poverty reduction and economic growth in Tajikistan by enhancing the development of Tajik agri-food value-chains, the competitiveness of agri-food enterprises and the quality and marketing of their products. For more details refer Project website http://www.ectap.org/

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Annexes

Annex 1. Vulnerability and Gain Indicators and GAIN Index of University of Notre Dame

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GAIN Index

GAIN Index that composes of two key dimensions of adaptations to climate change: vulnerability and readiness.

A vulnerability dimension measures a country's exposure, sensitivity and adaptive capacity to the negative effects of climate change. A country's exposure – the degree to which a system is exposed to significant climate change from a biophysical perspective. It is a component of vulnerability independent of socio-economic context. First, country's exposure indicators measure projected impacts for the coming decades and are therefore invariant overtime in ND-GAIN. Second, sensitivity indicator, can vary over time, measure the extent to which a country is dependent upon a sector negatively affected by climate hazard, or the proportion of the population particularly susceptible to a climate change hazard. Third, adaptive capacity indicator measure availability of social resources for sector-specific adaptation. In some cases, these capacities reflect sustainable adaptation solutions. In other cases, they reflect capacities to put newer, more sustainable adaptations into place. Adaptive capacity also varies over time.

Readiness dimension measures a country's ability to leverage investments and convert them to adaptation actions. ND-GAIN measures overall vulnerability by considering six life-supporting sectors – food, water, health, ecosystem service, human habitat, and infrastructure. ND-GAIN measures overall readiness by considering three components – economic readiness, governance readiness and social readiness. First, economic readiness – captures the ability of a country's business environment to accept investment that could be applied to adaptation that reduces vulnerability (reduces sensitivity and improves adaptive capacity). Second, governance readiness – captures the institutional factors that enhance application of investment for adaptation. Third, social readiness – captures the factors such as social inequality, ICT infrastructure, education and innovation that enhance the mobility of investment and promote adaptation actions.

A country's ND-GAIN is composed of vulnerability and readiness scores. Both indicators range from 0 to 1. The readiness indicator close to one is better, while vulnerability indicator closes to zero is better.

Source: University of Notre Dame, ND GAIN. https://gain.nd.edu/our-work/country-index/methodology/

Annex 2. Gaps on Climate Change Activities in Kyrgyzstan and Tajikistan

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Existed Gaps on Climate Change Activities

Policy, institution and governance gaps. Adaptation programs and projects are not clearly linked to existing development and sectoral policies in either country; (ii) lack of collaboration between local communities, policy makers and scientists in various fields; (iii) at the local level, lack of relevant information, and; (iv) insufficient short- and mid-term economic incentives to undertake adaptation measures.

Economic and financial gaps. (1) Limited knowledge of economic losses due to climate change and related disasters; (2) Financial literacy is limited, and regulatory frameworks to support CCA and Disaster Risk Reduction (DRR) and affiliated services (e.g., micro-credits, micro-savings, micro-insurance) are underutilized; (3) The governments have insufficient funding for disaster risk mitigation investments; (4) Economic and policy incentives also are insufficient for improving water efficiency, diversifying incomes, and promoting agribusiness industries; (5) At the local level, communities do not have easy access to different financial tools and limited opportunities for income diversification.

Education and capacity building gaps. (i) The public as well as some government officials are not yet adequately aware of climate change, climate-related disasters, and potential adaptation measures. Therefore, awareness programs are needed at various levels. (ii) Climate change education has yet to be integrated into national curricula, and public schools and universities do not offer courses or programs on climate change issues; (iii) Education and health professionals also have limited options to learn about climate change and related impacts on public health and other sectors. (iv) there are limited training opportunities on CCA and DRR for community members, local government authorities, and education, health, and other professionals.

Knowledge sharing gaps. (i) Sharing of available data is still in its infancy, although some noteworthy attempts have been made. A search engine is known as ''K-Link'' accesses documents and data from several knowledge platforms including UCA, CAREC, Kyrgyz State Agency for Environmental Protection and Forestry, GIZ and a few local NGOs, but it has not yet been adopted regionally. Additionally, there are sector-specific developments in regional data sharing and knowledge management in Central Asia, most notably FAO's Pastoralist Knowledge Hub and the GIZ-supported Regional Pasture Network (RPN), which brings together pastoralists and other actors working with them – both seeking to create synergies for dialogue and pastoralist development. Generally, though, more effort at multiple levels is still needed to significantly improve data sharing and knowledge management across a range of sectors in Central Asia.

Technologies, methodologies, practice, and infrastructure gaps. (i) Kyrgyzstan and Tajikistan do not have adequate weather and climate data monitoring systems. Their abilities to undertake large-scale vulnerability assessments are limited and they have no clear means to evaluate either past or current adaptation practices; (ii) Governments generally are slow to implement new adaptation approaches, such as climate-smart agriculture, climate smart disaster risk management, ecosystem-based adaptation (EbA), etc. (ii) Risk information and hazard maps also are not readily available to communities and there is a lack of adequate infrastructure to prevent climate-related hazards such as landslides, mudslides, flood, and drought; (iv) At the local level, communities are still unaware of potential adaptation measures (e.g. new agricultural technologies, new seed varieties, improved farming practices) to adapt to climate change and related disasters.

Science-based information and data gaps. (i) There is a huge demand for scientifically sound and actionable information and knowledge; (ii) Climate services that include the timely production, translation, and delivery of useful climate data, information and knowledge for individual and societal decision-making should be underpinned by research in climate and related sciences, along with research on sectoral applications (e.g. agriculture, water, health, energy, disasters) (Vaughan et al., 2016); (iii) Climate change research is slowly gaining momentum, but is still at an early stage of development. Little scientific research is carried out and limited information exists on climate change (both past and future trends), vulnerability, and potential risk and impacts in relation to various sectors and livelihoods (agriculture, livestock, forest, pasture, water resources, etc.); (iv) Potential adaptation approaches and measures also remain largely understudied; (v) Poor communication and information sharing on climate change, its potential risks and potential adaptation measures at the local level, and communities are mostly unaware of scientific facts and findings.

Source: University of Central Asia, Graduate School of Development, Mountain Societies Research Institute of (UCA, GSD, MSRI, January 2018). Climate Vulnerability & Adaptive Capacity of Mountain Societies in Central Asia. Research Report No 1. Retrieved from http://www.ucentralasia.org/Research/Item/1578

Annex 3. An Example of Approach Uses to Assess Technology in Agriculture Sector

Reducing water use and water waste in agriculture: Laser land levelling[38]

Much of the water loss in agriculture is a result of unnecessary runoff from fields. An important approach to reducing runoff is ensuring that agriculture fields are as level as possible. Recent technologies, including the use of laser technology, have improved the precision of field levelling before planting.			
		Effects	Findings
Effectiveness	More desirable	Water conservation; water efficiency; crop yield; better utilization of variable rainfall; Reduced groundwater depletion;	Singh et al. 2009; Lybbert and Sumner 2012; Akhtar 2006; Naresh et al., 2011; Kahlon and Lal 2011
Relative cost	More desirable	Only once in few years at cost $6–$13 per hour; Time & resource saved.	Lybbert et al. 2012; Ahmad, Khokhar & Badar, 2001.
Co-benefits	More desirable	Zero tillage and bed planting; Reduce irrigation time by 2–5 hours per hectare; Fertilizer efficiency & lessen reliance on diesel pumps; Save 1.5 million hectare/meters of irrigation water & up to 200 million liters (equal to US$1,400 million) [of diesel], and improve crop yields [by up] to US$500 million in three years and reduce greenhouse gas emissions [by up] to 500 million kilograms" Create new skilled jobs in agricultural regions	Naresh et al. 2011; Singh et al. 2009; Lybbert and Sumner 2012; Lybbert et al. 2012. Jat et al. 2006.
Co-cost	More desirable	Laser land levelling is an ideal technology because it does not involve a high level of risk & "more level plots are unambiguously better than less level plots"	Lybbert et al. 2012.
Barriers	More desirable	The need for further studies to determine any long-term effects is the often-cited barrier to the use of this technology.	Naresh et al. 2011
Feasibility of implementation	Intermediate	Because laser land levelling can be done on a contractual basis, individual farmers will not have to purchase their own equipment to benefit from the technology, provided that enough capable contractors and technological resources are available within a region.	
Scale of implementation	More desirable	E.g. in Uttar Pradesh, 7 years after laser land levelling was introduced, the number of levellers had increased to 925 and 200,000 hectares of land had been levelled with the help of the technology	Lybbert et al. 2012
Applicable locations & conditions	More desirable	Particular usefulness of laser levelling technologies in flood irrigation	Lybbert and Sumner 2012
Potential Financing & Market	More desirable	This model offers great entrepreneurial potential in agricultural regions	Lybbert et al. 2012

Source: own compilation based on ADB (2014) report "Technologies to support climate change adaptation in developing Asia". https://www.adb.org/sites/default/files/publication/149400/technologies-climate-change-adaptation.pdf

38 Technology evaluation scoring method: (1) More desirable = less than $100 per ha; (2) Intermediate = $100–$500 per ha; (3) Less desirable = more than $500 per ha.

Annex 4. An Example of Approach Used to Assess Technology in Water Sector

Water loss reduction technologies[39].

Water loss reduction technologies. Water losses can occur during storage, transmission, or delivery through evaporation, leakage (often due to aging infrastructure), or improper, illegal, or uncontrolled use.		
		Effects
Effectiveness	More desirable	Lining canals with bricks, plastic, or concrete controls seepage and may significantly reduce water losses.
Relative cost	More desirable to intermediate	A major source of water loss is aging infrastructure, which is costly to repair or replace.
Co-benefits	More desirable	Deliver the desired volumes to the user locations; Energy will be saved in the process GHG emissions will be reduced, etc.
Co-cost	More desirable	In some circumstances there may be indirect environmental impact from the construction associated with building or repair work.
Barriers	More desirable	Aging water distribution infrastructure, the paucity of research into such losses, cost–benefit analyses of repairs, and proper building or repair technologies
Feasibility of implementation	More desirable	Lining to control seepage and covers are more resource intensive, but can further reduce water losses.
Scale of implementation	More desirable	Household to regional
Applicable locations & conditions	More desirable	Water loss reduction is a suitable approach in almost any environment, but especially in locations with impervious soils that are facing water shortages
Potential Financing & Market	More desirable	Where water loss reduction offers financial benefits to the owners of water storage and distribution infrastructure, significant potential exists for financing mitigation measures. An alternative approach would be for the company financing leak reductions to receive a portion of the savings from the water utility (Barry 2007).

Source: own compilation based on ADB (2014) report "Technologies to support climate change adaptation in developing Asia". https://www.adb.org/sites/default/files/publication/149400/technologies-climate-change-adaptation.pdf

39 In this sector technology can be count more desirable if it less than $10 per unit, intermediate within $10–$10,000 per unit and less desirable if cost more than $10,000 per unit.