On behalf of:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

The GIZ regional project "Ecosystem-based Adaptation to Climate Change in High Mountainous Regions of Central Asia"

Protecting economic growth against climate change in Kyrgyzstan

Piloting Climate Risk and Vulnerability Assessments in transport and tourism

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This assessment document has been authored under the lead of adelphi consult GmbH associates to assist in adapting to climate change in the area of road infrastructure and tourism activities. While it has been prepared taking all professional care, it should not be relied on as a basis for selecting concrete technical measures, without a) a comparative appraisal of the adaptation options (this report does not include an appraisal of the proposed adaptation options) and b) adapting it to specific economic activities or environmental sites with local expertise. Nevertheless, provided information intends to shift paradigms and to envision directions of action and policy strategies that protect future economic development from climate hazards

Acronyms

CAIAG	Central Asian Institute for Applied Geosciences
CLD	Causal loop diagrams
CORDEX	Coordinated Regional Climate Downscaling Experiment
CRVA	Climate Risk and Vulnerability Assessment
EbA	Ecosystem-based Adaptation
GCF	Green Climate Fund
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
IPCC	Intergovernmental Panel on Climate Change
KSTCAU	Kyrgyz State University for Transport, Communication and Architecture
Kyrgyz Hydromet	Hydrometeorological Agency under the MES of the Kyrgyz Republic
MES	Ministry of Emergency Situations of the Kyrgyz Republic
MoE	Ministry of Economy of the Kyrgyz Republic
MTR	Ministry of Transport and Roads of the Kyrgyz Republic
NAP	National Adaptation Planning
NBSAP	National Biodiversity Strategies and Action Plans
NDC	Nationally Determined Contribution
NEX-GDDP	NASA Earth Exchange Global Daily Downscaled Projections
NISS	National Institute for Strategic Studies
SAEPF	State Agency for Environmental Protection and Forestry
SAWR	State Agency for Water Resources
SWOT Analysis	Strength-Weakness-Opportunities-Threats Analysis

Key terms

Accredited Entity	Private, public, non-governmental, sub-national, national, regional or international bodies with clear, detailed and actionable mitigation and adaptation projects or programmes that meet GCF standards based on financial standards, environmental and social safeguards, and gender policy (GCF, 2018).
Bioengineering	The term bioengineering (or biological engineering) describes the use of living plant material, i.e. vegetation (e.g. grass, shrubs and trees), to provide certain engineering functions.
Climate	The average weather, or the statistical description of weather in terms of the mean and variability of relevant quantities (typically surface variables such as temperature, precipitation and wind) over a period of time ranging from months to thousands or millions of years. Climate in a wider sense is the state, including a statistical description, of the climate system (IPCC, 2014)
Climate Change	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer, due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014)
Climate Finance	Climate finance is “finance that aims at reducing emissions, and enhancing sinks of greenhouse gases and aims at reducing vulnerability of, and maintaining and increasing the resilience of, human and ecological systems to negative climate change impacts” (UNFCCC, 2014)
Climate Service	The timely production and delivery of useful climate data, information, and knowledge to decision-makers that provides scientifically-based climate information in a way that enhances users’ knowledge and understanding about the impacts of climate on their decisions and actions (WMO, 2018)
Climate System	The highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere and the biosphere and the interactions between them (IPCC, 2014)
Climate Variability	Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events which may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPCC, 2014)
GCF Concept Note	A document submitted using the template provided by the GCF, which provides basic information about a project or programme that an entity can use to seek feedback from the Secretariat on whether the concept is broadly aligned with the objectives and policies of the Fund (GCF, 2018)
Disaster	Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2014)
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2014)

Funding Proposal	A set of documents submitted to the GCF to formally request funding for a project (GCF, 2018).
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources (IPCC, 2014)
Impacts	Effects on natural and human systems, such as lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure, caused by the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system (IPCC, 2014)
Intervention	Though in general not every intervention is an adaptation measure, all proposed interventions here represent adaptation measures. The reasoning behind is to be in line with terminology of the Ministry of Economy as the main stakeholder of this CRVA
Likelihood	The chance of a specific outcome occurring, where this might be estimated probabilistically (IPCC, 2014)
Resilience	The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (IPCC, 2014)
Risk	The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values (IPCC, 2014)
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014)

1. Introduction

It is well established that the impact of global warming on agriculture, water, forestry and disaster risk reduction sectors will continue to increase until the end of this century and beyond (Oppenheimer et. al. 2014). Climate change and its impacts in Kyrgyzstan and Central Asia have developed above world average and it is expected that they will continue to do so. A variety of climate risk and vulnerability assessments (CRVAs) have been conducted in these sectors (Broka et. al., 2016; Ilyasov et.al., 2013). Climate change will impact the Kyrgyz economy as a whole, affecting many sectors and endangering past and future development efforts. The Ministry of Economy in Kyrgyzstan has therefore requested support from the German Development Cooperation (GIZ) in conducting a CRVA for two sectors, tourism and transport, in order to complement the **Green Economy (GE) modelling** activities of the 2019 - 2023 GE development program (Ministry of Economy of the Kyrgyz Republic, 2019a).

Climate change is not only an environmental challenge, but also an economic, social, and developmental one. However, the knowledge of future climate impacts allows climate resilient planning. This knowledge was not available or not considered in industrial countries in the past. Bridges built in the 1980s or 1990s were not constructed to be suitable for today's heavy rain events; skiing resorts were not planned to operate under today's snow conditions. The skiing tourism sector in Kyrgyzstan now has the opportunity to assess climate change risks and use this information to "get it right" from the start - to invest where it makes sense economically, ecologically (including climatologically), and in view of local stakeholders.

Additionally, Kyrgyzstan profits from available and tested knowledge on how to use the economic value of protective vegetation in high mountains. **Functionable ecosystems protect future economic growth** not only in the agriculture sector, but also by providing long-term protection to road infrastructure from landslides or attracting increasing numbers of tourists. This is illustrated by a number of examples in the international arena. For instance, Switzerland spends about 165 million USD (2014) on protective vegetation. As a benefit, assets worth 220 billion USD are protected from damages of natural disasters (Losey, 2014).

The **aim** of this report, as requested by the Ministry of Economy, is to support and contribute to the GE modelling process by piloting a climate risk and vulnerability assessment (CRVA) for two climate sensitive sectors that have not been the focus of risk profiles in the past. These two sectors are the transport and tourism sector. Furthermore, this report shows how CRVAs can be institutionalized and be used for decision-making processes for addressing climate impacts, and thereby linked to the GE modelling process.

For the **transport sector**, this CRVA proposes a number of possible green solutions, such as using vegetation to decrease road maintenance costs by protecting road infrastructure, in Section 3. It supports a paradigm shift on how to address climate impact based on the climate impact chain. Not only is this approach cost-effective, but it also presents a promising way to access international climate finance.

Impact chains for the tourism sector are presented for **winter and summer tourism** separately in Section 4. Proposed adaptation options address the high dependency on snow cover in winter tourism through ecologically and socially sustainable diversification of tourism offerings. This report intends to inform and raise the awareness regarding climate risks and responses for skiing and snowboarding tourism, and for summer mountain adventure, eco-based, and community-based tourism. The role of ecosystems for adaptation is highlighted for operators, key public and private stakeholders. By doing the above, this report recommends some actions that can be taken to move to sustainable tourism development.

Findings of this report were elaborated in cooperation with the Ministry of Economy and Ministry of Transport and Roads, as well as in dialogue with the Ministry of Culture, Information and Tourism. All insights of this report rely on the **input and active participation of a multitude of stakeholder and sector experts** collected during a workshop for each sector in Bishkek. **Stakeholders and sector experts from a wealth of backgrounds were involved**: ministries, multiple government authorities, private companies, associations, NGOs (non-governmental organizations), and academia. Knowledge from international adaptation efforts was connected with local expert knowledge.

As a pilot effort, this report has **several limitations**. For example, it contains no ready-to-implement technical solutions. However, the techniques it highlights, such as bioengineering, can be very effective if they are adapted to the local context. Additionally, while this report has been prepared taking all professional care, no civil engineer was part of the author team and no field trips to mountainous road infrastructure and tourist sites were made for this report.

The focus is rather to highlight promising green engineering approaches that can be further adapted to the Kyrgyz content and to foster a paradigm shift on how to address climate impacts. The feasibility of concrete measures needs to be investigated further by an interdisciplinary team of local experts that knows site-specific risks and conditions. Successful implementation of green engineering requires complete site investigations and knowledge of available hydrological, geographical, and topographical conditions.

1.1. The benefit of CRVAs for sustainable development planning

Climate change is a significant threat for future economic development and not only for the environment and ecosystems. The Government of Kyrgyzstan has acknowledged the need for sustainable development planning and has elaborated a Green Economy Program, approved in November 2019. An inter-ministerial working group, led by the Ministry of Economy, was created to forecast the outcomes of GE interventions by applying economic systemic modelling approaches. The goal of the GE modelling process is to forecast the outcome of interventions identified within the GE program (Ministry of Economy of the Kyrgyz Republic, 2019a). This exercise relies on an understanding of the interrelations of economic, social and environmental (including climate impacts) indicators. As part of a systemic approach, causal loop diagrams (CLD) were generated to illustrate these interrelations as causal mechanisms and to provide intervention options. This was achieved by integrating the knowledge and concerns of more than 40 experts from various sectors. The focus of this group exercise was on national development. The impact of climate change was only one factor among many others with unequal importance for the experts involved. Knowledge on climate impact mechanisms and interventions is supplied by the underlying GE Program and its focus on climate change determines the inclusion of climate risks within the CLDs.

Although all sectoral CLDs feature climate change explicitly or implicitly, the degree of climate change consideration varies for different sectors. CLDs for the energy and agriculture sectors extensively incorporate climate change. In contrast, **CLDs for transport (Fig. 1.1.) and tourism (Fig. 1.2.) do not adequately feature climate risks and intervention options**. On the one hand, climate impact mechanisms are not explicitly illustrated in the CLD for the tourism sector and only marginally considered in the CLD of the transport sector. On the other hand, adaptation options for transport have not been identified, whereas the policy options for tourism would contribute to climate adaptation, e.g. sustainable farming and water efficiency.

The fact that climate impacts are not adequately featured in transport and tourism originates mainly from **a) a lack of awareness on climate risks** and **b) a lack of knowledge on climate risks and adaptation options** within these 2 sectors. The economists in the modelling group, who eventually translate the CLDs into a mathematical model, need to be sufficiently informed on how climate change impacts specific economic activities and what options for response exist.

A CRVA ensures that climate change has adequate priority within each sector when designing development programs and modelling the potential outcome of interventions. An economic modelling process as that of the GE program is a result of expert discussion and depends on available knowledge on climate risks and adaptation options. **The added value of a CRVA is that identified impact chains and adaptation options can be directly integrated into CLDs as mechanisms and intervention options.**

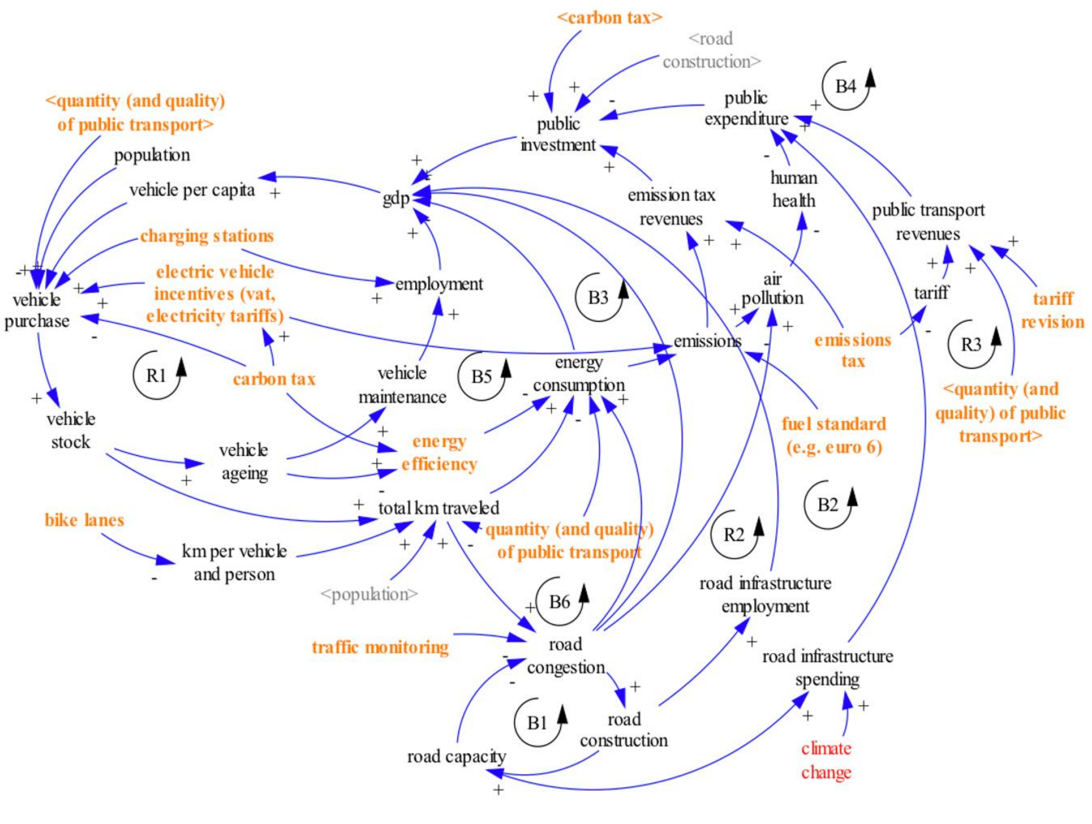

***Fig. 1.1**. Causal loop diagram for the transport sector. The impact of **climate change** (red) on **increasing road infrastructure spending** is acknowledged, but no intervention option for addressing climate change is suggested yet. Blue arrows denote causality. (-) indicates inverse proportional effect (e.g. an decrease in A will cause an increase in B and vice versa). Text in orange presents intervention options. R1 to R3 describe reinforcing feedback loops. B1 and B5 describe self-balancing feedback loops. (Ministry of Economy of the Kyrgyz Republic, 2019)*

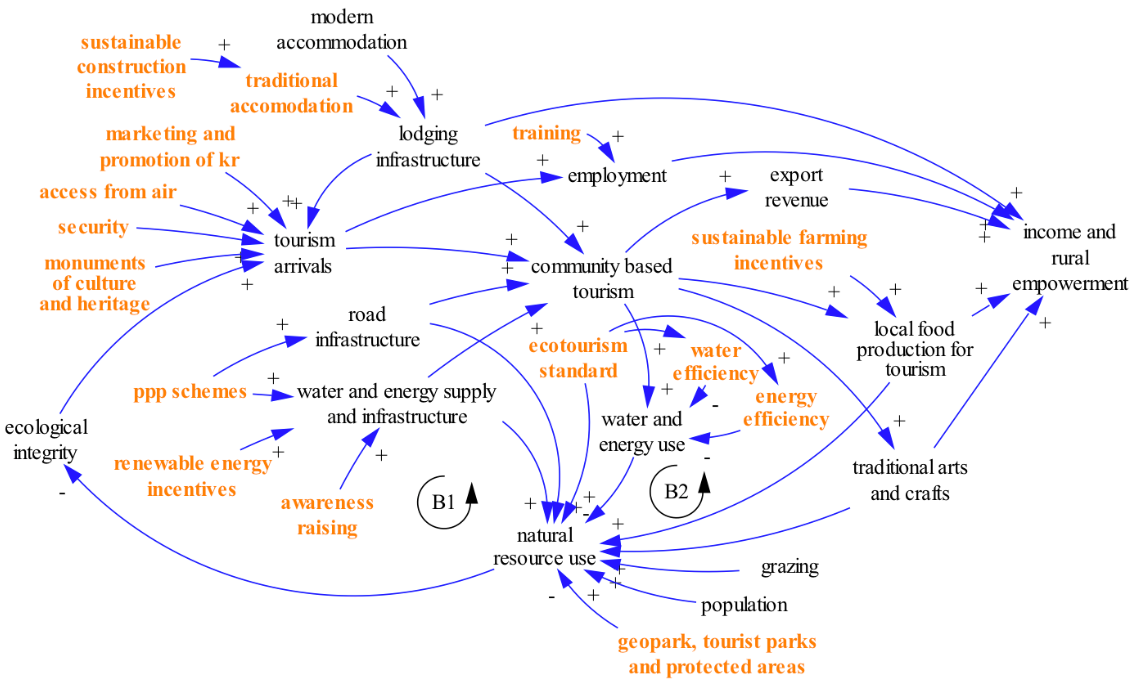

Fig. 1.2. *Causal loop diagram for the tourism sector. Impacts from climate change are not explicitly featured in the diagram. However, some of the interventions (text in orange) would contribute to climate adaptation and therefore represent adaptation options (e.g. sustainable farming and water efficiency). Blue arrows denote causality. (-) indicates inverse proportional effect (e.g. an decrease in A will cause an increase in B and vice versa). Text in orange presents intervention options. B1 and B2 describe self-balancing loops. Such loops describe a balancing response over time to a change of a factor. For instance, increasing tourism arrivals, which can lead to reduced ecological integrity, eventually causes also the tourism arrivals to decrease. (Ministry of Economy of the Kyrgyz Republic, 2019b)*

A CRVA connects available climate change scenarios with information on socio-economic systems. This is crucial as an informing basis for effective economic evaluation of adaptation options that support decision-making (Fig. 1.3.). A CRVA answers such questions as what a potential temperature increase of 5 or 6 °C under the worst case global emission scenario until 2100 would mean for specific economic activities. A CRVA assesses the impact channels that result in risks for economic activities and identifies adaptation options to reduce vulnerabilities. The methodology used in this CRVA does not evaluate risks and adaptation options as cost and benefits. However, results allow the economic evaluation of costs and benefits as a next step for decision making support on concrete adaptation options.

During the GE modelling all mechanisms that are shown in the CLD will be specified with indicators. This CRVA **proposes indicators for selected natural and human factors and resulting impacts**, which are given in the Annex together with data sources. These indicators can be used as templates for the quantitative part of the green economy modelling process in Kyrgyzstan. Nevertheless, it will be necessary to adapt the indicators to the requirements of input data for the specific damage functions of the green economy model.

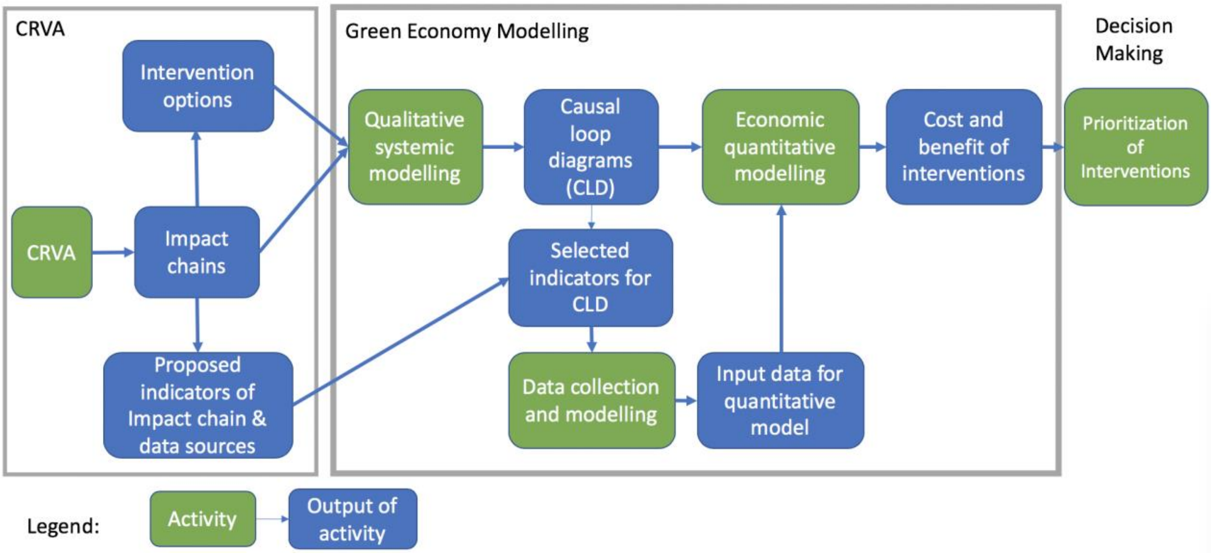

Fig. 1.3. *Linkage of a CRVA with the Green Economy Modelling process for decision making support.*

Quantified indicators will serve as input data for quantitative modelling. The quantification of indicators will be done partially by data collection and partially by computation. For instance, future climate data requires data processing and computation of climate change scenarios. Especially future climate variables beyond simple temperature and precipitation change, e.g. snow reliance, need more analytical efforts.

Quantitative economic modelling represents the core of GE modelling. The damage function translates the climate and other factors into economic damages over time. **The modelling is done with and without adaptation. The results allow the comparison of both cases and the prioritisation of proper adaptation options.**

In **Germany**, a vulnerability assessment (term used for CRVA prior to 2014's IPCC 5th Assessment Report) was first conducted in 2005 and again from 2011 to 2015. The assessment was funded by the German State Agency for Environment (UBA) and in total, 15 different state agencies were involved (UBA 2015). The assessment was conducted by Adelphi, the implementer of this pilot CRVA, in scientific cooperation with the EURAC research institute in Bozen that provided the CRVA methodology as a handbook, which was used here. Results were used by the German inter-ministerial working group for adaptation strategy and state agencies to elaborate policy instruments. Results also fed into the progress report of the German Adaptation strategy.

Kazakhstan has elaborated amendments to the environmental code that defines roles and responsibilities for conducting a CRVA within priority sectors in 2019. This law proposal was guided by a policy study that was elaborated with support of the National Adaptation Planning Global Network (NAP Global Network, Fig. 1.4).

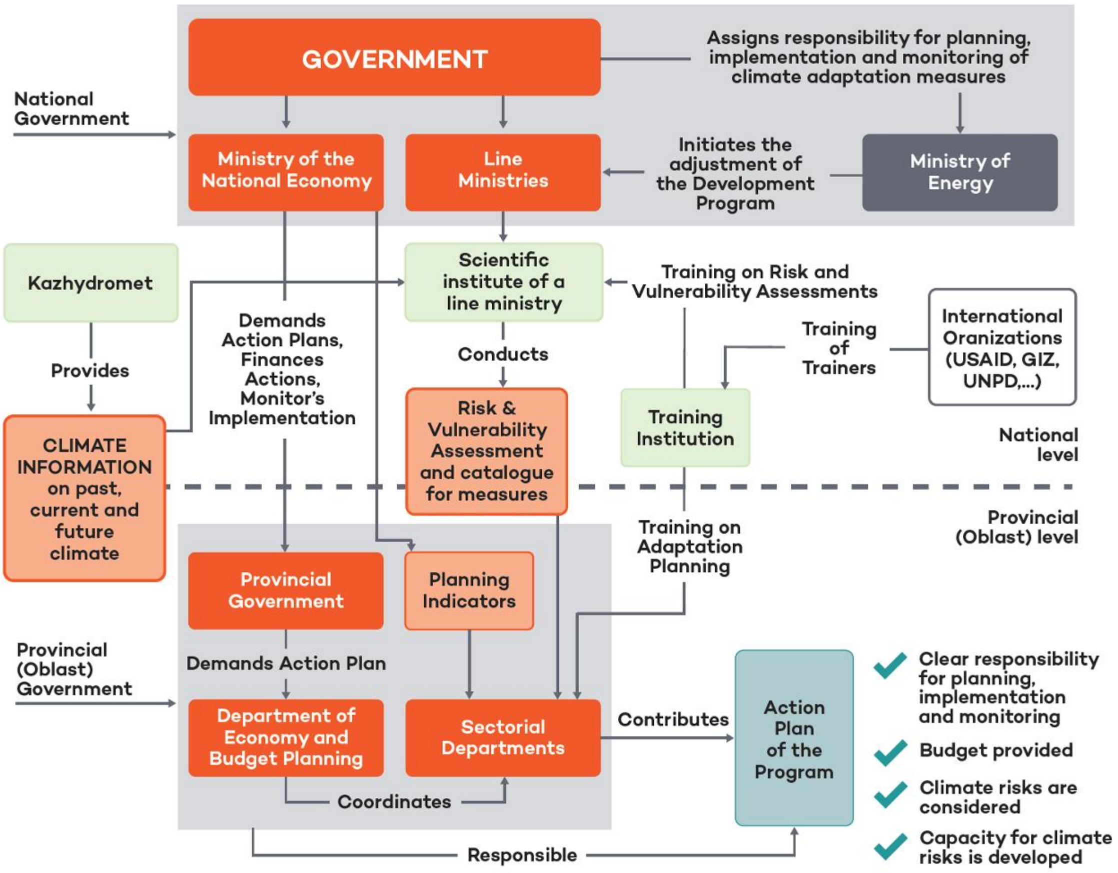

Fig. 1.4. *Proposed institutionalized framework for roles and responsibilities of the adaptation planning process in Kazakhstan. Amendments of the environmental code are partially based on this schematic framework. This scheme proposed that subordinate institutes of the line ministries are conducting the CRVAs. (Source: Bierkandt et al., 2019)*

1.2. Methodology for the CRVA

This section presents the methodology of the conducted CRVA. We used a methodology from *Climate Risk Assessment for Ecosystem-based Adaptation - a Guidebook for Practitioners* (GIZ, EURAC & UNU-EHS, 2018). This established methodology has been applied in different settings in approximately 20 countries, and explicitly focuses on Ecosystem-based Adaptation (EbA) for planners and practitioners.

It is important to point out that a wealth of other methodologies for conducting CRVAs exists. However, many of these different existing CRVAs are based on the same risk approach that was developed for the IPCC's 4th Assessment Report (Oppenheimer et al., 2014). Within this approach risks emerge from the interaction of climate hazards, exposure and vulnerability (Figure 1.5.). Exposure denotes elements that are exposed to hazards and impacts. Vulnerability describes a) the sensitivity to hazards and impacts and b) the capacity to respond to climate change. These interactions can be very complex. Climate impact chains are used to illustrate impact channels. Identifying these chains is the backbone of our CRVA. Identified adaptation options are capable of a) reducing exposure through relocation, b) reducing sensitivity and c) increasing the adaptive capacity (Figure 1.6.)

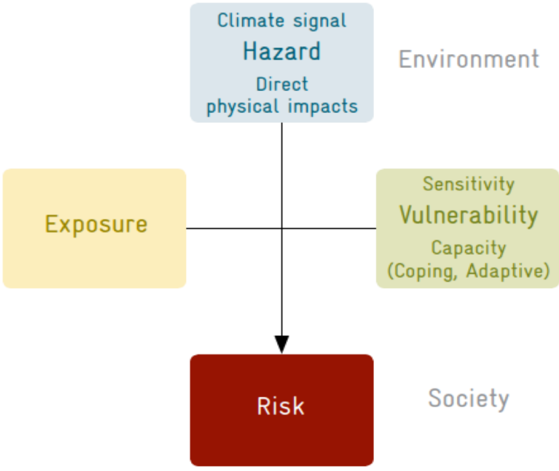

Fig. 1.5. *Risk results from the interaction of climate hazards, exposure and vulnerability. Exposure denotes elements that are exposed to hazards and impacts. Vulnerability describes a) the sensitivity to hazards and impacts and b) the capacity to respond to climate change. These inter*actions can be very complex and *climate impact chains are used to illustrate impact channels. Source: GIZ, EURAC & UNU-EHS, 2018.*

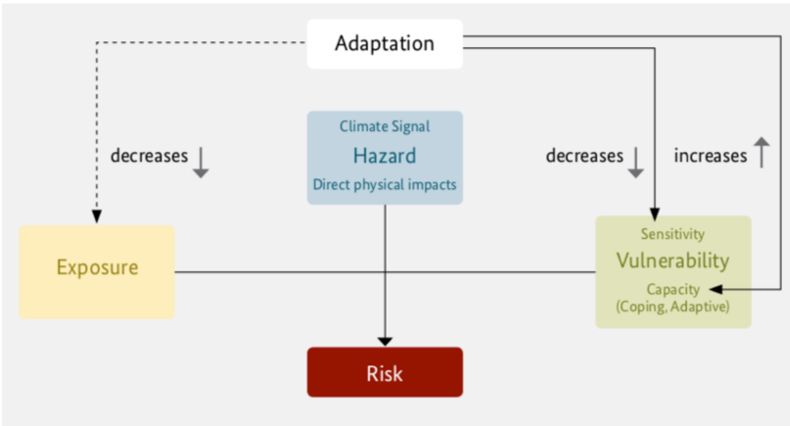

Fig. 1.6. *Identified adaptation options decrease a) exposure through relocation, b) sensitivities and c) increase the adaptive capacity to cope with climate change impacts. Source: GIZ, EURAC & UNU-EHS, 2018.*

The following definitions of the terms in Figures 1.5. and 1.6. are definitions which were *simplified* by the authors and based on the full definitions in the glossary of Working Group II contribution to the IPCC Fifth Assessment Report (2014), and the Risk Supplement to the Vulnerability Sourcebook, 2017 (GIZ).

- **Hazard**: Climate-related physical events or trends or their physical impacts that may cause loss and/or damage.
- **Impact**: Effect(s) on natural and human systems.
- **Exposure**: The presence of people, species, ecosystems, infrastructure, in places and settings that could be adversely affected.
- **Sensitivity**: The degree to which a system or species is affected by climate variability or climate change

- **Capacity**: In the context of climate risk assessments it refers to the ability of societies and communities to prepare for and respond to current and future climate impacts
- **Vulnerability**: A function of sensitivity and capacity
- **Risk**: Probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur, whereby the outcome is uncertain. Risk results from the interaction of vulnerability, exposure, and hazard.
- **Adaptation:** The process of adjustment to actual or expected climate and its effects.

This piloting CRVA conducted following 3 steps:

1) Preparing the assessment (scoping)
2) Developing the impact chains
3) Identifying adaptation options

Step 1: Preparing the assessment (scoping). The most important actions we took in this step were:

- Conducting a planning and orientation workshop for policy makers at the Ministry of Economy on two questions: Why and how to use CRVAs.
- Determine the scope of the CRVA with experts from the transport sector and the Ministry of Transport and Roads of the Kyrgyz Republic CRVA.
- Determine the scope of the CRVA with experts from the tourism sector and the Ministry of Culture, Information and Tourism of the Kyrgyz Republic for two tourism CRVAs.

Step 2: Developing the impact chains.

The initial impact chains were developed by and with sectoral experts in full-day participatory workshops. The impact chains are the **backbone of the CRVA**. These chains are an analytical tool which makes cause-effect relationships explicit. They unconditionally rely on AND further develop expert knowledge and a sound understanding of the system of concern. They help to better understand, structure, and prioritize the factors that drive risks in a system. Furthermore, they visualize the cause-effect relationships between drivers and their implications for the people.

The most important actions we took in this step were:

- Conducting a full-day participatory expert workshops for determining the climate impact chains for the CRVA in the transport sector
- Conducting a full-day participatory expert workshops for determining the climate impact chains for the CRVAs in the tourism sector
- Analysis, validation, refinement, and synthesis of impact chains

Step 3: Identifying adaptation options. The most important actions we took in this step were:

- Identifying conventional and Ecosystem-based Adaptation options for vulnerabilities and exposures in the transport sector impact chain
- Identifying conventional and Ecosystem-based Adaptation options for vulnerabilities and exposures in the two tourism sector impact chains

2. Transport sector

2.1 Scope of assessments

The drafted budget for 2020 indicates that the Ministry of Transport and Roads will spend 1.9 bln KGS, i.e. 83 percent of its total budget on repair and maintenance of roads (Kudryavtseva, 2019). Road deterioration is "largely a function of heavy traffic loading, road condition, physical geography, and climate" (Asian Development Bank, 2007). Climate-induced factors are expected to increase in the future under climate change. Consequently, the cost of road maintenance will increase and the demand for road protection measures will rise. This pilot CRVA for the Kyrgyz transport sector focuses on climate risks for mountainous road infrastructure. More specifically, the international road corridor that crosses Kyrgyzstan from China to Uzbekistan across the Taldyk pass with an elevation of 3600 m. The goal of this pilot CRVA is to identify the mechanisms behind natural hazards that already cause severe damage and are expected to increase in frequency and intensity in a changing future climate.

Fig. 2.1. *Map of the international corridor from Kashghar in China to Tashkent in Uzbekistan. (Source: Kabar.kg, 2018). The Taldyk pass at 3600m is located 89 km west of Irkeshtam.*

Relevance of the international corridor from China to Uzbekistan via the Taldyk pass

Regional cooperation is important to the landlocked Kyrgyz Republic and the international road is vital to reduce transport costs, improve access to markets, and increase regional trade and cooperation. The Osh–Sary-Tash–Irkeshtam road is part of a Central Asia Regional Economic Cooperation (CAREC) corridor that links the People's Republic of China (PRC), Kyrgyz Republic, Tajikistan, and Uzbekistan. It also connects with the Osh–Bishkek road, a key national route and extends south and west to Afghanistan and Tajikistan.

The mountainous topography and geographical location of the Kyrgyz Republic in Central Asia strengthen the role of the transport sector in achieving sustainable economic development. The sector is dominated by road transport, which accounts for 92% of freight transport and 99% of passenger transport (excluding intra-city transport). Freight traffic of the Osh-Irkeshtam international corridor is up to 300-350 trucks per day. (MTR, Transport system Development strategy for period 2020-2025).

This corridor also has a positive impact on the economy of the Kyrgyz Republic by significantly improving the conditions for transit traffic and facilitating the flow of transport, goods and passengers, increasing the growth of international trade, deepening economic relations, improving living standards and reducing poverty in the country.

Impacts of natural hazards on road infrastructure in Kyrgyzstan

Kyrgyzstan's geography makes the country highly vulnerable to risks from natural disasters such as floods, landslides, debris flows and river erosion, avalanches, heavy winds, heavy rainfalls, icing, frost, droughts, devastating glacier fluctuations, mountain lake outburst and rising groundwater levels. Decreasing forest cover in most mountainous areas due to grazing and logging contributes to more widespread phenomena such as floods, landslides and debris flows. Dangerous natural processes causing great damage, both in terms of loss of life, livelihoods and disruption of transport movement and economic activities.

In Osh oblast, where the international highway runs, there are from 10 to 127 emergency situations per year, with an average of 74-75. Emergency situations caused by debris flows and floods account for 29.7%; landslides and rockfalls for 18.8%; earthquakes for 13.6%; avalanches for 15.7%; meteorological hazards for 8.8%; man-made accidents and major fires for 7.6%. (Ministry of Emergency Situations of the Kyrgyz Republic (2016).

For most of the length of the road, from the outskirts of the villages adjacent to Osh (21 km) to the base of Taldyk pass (157 km), the road passes through quite narrow and, from the geological point of view, young valleys. The road straightens out parallel to the rivers and adjoins them, or clearly follows the streams, which every year depend on their increasing water resources. As a consequence, embankments and cut-off slopes occur along many sections of the road and are subject to erosion from adjacent streams, which turn into mountain streams during spring and summer thaws. Floods also cause problems, but they are more localised and random than permanent erosion occurring at the edges of the roadbed, which is the main cause of landslides and rockfalls.

Impact evaluation

According to the Ministry of Emergency Situations of the Kyrgyz Republic (MES), the impact of events related to natural hazards in the Kyrgyz Republic can be estimated at an average of 35-50 million USD per year.

Authorities estimate direct costs (damage to infrastructure, repair costs), but not indirect costs (higher transport costs, longer travel time, disturbance of infrastructure). Documents on repair and reconstruction costs are prepared by the Ministry of Transport and Roads (MTR).

Estimated landslide/grassland reclamation costs generally ranged from USD 6,000 to USD 11,800 per km in KR identified for "periodic maintenance", which may be associated with reclamation in the event of natural hazards.

The cost of periodic repairs and rehabilitation averages USD 23 million per year, of which 90% is spent on reconstruction, mostly as a result of natural hazards and degradation. Most of this amount is likely to be spent on rehabilitation and repair work related to hazardous natural processes. Funding and other means available and implemented to maintain road infrastructure and repair damage associated with the impact of hazardous processes is inadequate.

Based on SEACAP studies in the mountainous regions of Southeast Asia, for the Osh - Bishkek road (SIDD 2750) with an Unserviceable Maintenance Target (LOS) of 3 per year and with a response time of 24 hours, the annual cost of landslide damage can be around US$3.5 million (Wilson, 2008).

The Government has increased investment in rehabilitation of major international and national roads in the past (Eptisa, 2015). However, the overall limited budgetary resources have resulted in insufficient funding being allocated for road rehabilitation, and some government agencies may not have the required information and technology to address these problems.

2.2 The climate impact chain

Figure 2.2 illustrates impact channels that lead to a risk of economic losses due to higher maintenance costs and interrupted transport as a result of the interaction of climatic hazards, vulnerabilities and exposure. Impacts are caused by the interplay of 3 components - climate hazards, vulnerability and exposure.

The impact chain in Figure 2.2 illustrates how factors from all 3 components lead to impacts and risk along the selected international corridor. Please note, that for a specific road segment only a subset of impacts are relevant. In other words, the risk for slope instabilities, floods and avalanches are highly site specific. Although the impact chain is quite complex, all individual impact channels pass one of the three intermediate factors: a) **slope instabilities**, b) **concentrated water flows** and c) **avalanches**. This CRVA focuses on mitigating **slope instabilities** and **concentrated water flows**, where the green approaches, such as bioengineering is most effective.

For instance, Taldyk pass is more vulnerable to landslides than other segments, due to the steep slope and fewer protective vegetation at high elevation. Hazard maps of the MES indicate where to expect what kind of hazard. In this report, we focus on the impact channels and how to address them (section 2.3).

Proposed indicators for selected factors of all 3 components that contribute to climate impact and risks are shown in the Annex.

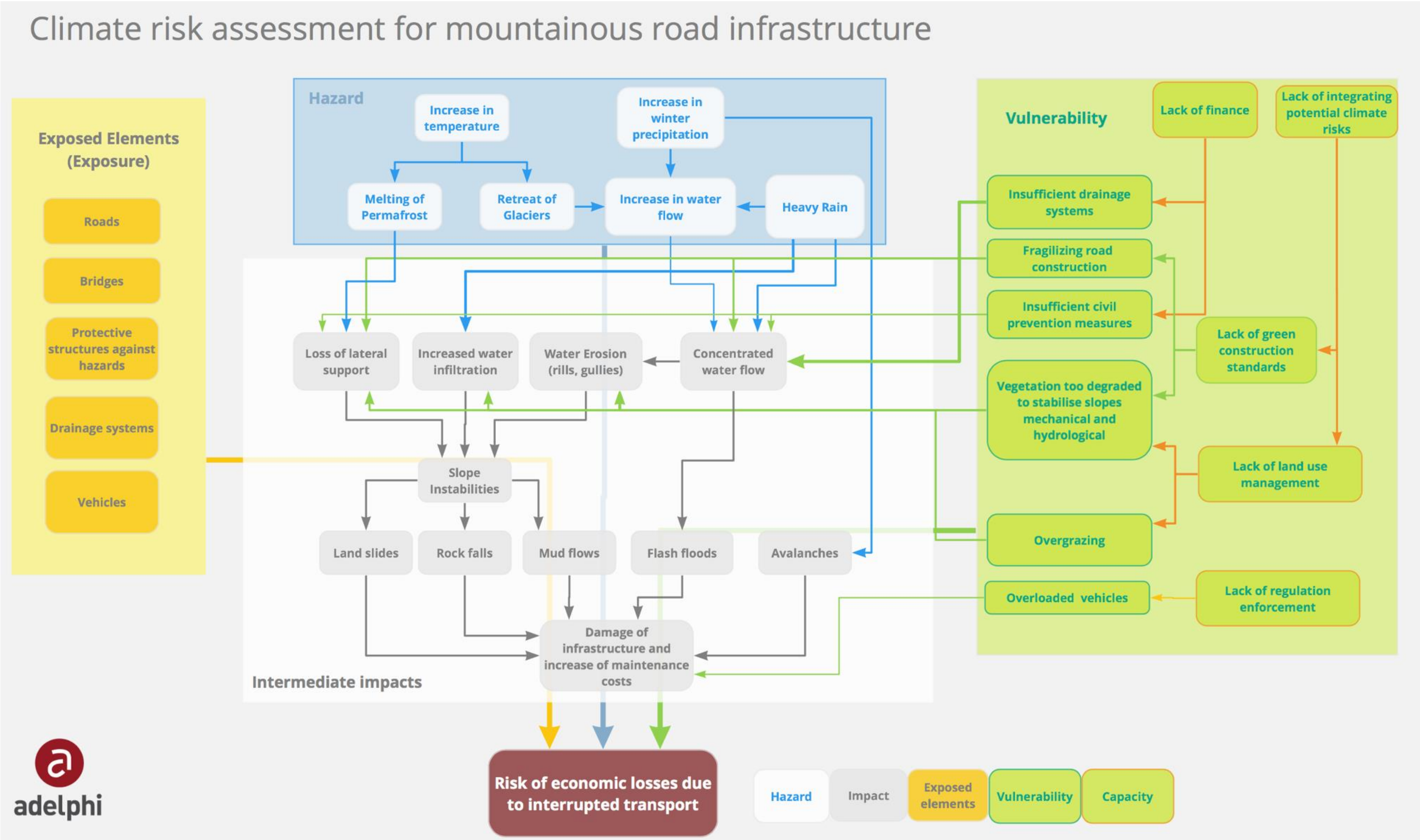

Fig. 2.2. *Illustration of the climate impact chain for road infrastructure along mountainous segments of the international corridor from China to Uzbekistan, including Taldyk pass.* ***Impacts*** *(white frame) result from the interaction of* ***hazards*** *(blue frame),* ***exposure*** *(yellow frame) and* ***vulnerabilities*** *(green box). All interplay of all those factors (single box) of the 3 components lead to a* ***risk of economic loss due to road damage and interrupted transport****. Different thickness of arrows has no meaning and only helps to differentiate the direction of crossing arrows.*

Climate hazards

Most Climate hazards are expected to increase in the future. Due to global emissions of GHG, **temperatures** and **winter precipitation** are expected to increase. Consequently, **permafrost will continue to melt**, which will cause **slope instabilities**, and **glaciers will retreat**, causing a temporary contribution for **water flows**. Water flows are likely to intensify with **increased winter precipitation** and increased likelihood of **heavy rain events.**

Impacts and risks

The risk of economic losses due to road damage and interrupted transport is caused by the interplay of natural factors (hazards) and human factors (vulnerabilities, exposures). Impacts (white frame in figure 2.2) result from the interaction of hazards, exposure and vulnerabilities. Impacts cause further impacts and eventually result in risks.

Although the interplay of factors is complex, figure 2.2 shows that the impact channels concentrate on **slope instabilities**, **concentrated water flows** and **avalanches**. **Slope instabilities** are influenced by steep slopes (**loss of lateral support**), increased **water infiltration** (caused by **heavy rain**) and surface **erosion** (caused by **heavy rain** and uncontrolled **water flows**). Concentrated **water flows** can lead to **flash floods**.

Slope instabilities cause **landslides**, **debris flows** and **rock falls**. Deep-seated and shallow-seated landslides exist, where the former can be characterised by earth that becomes detached from deeper in the ground. All these impacts, together with avalanches, lead to **road and infrastructure damage** with increasing **maintenance costs** and **economic losses** due to interrupted traffic.

Human and environmental factors - Vulnerabilities

Vulnerabilities describe the human (and environmental) factor that contributes to intermediate impacts that are only triggered by natural hazards. Vulnerabilities represent the **sensitivity** of a human system/sector (here: mountainous road infrastructure of the transport sector) to environmental impacts and the **lack of capacity** to decrease this sensitivity. Vulnerabilities are crucial for adaptation, because in contrast to hazards, which (with the exception of global GHG mitigation) cannot be influenced (apart from global greenhouse gas mitigation), vulnerabilities can be reduced by **adaptation options**, identified in section 2.3. **Exposure** to impacts and risk can also be reduced by relocating elements that are exposed to impact. Human activities can provoke conditions that increase the sensitivity of slopes to impacts triggered by natural hazards. For example, **heavy excavation in the slope and setting up unfavourable loads can fragilize slopes**. The right figure of figure 2.3 portrays heavy modification of the slope, especially at the toe, due to road construction. One can conclude that the road construction itself represents a destabilizing activity. In addition, inappropriate land use, e.g. grazing on fragile slopes, increases the impact of slope instability. The picture on the left in figure 2.3 from 2008 shows clear evidence of pasture activities.

Fig. 2.3. a) Taldyk pass in 2008 before construction. (Source: Wikipedia)

Fig. 2.3.b) *Taldyk pass in 2018 after construction with heavy excavations in the slope.* (Source: dreamstime)

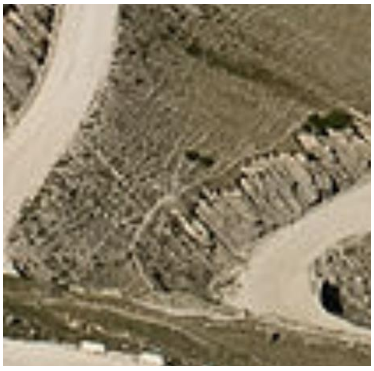

Fig. 2.3 c) *Livestock trails along slopes above roads at the Taldyk pass. Enlarged detail of Fig. 2.3 a), indicated there by a red frame.*

Exposed elements of the transport sector - Exposure

The concept of exposure accounts for the fact that the geographic location of elements determines the risk of damage. In the transport sector, roads, bridges, protective structures, drainage systems and vehicles are exposed to climate impacts. The degree of exposure varies for different road segments. Road infrastructure and traffic increases with economic development and more vulnerable elements become exposed to climate impacts. **Therefore, economic development planning requires climate resilient planning. It is much more challenging to relocate exposed elements than to reduce their vulnerabilities.**

2.3 Adaptation options

[1]This section presents climate adaptation options for mountainous road infrastructure that have been identified during the assessment. All proposed adaptation options reduce the vulnerability or exposure

[1] Terminological Note: Although all adaptation options represent interventions, not all interventions represent adaptation options. The term intervention is used in the Green Economic Modeling process.

factors indicated in the climate impact chain (Figure 2.4) and consequently mitigate road damage from natural disasters to some extent. Proposed adaptation options include green adaptation options approaches, conventional adaptation options and combined options alongside.

1. Institutionalizing CRVA (Section 6.4)
2. Paradigm shift (Section 2.3.1)
3. Sufficient drainage (2.3.2)
4. Bioengineering and vegetation management (Section 2.3.2)
5. Standards for green construction (Section 2.3.3)
6. Zoning and land use management (Section 2.3.4)
7. Climate finance (Section 2.3.5, 6.1, 6.2)
8. Civil structures
9. Tunnel
10. Axle weight controls and penalties

Figure 2.4 lists adaptation options and indicates the vulnerability (or exposure) factor that is reduced. In general, adaptation options are highly elevation and site specific. Especially at high elevations along the Taldyk pass, options that include trees are unlikely to be viable. However, the slope toe is most important for slope stability and Figure 2.3 indicates that vegetation in the valley in the form of shrubs and small trees is possible. Figure 2.3 also shows that the road to the Taldyk pass crosses the grass zone, which indicates the presence of vegetation which can be used within biological engineering

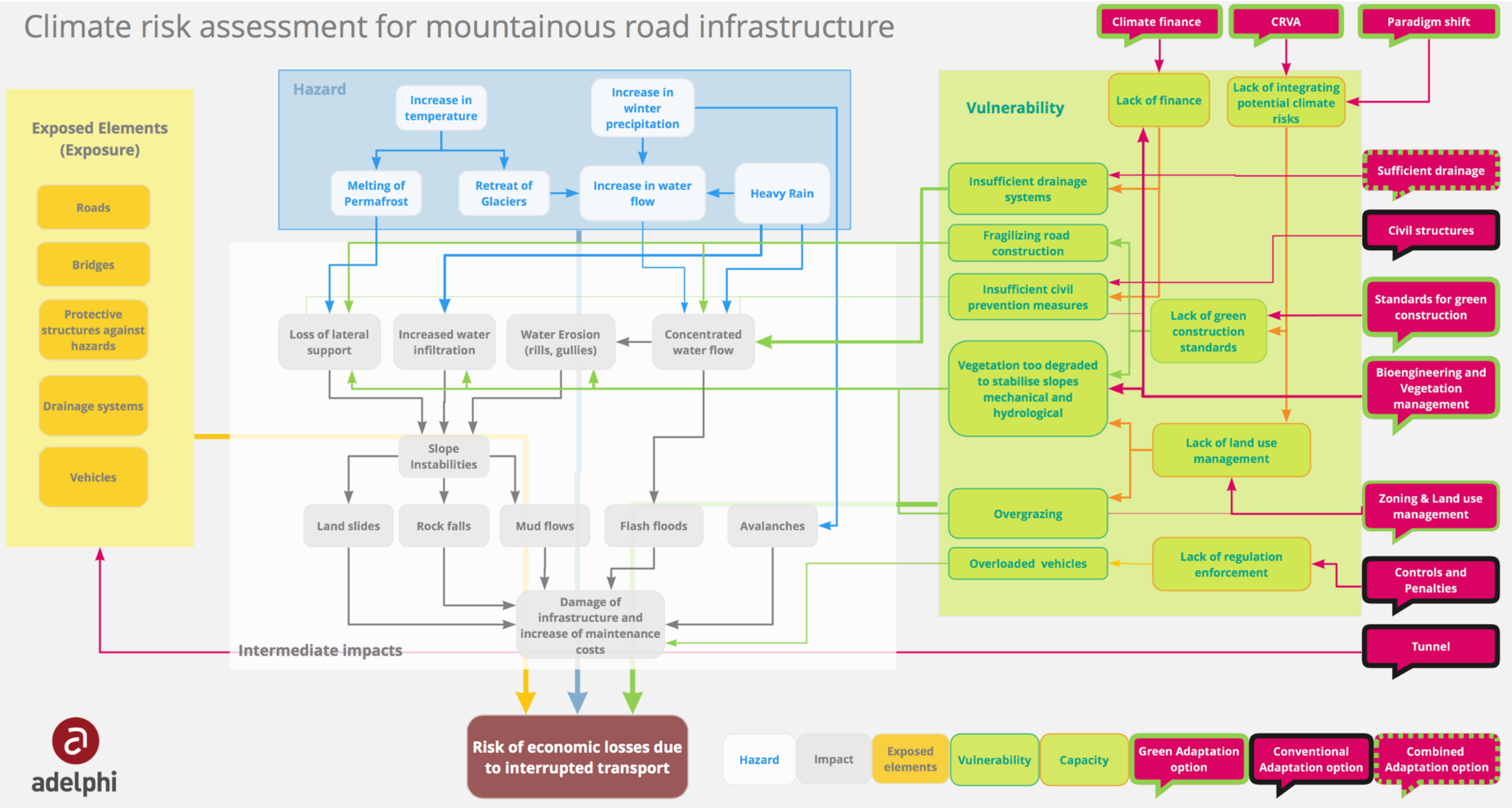

Fig. 2.4. *Illustration of the climate impact chain for road infrastructure along mountainous segments of the international corridor from China to Uzbekistan, including Taldyk pass, with adaptation options. Impacts result from the interaction of hazards, exposure and vulnerability and lead to a risk of economic loss due to road damage and interrupted transport. Adaptation options (red) are differentiated between options that align with green (green frame), conventional (black frame) and combined (dotted green frame) adaptation approaches. All presented adaptation options reduce vulnerabilities, except the tunnel, which reduces the exposure. Different thickness of arrows has no meaning and only helps to differentiate the direction of crossing arrows.*

Large road construction projects that make extensive use of **conventional civil engineering** have been implemented in Kyrgyzstan (Asian Development Bank, 2016). Especially deep-seated landslide areas require complex conventional civil engineering structures. A wide range of conventional technical measures exist: large supporting walls, dams and drains for extensive drainage, technologies for anchoring unstable slopes to more solid ground.

At road segments that suffer from intense and frequent damage, e.g. the Taldyk pass, the construction of a tunnel might be useful and cost-effective. Such calculations need to be made by civil engineers and are outside the scope of a CRVA. In the framework of the methodology used here, a tunnel relocates exposed elements, i.e. reduces exposure, instead of addressing vulnerabilities. In general it is easier to reduce vulnerabilities rather than relocate exposed elements, but a tunnel might be a cost-effective option for extremely vulnerable road segments.

Overloaded trucks contribute to road damage in mountains as well as in valleys. Although there is an axle limit in place in Kyrgyzstan[2], no penalty scheme is strictly enforced. It seems that overloading is tolerated to some extent. However, tightening the control of axle load provides clear economic benefit. In Southeast Asia a "10% reduction in the rates of overloading and in the degrees of overloading" was estimated to result in potential savings of "around $10 million per 10 billion t-km of freight" (Asian Development Bank, 2019). The same study proposes "that the financial and economic benefits and costs of tolerance should be analysed daily and distributed to all media, political representatives and stakeholders, with the purpose of achieving a better understanding of the countries' choices in policies and operations." Technology advancement, e.g. weigh in motion (WIM) sensors, has automated weighing and recording. Moreover, closed circuit television (CCTV) allows for monitoring of traffic and staff. Instead of using CCTV, Switzerland focuses on the use of mobile scales.

***Fig. 2.4b** The Police in Switzerland uses mobile scales for control of axle weight. (Source: Schweizer Bauer, Heinz Röthlisberger)*

[2] 48.5 tonnes for a semi-truck with 3 axles and a trailer with 4 axles (Government of Kyrgyz Republic, 2015).

Here we will focus on green approaches in general and bioengineering specifically, to address today's and future climate hazards in a cost-effective way. The term **bioengineering** (or biological engineering) denotes the use of living plant material, i.e. vegetation (e.g. grass, shrubs and trees), to provide certain engineering functions. Bioengineering techniques are predominantly suitable for shallow-seated landslide areas. They are most effective combined with conventional civil engineering. However, elevation has a strong impact on what bioengineering options are available. The range of bioengineering measures decreases at higher elevation, because fewer plant species can survive there.

2.3.1 Paradigm shift to green construction approaches

Climate change is a significant threat for future economic development and not only for the environment and ecosystems. The Government of Kyrgyzstan has acknowledged the need for sustainable development planning and has elaborated a Green Economy Program, approved in November 2019. An inter-ministerial working group, led by the Ministry of Economy, was created to forecast the outcomes of GE interventions by applying economic systemic modelling approaches. This systemic approach, which evaluates causal relations on and within the economy, is an entry point for integrating direct and indirect climate impacts. Additionally, the MoE recently became the focal point of the GCF. This, together with the ongoing GE modelling effort, reflects the importance of protecting future economic development from climate change impacts for the Ministry of Economy. In summary, a paradigm shift to sustainable development with green approaches has already started within the Ministry of Economy, who requested this piloting CRVA. Moreover, the current national development program until 2022 states that development measures need to consider climate change (Jogorku Kenesh of the Kyrgyz Republic, 2018).

However, this acknowledgement, spearheaded by parts of the MoE, has not reached all sectoral and regional planning procedures. In addition to a lack of awareness within some line ministries, there is 1) a lack of analytical tools, methods and procedures to assess the future climate resilience of specific development measures and investments and 2) a lack of knowledge about alternative cost-effective intersectoral approaches. Hence, action plans of sectoral and regional programs do not yet integrate climate change scenarios and climate-smart solutions to support investment decisions sufficiently.

This section presents knowledge on green alternative approaches. Cost-effective use of ecosystem services, such as the use of vegetation for biological engineering, has great potential to be integrated into construction standards and development programs. Vegetation provides services of economic value and is more than just a natural environment that needs to be protected or managed by SAEPF. Consequently, the degradation of vegetation caused economic losses, limiting potential of development. For instance, road maintenance cost can be reduced significantly by using bioengineering.

> "Bioengineering techniques, along with civil and social engineering measures, can considerably reduce the overall cost of slope stabilization, which remains a key factor for many developing nations"
>
> (Harari et al. 2017; Kumar 2010).

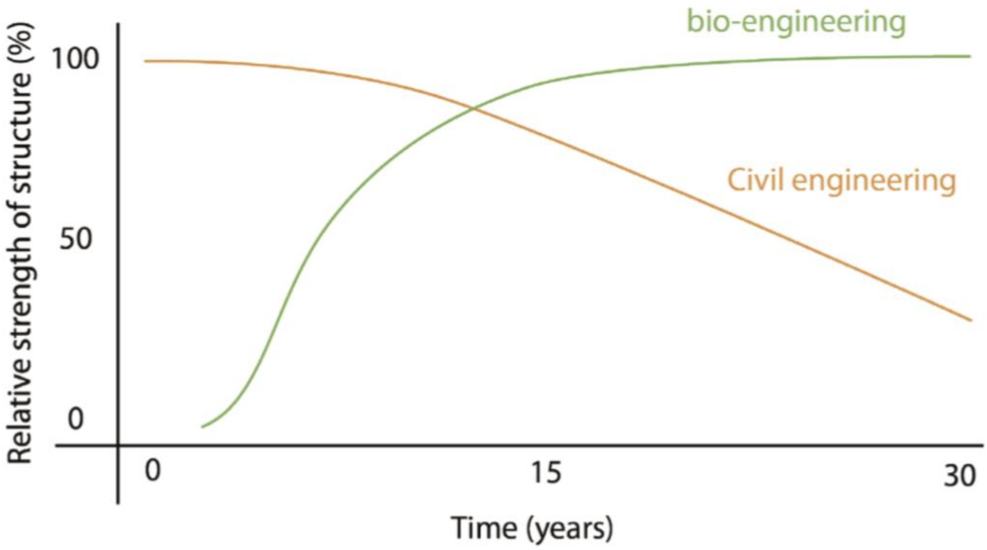

Fig. 2.5. Schematic comparison of relative strength of bio-engineering versus civil engineering structures for slope stabilisation. If used together, civil structures hand over engineering functions to vegetation, which need a few years to gain engineering function and become more effective overtime. In contrast, civil structures weaken as they age. This allows long-term stabilization of slopes. Source: Devkota et al (2014), modified from Marongiu and Cencetti (2013).

Figure 2.5 illustrates how these engineering functions of vegetation increase overtime, in contrast to conventional civil engineering. Alongside civil and social engineering measures, bioengineering can considerably reduce the overall cost of slope stabilization.

Due to its cost-effectiveness this combination of conventional and bioengineering measures has been applied, for instance, in Nepal and Switzerland. A wide range of bioengineering, i.e. ecosystem-based options, have been developed and implemented to reduce the risk from slope instability events. Specifically, the use of local workforce, local plant species and other local resources make bioengineering economical, practical, and effective.

In **Nepal** bioengineering in road construction was introduced 40 years ago with roadside plantations in a US-assisted project (Paudyal, 2007)). Estimated average costs per km for conventional road construction and its 20 years maintenance in Nepal Middle Hill ranges from USD 51,000 to USD 88,000 (2013), depending on the local environmental challenges (Devkota et al., 2014). It needs to be noted that this calculation is limited to rural earthen roads. The use of bioengineering reduced the cost range to 28,000-62,000 USD - a **reduction of 30 to 45%**.

Switzerland annually spends about 165 million USD (2014) on the management of forests that protect infrastructure valued at least 220 billion USD (Losey, 2014). 50% of this value consists of roads (24%) and railway lines (26%). The average cost per hectare for the management of these protection forests denotes 14,000 USD.

Fig. 2.6. *A protection forest in Switzerland that prevented a rock from falling further downwards and potentially causing damage. Specifically, designated forests in Switzerland protect a value of 220 billion USD (2014), where 110 billion USD are represented by transport infrastructure. (Source: Losey, 2014)*

Protection structures such as wooden snow rakes, including their maintenance, cost up to 12 times more than forest management. In other words, a **forest management approach reduces the costs by up to 90%** compared to the installation and maintenance of wooden snow rakes (Losey, 2014).

Almost **50% of Japan's land is covered by forests designated for protection** (Figure 2.7). Over the past decades, the area of forests designated for protection has expanded significantly in China, South Korea, Myanmar, Thailand and Viet Nam (FAO, 2010). The occurrence of natural disasters and their impacts have caused policy interventions in favour of protection forests and green approaches

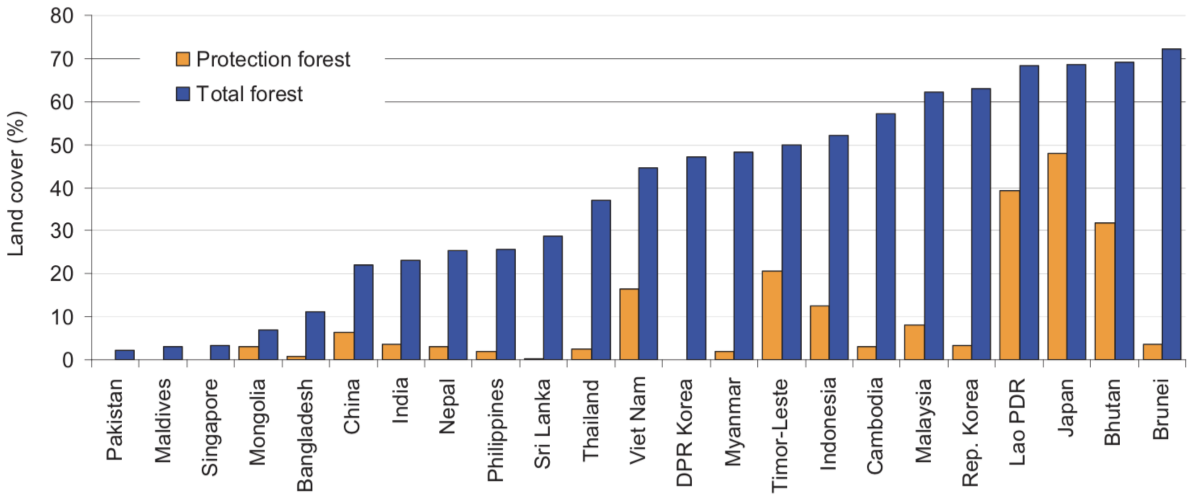

Fig. 2.7. Share of total forest and forest designated for protection in Asian countries (FAO, 2010).

It needs to be noted that Kyrgyzstan has only limited areas of forests. However, these examples show how countries use ecosystem services to protect infrastructure and economic activities. If the economic value is recognized, forest protection, management and extension receives more support from development planners.

2.3.2 Biological engineering - Use of vegetation and its management

Before slopes can be stabilized, water needs to be managed. Hence, drainage is a crucial prerequisite for all stabilization measures including biological and civil engineering. It reduces the contribution from climate hazards and allows to apply measures that reduce vulnerabilities. The techniques for slope stabilization focus on shallow-seated landslides. Deep-seated landslides require major conventional engineering structures.

Slope stabilization requires:

1. the removal of water in the soil (hydrological function),
2. mechanical stabilization of the soil.

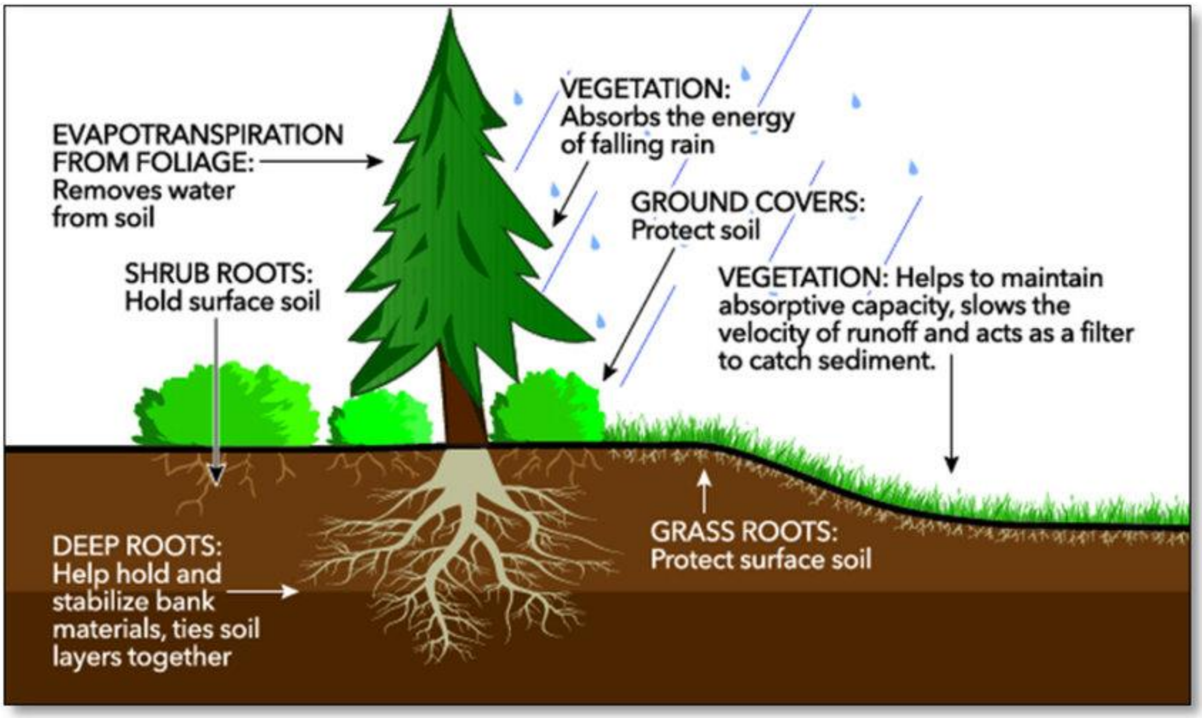

Fig. 2.8. Diagrammatic representation of vegetation with its various functions (Source: Raut and Gudmestad, 2018; Stewards, 2017).

"**Hydrologic** effects involve removal of soil water by evapotranspiration through vegetation. It increases ground suction or reduces pore water pressure, which ultimately increases the shear strength of the soil. Furthermore, evaporation reduces not only the moisture content but also the weight of the soil mass".

Plant roots significantly contribute to maintaining **mechanical** slope stability via (Steinacher et al., 2009):

i) anchoring,
ii) lateral support by crossing zones of weakness,
iii) acting as large fibrous binders within a weak soil mass.

All bioengineering options presented in this section improve the stabilization of slopes, mitigate the risk of shallow-seated landslides and soil erosion and can be combined with conventional measures. If trees, shrubs or grass can be used depends highly on the area and elevation. Bioengineering techniques and their effects are listed in Table 2.1.

Table 2.1. *Selected bioengineering techniques and their intended effects. Modified from: (Source: Raut & Gudmestad, 2018; Dhital, 2013; Howell, 2001). For more detailed information on these measures please refer to the given references. Useful illustrations of the techniques are found in the handbook published by the International Union for Conservation of Nature (Devkota et al, 2014).*

No.	Bioengineering technique	Description	Effects
1.	Planted grass lines (horizontal)	Rooted cuttings are planted in lines across the slope	Provides surface cover Reduces runoff speed Catches debris and protects the slope
2.	Planted grass lines (diagonal)	Rooted cuttings are planted in lines running diagonally across the slope	Effects similar to (1) Drainage of surface water
3.	Grass seeding	Grass seeds sown directly on the site	Easy vegetation of larger, rocky, and steep slopes
4.	Shrub and tree planting	Shrubs and trees are planted at regular intervals on the slope	Reinforces and anchors the slope Increases slope stability as they grow
5.	Brush layering	Woody cuttings are laid across the slope following the contour	Prevents the development of rills Strong barrier to trap debris Reinforces the slope Provides drainage
6.	Palisades	Similar to brush layering, but the cuttings are planted	Effects similar to brush layering
7.	Fascines/Contour wattling	Bundle of live branches laid in shallow trenches being buried by soil	Effects similar to brush layering
8.	Vegetated stone pitching	A combination of dry stone walling where vegetation is planted in the gaps	Provides a very strong form of armouring
9.	Live check dams	Large woody cuttings planted across a gully following the contour	Catches debris Armours and reinforces gully floor
10.	Vegetated bamboo crib walls	Specialized form of gravity retaining structure using on-site fill material	Immediate protection Provides long-term advantages of slope stabilization

2.3.3 Standards for green road construction

Systemic stabilization of slopes throughout Kyrgyzstan by using bioengineering techniques requires national standards for the application of techniques and appropriate plants. What types of plants are to be used for specific techniques and elevation in the Kyrgyz context needs to be specified in a piloting project by an interdisciplinary team of experts. Nepal has nationally mainstreamed the use of bioengineering for road construction.

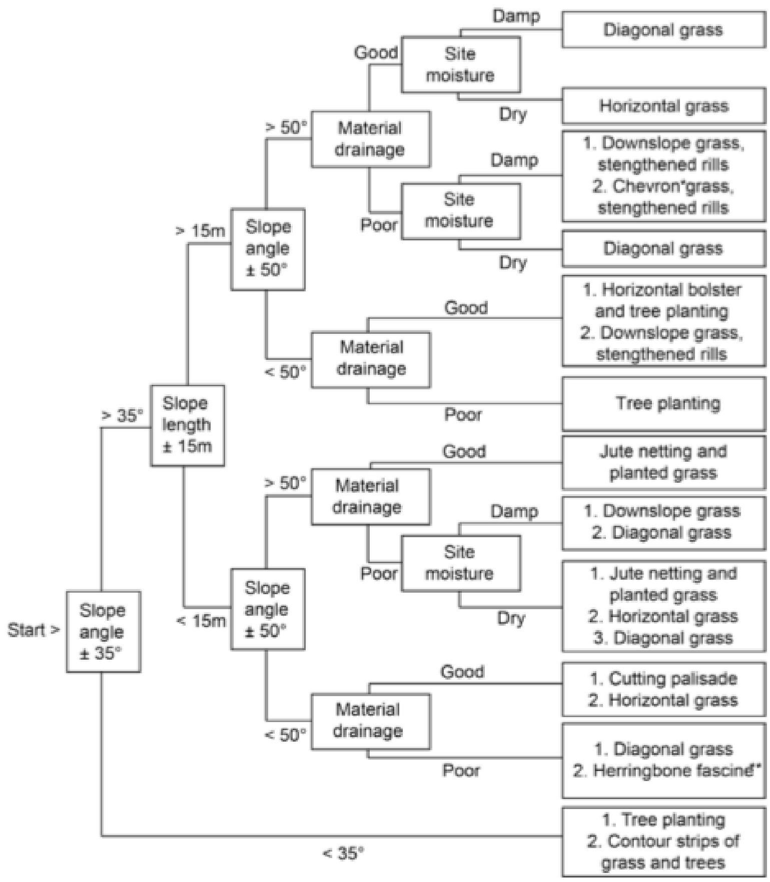

Fig. 2.9. *Example on how to standardize decision making for different slope angles, drainage material and moisture conditions. Some plants are Nepal specific, e.g. jute. Therefore, it needs to be adapted to the Kyrgyzstan context. (*Chevron is a zigzag pattern ** Herringbone is a diagonal pattern); Source: Devkota et al, 2014*

2.3.4 Zoning and guidelines for land use

The Ministry of Emergency Situations is creating hazard maps for landslides on an operational basis. These hazards maps allow to define vulnerable zones with respect to different hazards, e.g. avalanches, landslides or floods.

State-of-the-art process-based computer models allow the simulation of the flow of snow (avalanches) or earth (landslide or debris flow) downhill. This knowledge can be connected to the economic value that is exposed to simulated hazard zones. Determination of the exposed value requires the quantification of exposed elements. The linkage of hazard zones with potential damages allows the prioritisation of protective measures and the zoning of areas. Further, land use guidelines can be derived. For instance, fragile slopes need to be protected from grazing. This can be achieved by land use management that accounts for the interests of all involved stakeholders, including local communities.

In **Switzerland**, project SilvaProtect-CH of the Swiss state agency for environment has developed a method on how to assess the impacts of modelled natural hazards nationwide, how to determine protection forests and the value of protected assets (BAFU, 2016).

2.3.5 Designing projects for international climate finance

Lack of financing is a major barrier for addressing future climate risk by adequate mitigation of damages from natural disasters. To overcome this obstacle, applying for climate finance is another promising opportunity, in addition to cost-effective bioengineering. However, international funds, such as the GCF, have specific requirements for financing climate adaptation programs. In addition to a number of others, three important requirements have to be met by proposed adaptation programs:

1. it needs to be shown what impact can be avoided through planned measures compared to a business-as-usual scenario, i.e. it needs to be clear delimitation from a development project (this is called the climate rationale);
2. generation and use of climate services need to increase;
3. Paradigm shift potential needs to be shown.

These conditions can be met by institutionalizing the CRVA and the economic evaluation of the GE modelling process (Section 2.3.4 and 5.1). These activities present intermediate climate services that use climate information to assess impacts. The following table illustrates the potential for funding of a project that protects mountainous road infrastructure in Kyrgyzstan by using bioengineering and proper land use management.

Table 2.2: Overview of GCF result areas that need to be indicated in a GCF Concept Note. A project on road protection by using bioengineering and proper land use management would increase resilience in 3 GCF result areas and reduce emissions from forestry and land use.

Mitigation: Reduced emissions from:

☐ Energy access and power generation

☐ Low emission transport

☐ Buildings, cities and industries and appliances

☒ Forestry and land use

Adaptation: Increased resilience of:

☒ Most vulnerable people and communities

☐ Health and well-being, and food and water security

☒ Infrastructure and built environment

☒ Ecosystem and ecosystem services

Example for a GCF transport sector program from Djibouti: jointly with UNDP, Djibouti has developed a program that aims to reduce the flood impacts on transport corridors by mobilizing upstream surface water for the most vulnerable agro-pastoralists. Over 7 years (2019-2025) USD 29 million USD will be invested, where 25 million USD will be provided as funding from GCF. 350,000 people (37% of the total current population) will benefit from the adaptation impact of this program (Green Climate Fund, 2018).

3. Tourism sector - a brief introduction

The tourism sector is one of the priority sectors in the Kyrgyz Republic's economy. This priority is highlighted in the National Development Strategy 2018-2040 and the resulting Tourism Development Program of the Kyrgyz Republic for 2019-2023.

Following the introduction of a visa-free regime for 45 countries in 2012 and seven more countries in 2019, as well as marketing efforts, promotion efforts, and launches of new offerings, the Kyrgyz Republic is experiencing a steady increase of tourist arrivals. Fig. 3.1. below shows the numbers of tourist arrivals in the past seven years.

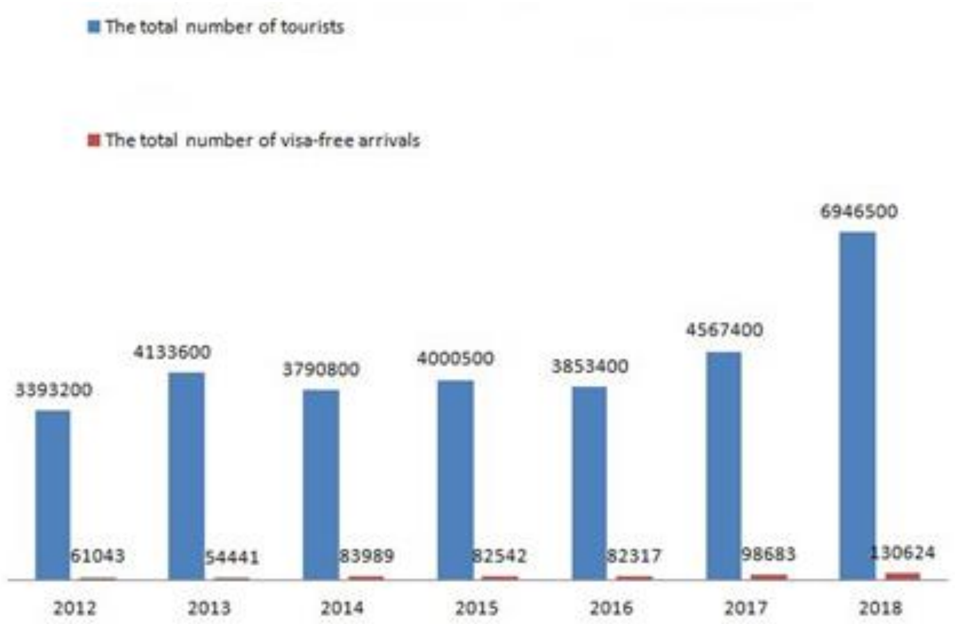

Fig. 3.1. *Number of tourist arrivals in the Kyrgyz Republic (2012-2018) (Source: Tourism Department under MCIT of the Kyrgyz Republic based on the data of the State Border Service of the Kyrgyz Republic).*

According to the National Statistics Committee (NSC), the tourism sector's contribution to GDP in 2018 was 4.99% vs. 4.96% in 2017 (Fig. 3.2). The revenues of the tourism sector increased by USD 35,2 million and amounted to USD 453,4 million (vs. USD 418,2 in 2017).

While showing dynamic growth and a multiplicative effect on other economic sectors, society and the environment, the tourism sector of the Kyrgyz Republic is extremely vulnerable to climate risks. The majority of the tourist offerings are built around adventure tourism experiences in the mountains. Given the vulnerability of mountainous landscapes to climate-induced disasters and based on the results of stakeholder consultations, this assessment focuses on the two aspects of the tourism industry in Kyrgyzstan:

1) Winter skiing and snowboarding in the regions of Chuy and Issyk-Kul, and

2) Summer adventure, eco- and community-based tourism on the South Shore of Issyk Kul and in the mountains around Karakol and Naryn

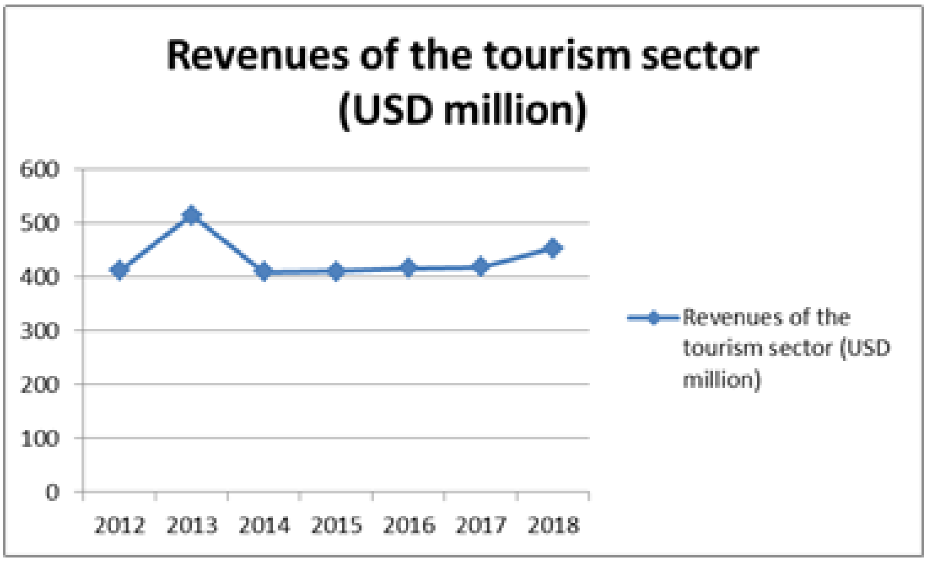

Fig. 3.2. *Revenues of the Kyrgyz Tourism Sector (Source: NSC of the Kyrgyz Republic).*

4. Winter tourism

4.1. Scope of assessment

Karakol (from Barskoon to Jyrgalan) and Bishkek South (from Ala Archa to Issyk Ata) are currently the best-known areas for winter tourism in Kyrgyzstan (see Figure 4.1 below). Based on consultation with the winter tourism stakeholders and experts (i.e. ski base managers, the Ministry of Culture, Information and Tourism, the Ministry of Economy and academia) it was decided to focus the geographic scope of the winter tourism assessment on the ski tourism sector of Issyk Kul and Chui Provinces. The reasons behind this decision were a) delineating a system and geographic area which are specific enough to allow for relevant and useful insights, yet general enough to allow for conclusions which are applicable elsewhere, and b) the limited amount of time for analysis in the project.

The aim of the CRVA for winter tourism was to assess the risk of profitability and economic loss for winter skiing and snowboarding tourism due to decreasing snow reliability with a focus on Chuy and Issyk-Kul. The CRVA covered the most essential elements of ski tourism: ski slopes, access roads, ski lifts, hotels, restaurants and guest houses around ski bases.

The assessment results and recommendations are also relevant for other regions in Kyrgyzstan where ski tourism is at a nascent stage of development (e.g. in the Alay mountains of Osh Province and in the mountains of Naryn Province).

Fig. 4.1. *Map of the currently best-known locations for winter tourism in Kyrgyzstan: Karakol (from Barskoon to Jyrgalan) and Bishkek South (from Ala Archa to Issyk Ata) (Source: Google Maps).*

4.2 The climate impact chain

The primary results of the winter tourism assessment are the climate impact chain displayed in Figure 4.2, and the version of the climate impact chain with adaptation options (Section 4.3, Figure 4.3.). Proposed indicators for selected factors that contribute to climate impact and risks are shown in the Annex.

Climate Hazards

This section focuses on the blue box, the climate hazards. Figure 4.2. shows that the **increase in mean temperature** is the primary climate hazard driving the impacts of climate change on winter tourism. It is the cause of four subsequent hazards, which then cause intermediate impacts in the white box.

The **increase in mean temperature** has four major consequences. First of all, it **leads to an altitudinal increase of the snow line.** Secondly, it leads to **melting of permafrost soil**. Thirdly, it **decreases the reliability of the onset and duration of the winter season.** Finally, it **decreases the average meteorological duration of the winter season.**

Impacts and risks

The intermediate impacts caused by the climate hazards (blue box) and influenced by the vulnerabilities (green box) are displayed in the white box in Figure 4.2. The following text gives a key example from the Figure for how the climate hazard of **increasing mean temperature** ultimately increases risk of profitability and economic loss for winter skiing and snowboarding tourism. The climate hazard **altitudinal increase of the snow line** leads to a **decrease in the duration of snow cover**. This leads to a **decrease in the number of skiing days**, i.e. the days on which skiing is feasible. A decreasing number of skiing days ultimately leads to a **decrease in the number of skiing tourists**. A reduction of these numbers decreases the revenue from tourists. The decrease in the number of skiing tourists **increases the downtime of ski resort equipment and infrastructure**. Furthermore, the lack or absence of tourists **increases seasonal planning difficulties**.

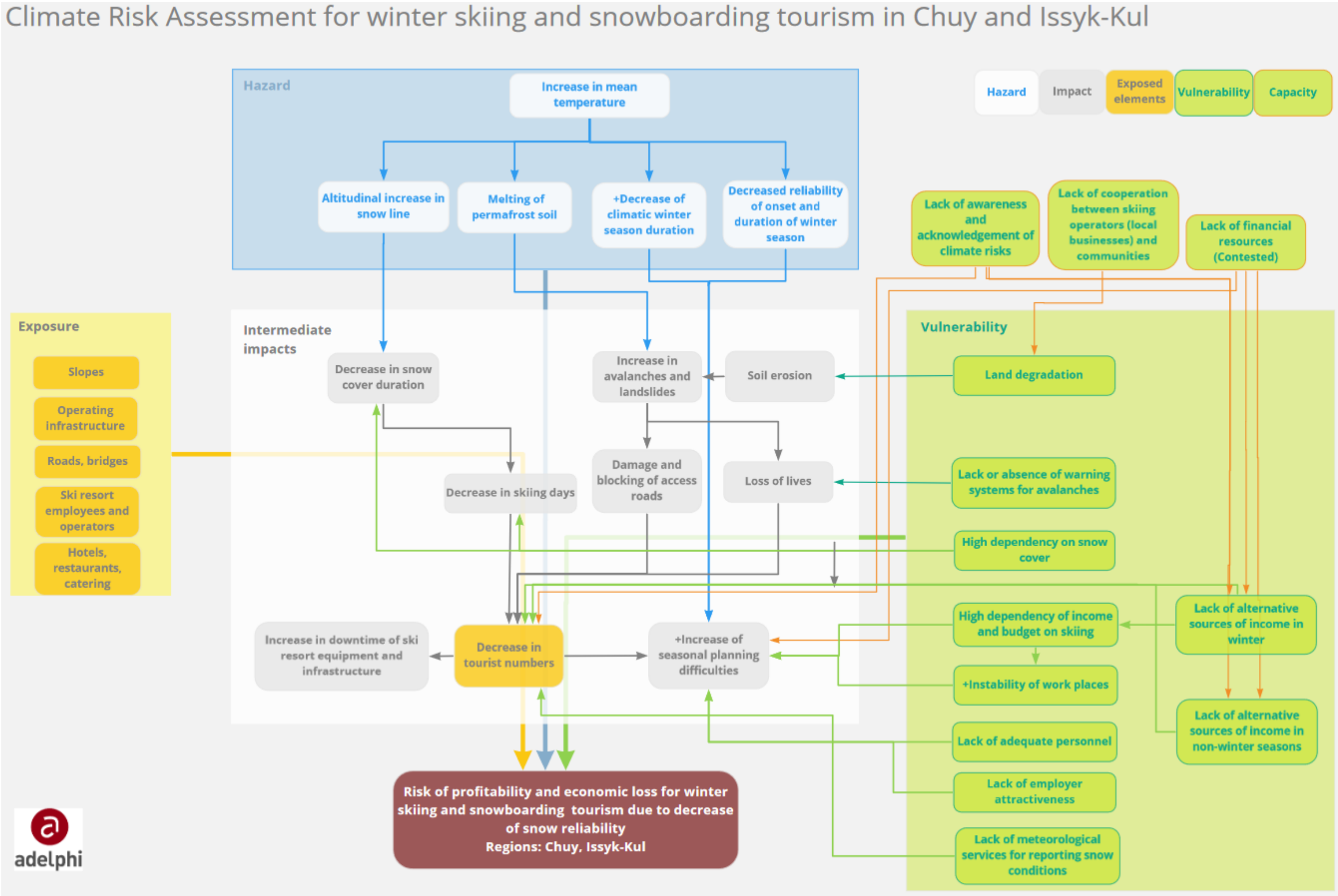

Fig. 4.2. *Climate impact chain for winter skiing and snowboarding tourism due to decrease of snow reliability in the regions of Chuy and Issyk-Kul. Impacts (in the big white box) result from the interaction of hazards (blue box), exposure (yellow box) and vulnerability (green box) and lead to a risk of profitability and economic loss due to decrease of snow reliability.*

Human and environmental factors - Vulnerabilities

The societal and ecosystemic vulnerabilities which influence how the impacts translate into risk are shown in the green box in Figure 4.2. This section elaborates on two examples of how vulnerabilities influence the overall risk of profitability and economic losses through climate hazards.

The first example focuses on how vulnerabilities influence **the decrease in the number of tourists**: The decrease is primarily influenced by the lack of alternative sources of income from tourists. On the one hand, there is a lack of **alternative sources of income from tourism in winter** apart from skiing and snowboarding. Therefore, there are no alternatives to avoid a decrease in the number of tourists if the snow cover duration decreases. On the other hand, there is a lack of **alternative sources of income from tourism in non-winter seasons**, i.e. when conditions are infeasible for skiing. In summary, there is a current lack of alternatives for income from tourism apart from skiing. The lack of alternatives is in part caused by a **lack of financial resources**. However, the lack is also explained by a **lack of awareness and acknowledgement of climate risks**.

Second, we discuss an example for how societal and ecosystemic factors have direct influence on another key impact - the **increase in seasonal planning difficulties**. On the one hand, a lack of **alternative sources of income from tourism in winter** apart from skiing leads to a **high dependency of income on skiing** and snowboarding. This contributes to the **instability of work places**. Both of these instabilities lead to **seasonal planning difficulties**. On the other hand, a **lack of employer attractiveness** and **lack of adequate personnel** increase seasonal planning difficulties for ski resort operators.

Exposed elements of the winter tourism sector - Exposure

A number of people, economic assets, facilities, ecosystems, and environmental functions in skiing tourism settings can be adversely affected by the climate hazards:

- **Slopes**
- **Operating infrastructure**, including ski lifts and ski runs
- transport and access infrastructure such as **access roads** and **bridges**
- Skiing facilities such as **hotels, restaurants, and catering.**
- Finally, **ski resort employees and operators** are exposed, as their income or, in the worst case, their livelihood is based on specific climatic conditions.

4.3 Adaptation options[3]

Qualitatively, the current negative impacts of climate hazards are well understood. Now, the question is how to reduce or avoid these negative impacts. This chapter introduces conventional and EbA options that can reduce factors in the vulnerability and exposure components identified in the climate impact chain. Reducing these factors decreases the climatic impacts and the risk of profitability and economic loss in Chuy and Issyk-Kul.

Figure 4.3. shows nine adaptation options for the climate impact chain for winter skiing and snowboarding tourism in the area of focus. Each adaptation option is introduced below. The proposed adaptation options were derived through consultations with the tourism stakeholders, expert community and the review of literature and web platforms on EbA.

[3] Terminological Note: Although all adaptation options represent interventions, not all interventions represent adaptation options. The term intervention is used in the Green Economic Modeling process.

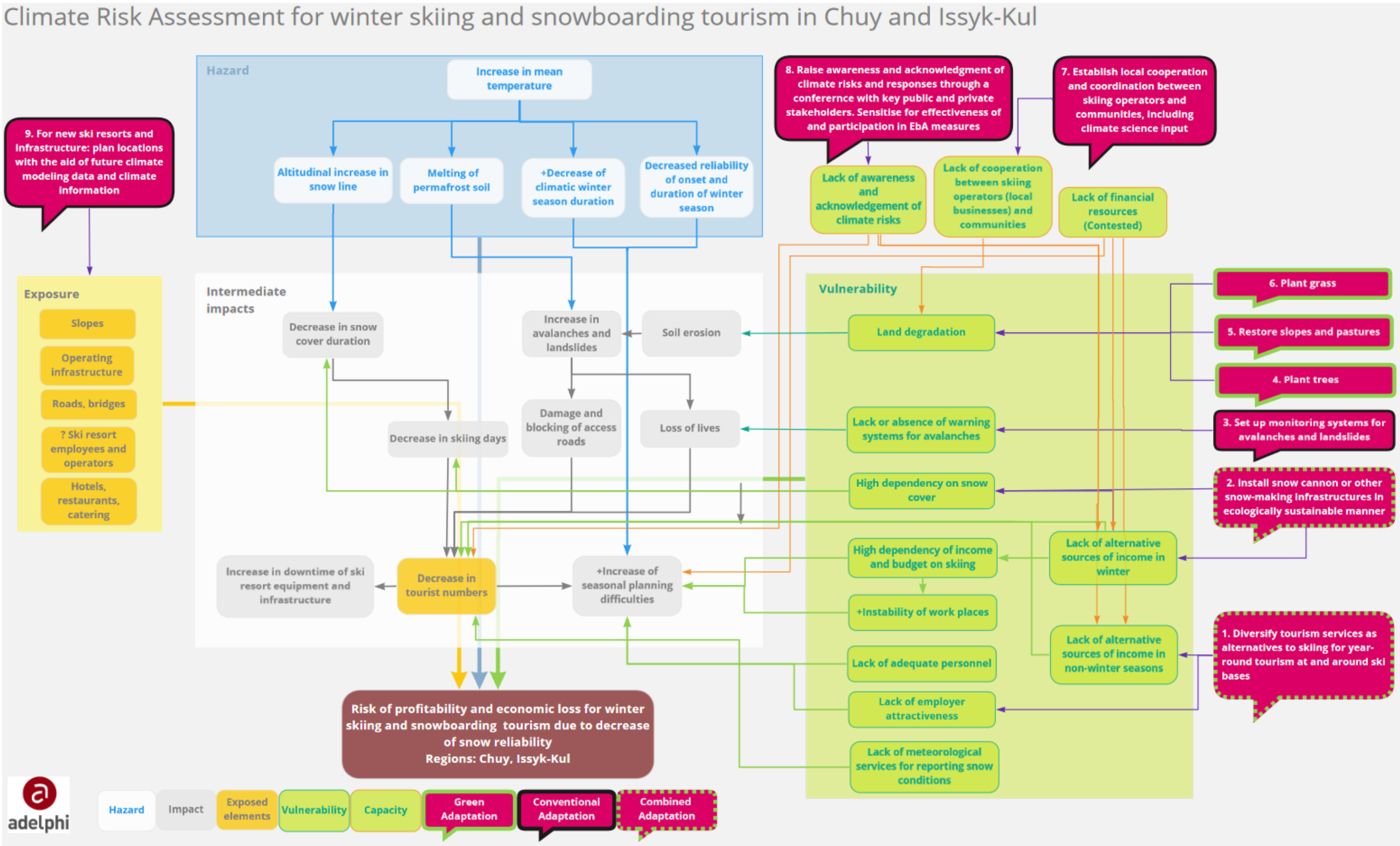

Fig. 4.3. *Adaptation options for the climate impact chain for winter skiing and snowboarding tourism due to decrease of snow reliability in the regions of Chuy and Issyk-Kul. Impacts result from the interaction of hazards, exposure and vulnerability and lead to a risk of profitability and economic loss due to decrease of snow reliability. Adaptation options (red) are differentiated between options that align with green (green frame), conventional (black frame) and combined (dotted green frame) adaptation approaches. Adaptation options 1-8 reduce vulnerabilities. Option 9 reduces the exposure. Different thickness of arrows has no meaning and only helps to differentiate the direction of crossing arrows.*

Adaptation measures that reduce sensitivity:

1. Diversify tourism services as alternatives to skiing for year-round tourism at and around ski bases

Background: The primary strategy to increase the current lack of alternatives for income from tourism is to introduce new tourism services and thereby diversify. The aim is to provide alternatives to skiing for year-round tourism at and around ski bases in order to **counteract two key impacts** in the climate impact chains: offsetting the **decrease in tourist numbers,** and **decreasing the season planning difficulties**.

Specific actions: A multitude of **alternative sources of income from tourism in non-winter seasons** exist. With the aim of diversifying income sources from tourism and reducing the dependency on snow cover, these alternative sources can be introduced by implementing the following measures:

1. Building yurt camps
2. Introducing mountain biking
3. Introducing horseback riding
4. Introducing agrotourism: Engaging the local community in provision of agricultural tourism products (cheese making, milking, cooking classes with local families etc.)
5. Creating an infrastructure for hiking and trekking
    a. Marking mountain trails
    b. Trekking, mountaineering
    c. Training ski instructors to work as mountain guides in summer.
6. Installing summer lifts

Alternative sources of income from tourism in winter seasons at or around ski bases require a clear strategy for managing a decrease of reliability and snow cover duration. (Theoretical alternatives such as snowshoeing and cross-country skiing are also dependent on (a decreasing) snow cover, and are unlikely to attract as many tourists per night and ski base as skiing or snowboarding).

Presenting alternatives to skiing as weather conditions become growingly unstable, has been one of the central reasons for the skiing region Alta Badia in the **Italian Dolomites** to develop a diversified offer of touristic activities in the winter months and year-round tourism. Many winter offerings still rely on a certain amount of snow, such as excursions with snowshoes, sledging or ice-skating. The number of activities proposed as alternatives is however considerable and includes an extended network of walking and hiking trails and tours, swimming pools and spas, indoor tennis, horse-back riding, museums and nature parks, or cooking courses.

A survey of **Swiss** cableway operators showed that most actors already plan for decreasing snow safety by investing in technical measures to increase artificial snowmaking (66%, Amt für Wirtschaft und Tourismus Graubünden, 2013). Operators also already work on diversifying their fields of action in numerous domains such as summer and winter hiking (63 and 62%), or by providing snowshoeing (51%), thematic hikes (46%), developing a more refined gastronomical offer (38%) or events (summer and winter: 29-37%), Mountain biking (36%) and other outdoor sports activities (33%).

The long-term strategy to diversify the economy, tourism offer and infrastructure in the mid-range mountains of the Vercors mid-high mountain range in **France** recognises the impacts of climate change and seeks to decrease their dependency on snow-related tourism (2007 – 2013). By rethinking the entire economic model on which the ski stations were built and completely restructuring their touristic offer, a wide range of activities could be developed, such as hikes, outdoor sport (i.e. mountain biking, climbing, crayoning, cave exploration…), cultural visits (i.e. historic memorials, monastery or restored castle) or activities having to do with regional foods (i.e. blue cheese, walnuts, ravioli). As early as in 2015, first positive results already clearly showed, with **nearly the same amount of booked overnight stays on days without snow compared to snow-days** and a growing attractiveness for conferences and festivals.

2. Install snow cannons or other snow-making infrastructures in an ecologically sustainable manner - these are only interim and "in-between" solutions.

3. Set up monitoring systems for avalanches and landslides

4. Plant trees (e.g. fast-growing poplars, if ecologically justified)

5. Restore slopes and pastures (collaboration between skiing operators and local communities). Restoration measures (i.e. **planting grass (6.)**, afforestation, restoring slopes and pastures) can help increase the attractiveness of the regions for non-winter recreational activities. At the same time, these measures can address local ecosystemic vulnerabilities (soil erosion and land degradation). These restoration measures may also create synergies (avoid avalanches) and trade offs (interference with ski routes) for winter season

Adaptation measures that increase (adaptation) capacity:

7. Establish local cooperation and coordination between skiing operators and communities, including climate science input.

8. Raise awareness and acknowledgment of climate risks and responses through a conference with key public and private stakeholders. Sensitise for effectiveness of and participation in EbA measures.

Adaptation measures that avoid exposure:

9. For new ski resorts and infrastructure: plan locations with the aid of future climate modeling data and climate information

Background: In planning new skiing resorts and subsequent infrastructure today, integrating climate modeling data on snow cover and reliability is becoming crucial for planning skiing activities in the future. They inform the decision of WHERE (NOT) to do what. For example, they inform where it is more feasible, and infeasible, to plan new skiing bases. Informing decisions with climate modeling data will help decrease risks for all parties involved and ensure longer-term positive economic impacts of investments. Well-planned projects now might result in comparative advantages, as numerous skiing resorts might become unprofitable over time.

Specific actions: Climate data can help identify areas where future snow safety will develop well (or less negatively), helping to compare advantages for future locations of ski resorts. This approach has already been used internationally.

Seasonal Holiday Climate Index (provided by the EU Copernicus Climate Change Service) data will be used in Ljubljana, **Slovenia**, in order to adjust their promotional and city marketing to optimise and manage tourism flows.

Visualisations based on natural snow projections show that turning towards the skiing industry in the most northern regions in **Sweden**, may represent a strong comparative advantage under climate change. Determining factors of their comparative advantage are their high latitudes and altitudes and subsequent high reliability of snow cover. This could make them "winners" of climate change, as other skiing stations become forced to close operations.

5. Summer tourism

5.1 Scope of assessment

Resulting from a survey of and consultations with stakeholders from the public, private and educational sectors, a decision was made to conduct the CRVA for Summer Adventure, Eco- and Community-Based Tourism in Kyrgyzstan. Its geographic scope covers the Southern Shore of Issyk Kul Lake, mountains around Karakol and mountains of Naryn Province (See map in Figure 5.1 below). These territories have been developing as destinations for natural attractions, outdoor activities (trekking, horseback riding), ethno-cultural, nomadic and agro tourism. Selection of this geographic area was also strongly recommended by A. Jamankulov, the Minister of Culture, Information and Tourism of the Kyrgyz Republic.

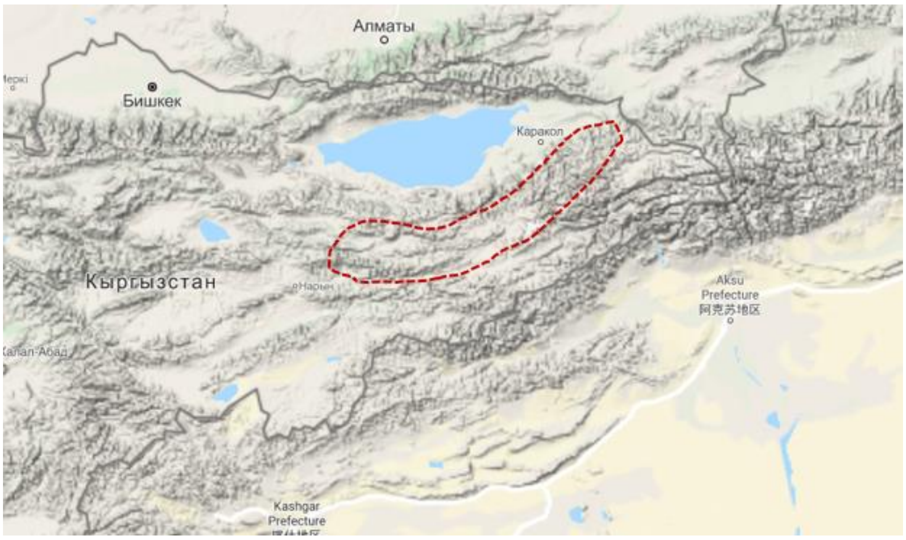

Fig. 5.1. *Geographic scope of CRVA for the summer adventure, eco- and community-based tourism (South Shore of Issyk Kul, mountains around Karakol and Naryn) (Source: Google Maps).*

5.2 The climate impact chain

The primary result of the summer tourism assessment is the climate impact chain displayed in Figure 5.2. The version of the climate impact chain with adaptation options included can be found in Section 5.3. (Fig. 5.4.). Proposed indicators for selected factors that contribute to climate impact and risks are shown in the Annex. These proposed indicators can be used as templates for the quantitative part of the green economy modelling process in Kyrgyzstan. Nevertheless, it will be necessary to adapt the indicators to the specific equations of the green economy model.

The indicators listed in the Annex are some of the key proposed indicators for factors of the summer adventure, eco- and community-based tourism impact chain.

Climate hazards

Increase in the mean temperature an**d increasing precipitation** were identified as the key hazards for summer adventure, eco- and community-based tourism.

The climatic hazard **of an increase in the mean temperature** leads to sub-hazards of **glacial melting** and **raising heat waves. Increase in precipitatio**n leads to **landslides and floods,** as well as **pasture degradation.**

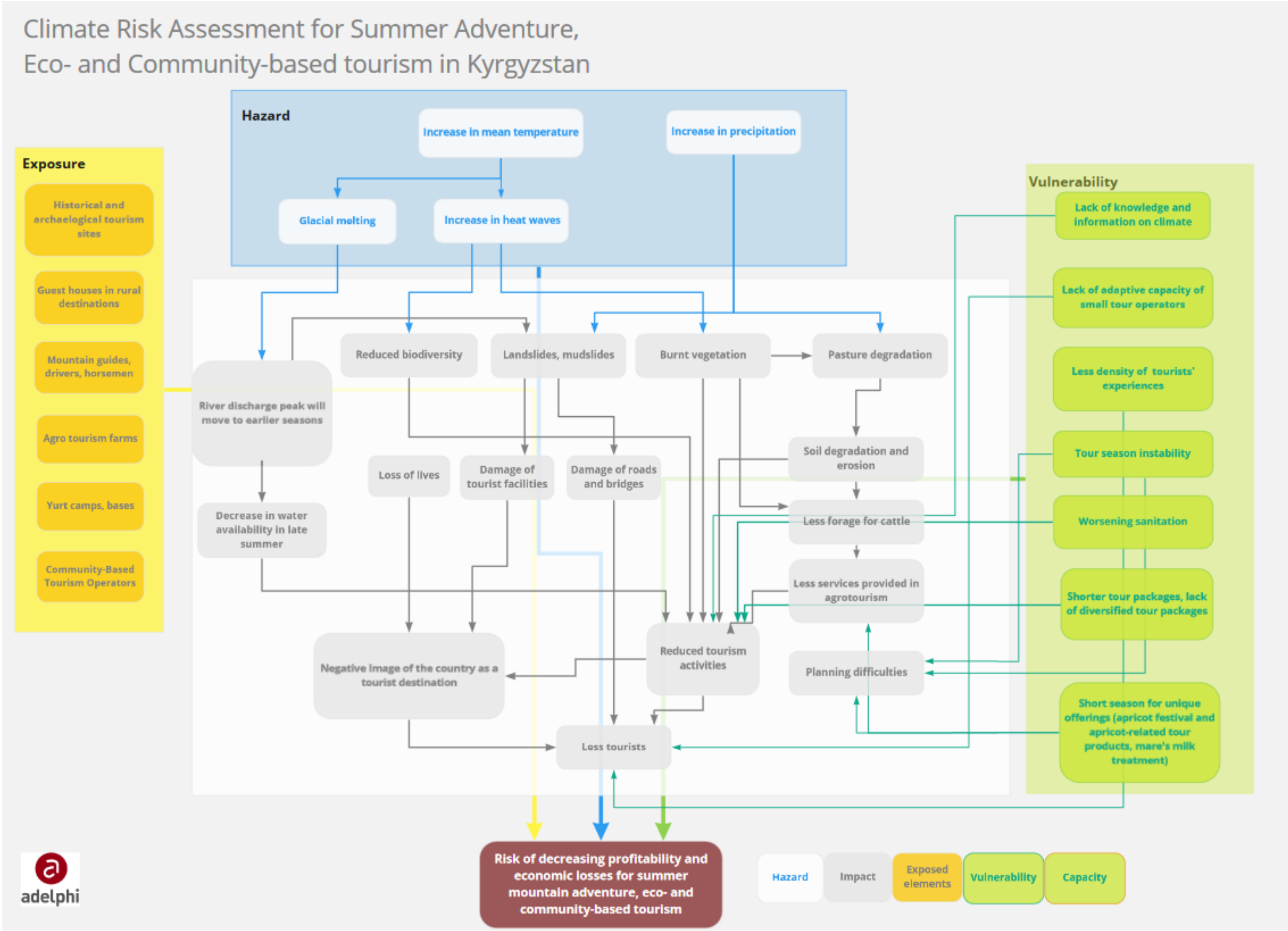

Fig. 5.2. *Summer tourism impact chain*

Impacts and risk

Glacial melting leads to river discharge peak moving to earlier seasons and consequently a decrease in water availability in late summer. Increasing heat waves lead to reducing biodiversity and burnt vegetation. Reduced biodiversity leads to reduced tourism activities, which negatively impacts the image of the country as a tourist destination. Another key driver of impact is the burnt vegetation which leads to shorter tour packages, less services in agrotourism and less density in tourists' experiences.

Combination of the above key impacts and the other impacts reflected on Figure 5.2 above leads to a **reduction in the tourist flow** resulting in **less revenues from tourists** and the **risk of decreasing profitability and economic losses for summer adventure, eco- and community-based tourism**.

Figure 5.3 below shows an example of the intermediate impact of abnormally hot summer days resulting from the **rising heat waves.** The season for using mountain trails in Naryn as part of the tour packages was shorter in 2019 resulting in a **decreasing density of tourists' experiences** and **decreasing revenues** of tour operators.

Fig. 5.3. *Example of an intermediate impact of the abnormally hot days in summer resulting from the rising heat waves. The season for using mountain trails in Naryn as part of the tour packages was shorter in 2019 resulting in a decreasing density of tourists' experiences and decreasing revenues of tour operators (Source: Jumgal Destination tour operator).*

Human and environmental factors - Vulnerabilities

The societal and ecosystemic vulnerabilities which influence how the impacts translate into risk are shown in the green box in Figure 5.2. This section gives examples of how vulnerabilities influence the overall risk of profitability and economic losses through climate hazards.

What are the societal and ecosystemic factors which have a direct influence on one of the key impacts - **the decrease in the number of tourists**? One of them is the **instability of the tourism** season coupled with **shorter tourism packages. Lack of diversified tourism offerings** is the root cause for **a** decrease in the number of tourists if there is a lack of **alternative sources of income from tourism in summer** apart from natural and outdoor activities. A decrease in the number of days when trekking, mountaineering and other outdoor activities can be offered leads to the risks of economic losses for the tourism sector. Furthermore, vulnerabilities exist in the **provision of unique offerings**, like the apricot blossom season, apricot festival, apricot-related master classes on the South Shore or the season for mare milk treatment in Naryn. A decrease in duration of the season suitable to provide these tour products results in the **less dense tourists' experience, less revenues and the negative**

image of the country as a tourist destination in the worst cases. **Worsening sanitation** can additionally impede or possibly reduce tourism activity.

On the other hand, there is a lack of **alternative sources of income from tourism in non-summer seasons**. This is particularly relevant for the areas where ski tourism is not developed or operates at low altitudes. In summary, there is a lack of alternatives for income from tourism, i.e. a lack of diversity. The lack of alternatives is caused by a lack of product development/marketing/promotion capacity and financial resources of the community-based tourism operators.

Exposed elements of the summer tourism sector - Exposure

Various ecosystems, societal groups and infrastructure assets used for providing mountain adventure, eco- and community-based tourism offerings are exposed to climate-induced impacts.

These include:

- **community-based tourism operators;**
- **guest houses in rural destinations;**
- **yurt camps;**
- **tourism bases in mountainous zones;**
- **mountain guides, horsemen, drivers;**
- **historical and archaeological tourism sites;**
- **agritourism farms.**

5.3 Adaptation options

Figure 5.4. shows adaptation options for the climate impact chain for summer adventure, eco-and community-based tourism in the area of focus. Each adaptation option is introduced below. The proposed adaptation options were derived through consultations with the tourism stakeholders, expert community and the review of literature and web platforms on EbA.

The adaptation options proposed in this section were developed through consultations with the tourism stakeholders, expert community and review of the online and offline sources on EbA.

These adaptation options will help reduce the risk of decreasing profitability and economic losses for summer mountain adventure, eco- and community-based tourism.

Considering the fragility of ecosystems used for tourism operations in the Kyrgyz Republic and the climatic hazards discussed in the sections above, the primary adaptation option is to ensure the **sustainable use of national resources through:**

- **integrating EbA approach in tourism development planning (an example given below),**
- **implementing pasture protection measures,**
- **implementing protection from soil erosion measures,**
- **planting fast-growing trees** (e.g. poplars, if ecologically justified).

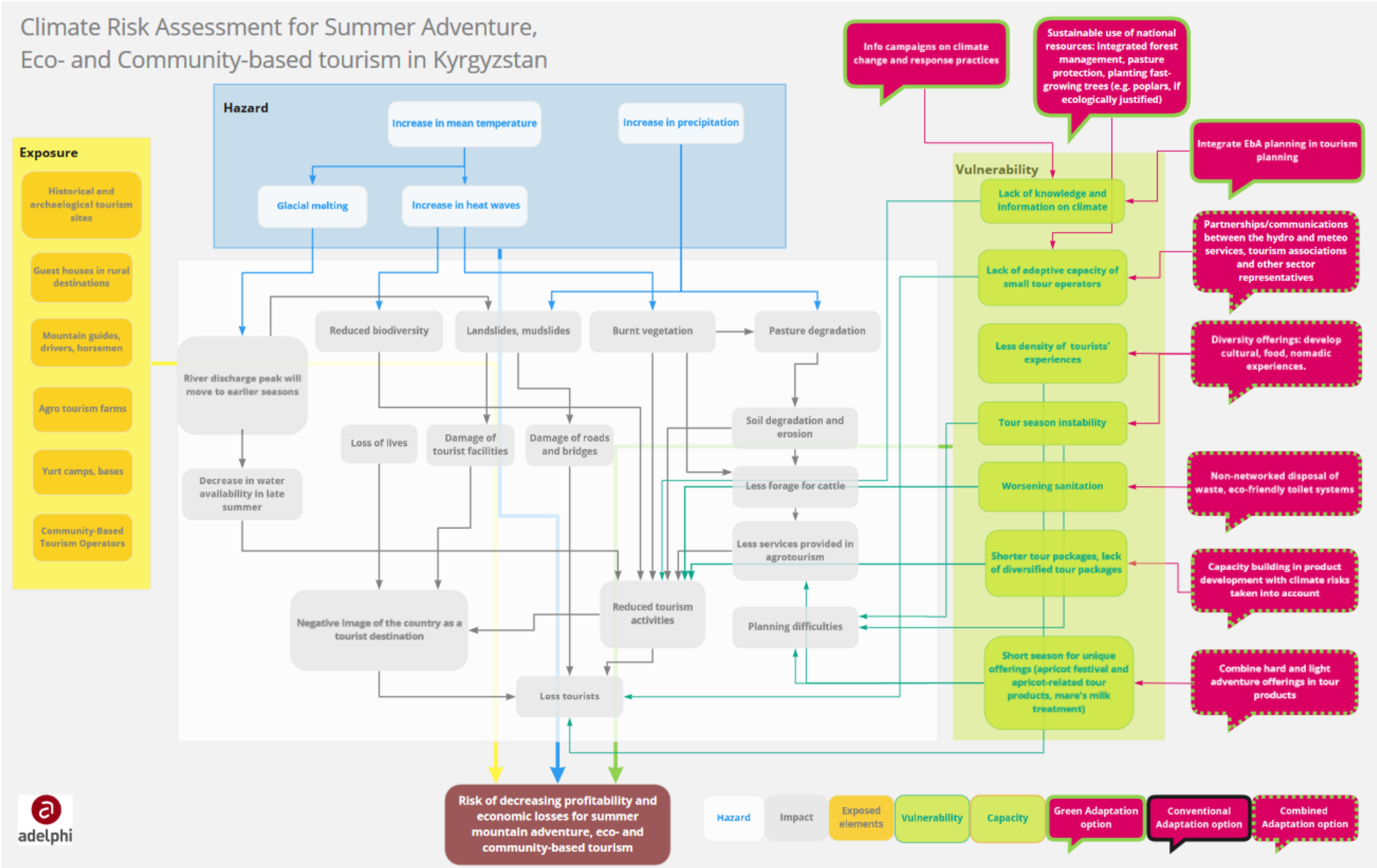

Fig. 5.4. *Impacts result from the interaction of hazards, exposure and vulnerability and lead to a risk of profitability and economic loss due to decrease of snow reliability. Adaptation options (red) are differentiated between options that align with green (green frame), conventional (black frame) and combined (dotted green frame) adaptation approaches. In this call, each proposed adaptation option reduces vulnerabilities. Different thickness of arrows has no meaning and only helps to differentiate the direction of crossing arrows.*

Capacity-building related adaptation measures to address the vulnerability factors of a **lack of diversified tourism offerings, shorter tour packages, less density of tourists' experiences and decreasing season for unique offerings** (e.g. apricot-related tour products on the South Shore of Issyk Kul and/or mare's milk treatment in Naryn mountains) include:

- Conduct information campaigns on climate change and response practices
- Build partnerships/communications between the hydro and meteo services, tourism associations and other sector representatives
- Train tourism service providers in product development with climate risks taken into account
- Diversify offerings through development of cultural, food, and nomadic experiences
- Combine hard and light adventure offerings in tour products

Adaptation measures to address the **vulnerabilities of worsening sanitation** are:

- Introduce non-networked solutions for disposal of sewage
- Innovative solutions for human waste treatment/disposal
- Build eco-friendly toilet systems (an example given below)
- Create nature-friendly pavement along mountain lakes/Limit vehicle passage around the mountain lakes

Described below are examples of the EbA options that were implemented in other countries and helped reduce the impacts of factors considered by this CRVA.

Integrate EbA approach in land use and tourism development planning

Given that the National Development Strategy of the Kyrgyz Republic by 2040 prioritizes regional development, and considering the regional importance of tourism development, it is recommended to include EbA measures in drafting regional development plans and strategies. Since EbA is a relatively new concept in Kyrgyzstan, and in the regions in particular, the proposed example from Vietnam can be useful in the Kyrgyz Republic through the experience of involving local governments and communities in land use planning and regional development with EbA taken into consideration.

"*Strategic mainstreaming of Ecosystem-based Adaptation (EbA) into planning frameworks in Ha Tinh and Quang Binh Province."*

"The solution supports Vietnamese government's efforts to anchor EbA solutions systemically into land use planning law as well as mainstreaming into climate change regional action plans at provincial level in Ha Tinh and Quang Binh. This helps raise awareness on EbA approaches. Many project partners have shown interest and commitments in integrating EbA solutions into current policy elaborating processes and daily works based on vulnerability assessments and capacity development measures" (Nguyen Thi 2016).

Furthermore, as was discussed above, it is recommended to the public and private stakeholders working in tourism to integrate the climate information in tourism development planning.

The example of the **"***Conservation Standards-based method for planning and implementing Ecosystem-based Adaptation projects"* by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, can be useful in integrating risk-based adaptation measures in local development plans.

"A systematic EbA planning method has been developed and applied based on the Open Standards for the Practice of Conservation. Within this method, identified dependencies and vulnerabilities, climate change information, and planning as well as monitoring of measures build on each other in a logical

way. EbA measures have been applied in Central Asia before, but without systematic identification, often neglecting relevant climate information, which could even lead to maladaptation." (Schumacher 2017).

Implement pasture protection measures and measures to protect soils from erosion

To rehabilitate the eroded lands and avoid further land degradation locally applicable erosion control measures can be introduced to the Kyrgyz land users, yurt camps and guest houses. Measures include 'grey' measures (terraces, fences) as well as 'green' measures (afforestation, orchard management) and can be combined with alternative income generating practices.

Socio-economic and ecological benefits of better land management and erosion control measures should be monitored, documented and demonstrated to surrounding communities. The example of ecosystem-based erosion control in Azerbaijan (below) can be useful in replicating the ecosystem-based approaches to erosion control and protection of lands used for tourism.

"Ecosystem-based erosion control in Azerbaijan"

"Pastures in the South Caucasus region are under pressure through unsustainable use and climate change processes. The GIZ Programme "Integrated Biodiversity Management, South Caucasus" inter alia implements and tests affordable solutions together with local communities, preventing erosion and managing the mountainous ecosystems in a sustainable way. Piloted measures include: stabilization of slopes and river beds, setup of hay-meadows, afforestation, orchard management and construction of a tree nursery." (Koeppler 2017).

Introduce non-networked sanitation and eco-friendly toilet systems

Given that the mountainous areas covered by this CRVA lack centralized sewage collection and disposal systems, it is proposed to address the vulnerability factor of worsening sanitation with an adaptation option of introducing non-networked sanitation (human waste disposal) systems and eco-friendly toilet systems. Below given is an example of such a sanitation system (Fig. 5.5.).

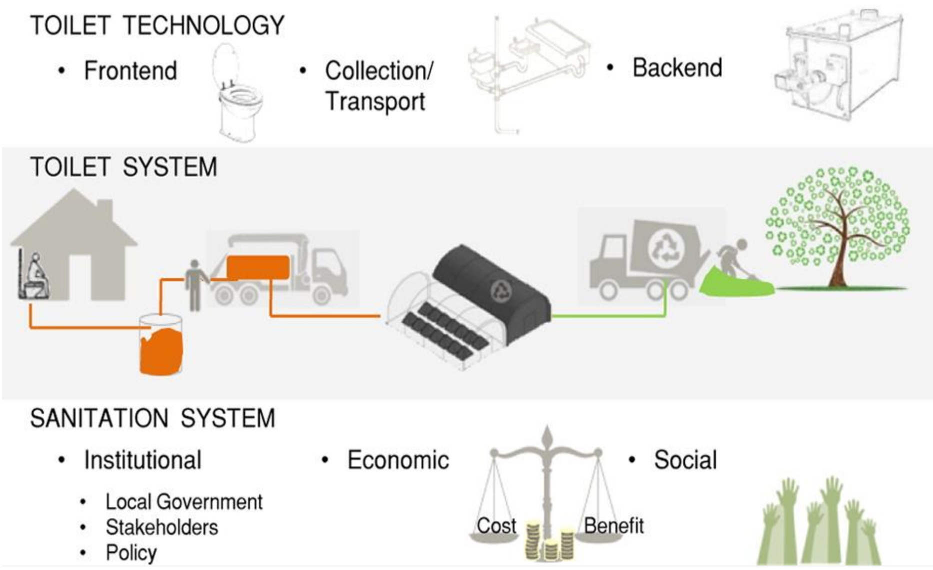

Fig. 5.5. *An example of a non-networked sanitation solution (Sources: Allen et al. [2017] and Stark et al. [2015])*

6. Recommendations

Climate change is not only a fundamental environmental problem. It is a developmental, social, and economic problem that threatens the economic development of Kyrgyzstan. In order to protect economic growth, climate risks need to be considered at all levels and in all sectors. This piloting CRVA concludes that today's climate impacts also challenge the transport and tourism sectors. Their effects are expected to increase over the decades to come in this century.

- Within the **transport sector** the risk of road damage and higher maintenance cost is expected to increase.
- Within the **tourism sector**, climate impacts put tourist activity under pressure. Future growth in this sector depends highly on the ecological integrity of Kyrgyzstan, and the sustainable development of the tourism sector.
- In addition, snow-reliant **winter tourism** will be increasingly at risk as winter seasons shorten and the number of skiing days decreases.

The well-being of ecosystems ensures the attractiveness of a Kyrgyz tourism sector with high growth potential. This is particularly evident for summer tourism. In addition, vegetation plays a crucial role in reducing the climate impact on mountainous roads and consequently balances road maintenance costs.

6.1 International climate finance

The bottleneck for climate resilient planning is the financing. The best action plan is a toothless tiger, if no financial resources are available for its implementation. That is why National Adaptation Planning (NAP) is a process with many aspects, including financing. Kyrgyzstan is impacted by climate change above the international average and is highly eligible for international climate finance funds as the GCF.

- **Identify a promising general adaptation topic of your interest:** Use insight on bioengineering for the infrastructure protection from this study and others, as well as your expert institutions to identify potential topics that show a paradigm shift to green approaches. Discuss potential topics with international accredited entities, which can be project partners. Do not surrender initiative to international organisations that are not as intimately familiar with the local context and so may propose ideas that do not fit your overall strategy.
- **Propose a Concept note to GCF:** Provide basic information about a project or programme in the template provided by the GCF, to seek feedback from the Secretariat on whether the concept is broadly aligned with the objectives and policies of the fund.
- **Use your institutionalised CRVA and economic evaluation** for the GCF concept to be clear about the cost and benefits of adaptation options and benefits in the form of mitigated impact.
- **Involve non-governmental institutions:** Existing institutions, for example, the TIAN SHAN Policy Center of the American University of Central Asia, Regional Mountain Centre of the Kyrgyz Republic and Camp Alatoo already have capacities and experience on climate risk assessments. Lack of available funding from the national budget might be a barrier for their involvement. However, the government can potentially apply for international funding jointly with these organizations.

6.2 National climate finance

Although it is challenging for Kyrgyzstan to mobilize finances for climate adaptation options, a variety of mechanisms exist to ensure climate resilient development. Economic growth is a key goal of development programs, which are under the responsibility of the Ministry of Economy in close collaboration with the Ministry of Finance. Continuing investments into infrastructure increases the assets that are exposed to climate hazards. Furthermore, these infrastructure investments have a lifetime of several decades. Hence, investments need to be chosen well. If investment planning is done in a climate resilient way, climate adaptation is achieved.

- **Make climate risk consideration as threats in SWOT analysis mandatory:** Action plans for development programs need to justify their investments. A SWOT or similar tool is used for this. The consideration of climate risk within the threat section of a SWOT can be easily made mandatory. However, people elaborating action lists need to have access to information regarding climate impact and risks in their sector and region. The Ministry of Economy is a key actor for making climate risk assessments mandatory in the SWOT for action planning.
- **Adjust indicators for economic development programs:** We recommend adjusting the indicators for each sectoral economic development program so that investment decisions are made with a view to climate resilience. This can be done by defining what proportion of investments need to have an adaptation effect. Here as well, the access to sectoral and regional climate impacts and risks is necessary. The Ministry of Economy is a key actor for changing indicators for development planning.
- **Central coordination of achieving prerequisites:** The proposed adjustments for development plans require prerequisites: 1. available sectoral and regional CRVA results, including adaptation options, 2. economic evaluation of adaptation options 3. Trained capacities for 1) and 2) and 4. future climate information. The provision of all these prerequisites needs a central coordinator that orchestrates the support of all international organizations. Without coordination, the very beneficial resources of international organizations cannot be utilized to their full potential.
- **Support of climate information providers:** Increased generation and use of climate services is also one criteria for GCF funding. More information on this can be found in **section 6.4.**
- **Vertical integration of CRVAs into the subnational level:** Climate adaptation mostly happens at the local level. The role of policy implementation on the national level is to facilitate climate action implementation at the local level. Therefore, CRVA's should be integrated into sub-national development planning.

6.3 Awareness raising

Raising awareness about climate change impacts makes them more visible in the political agenda. The insight that climate adaptation protects development has not reached all levels and sectors. Raising awareness targets high-level governmental representatives to induce decisions on priority sectors, institutional arrangements, selected methodologies for CRVA and green adaptation techniques.

- **Framing climate change as an economic issue:** Awareness raising for the economic benefit of climate change adaptation is a key entry point. However, climate risks need to be framed preliminary as costs and adaptation options as benefits to stakeholders of economic development planning.

- **High level strategies:** If climate change adaptation is part of high level strategy, the integration of climate risks into development programs is easier.
- **Advocate green solutions:** Raise awareness within all line ministries on green approaches that benefit from and protect the economic value of ecosystem services.
- **Promotion of sustainable tourism, including ecotourism:** Visibly and credibly guide a diversification strategy for winter and summer tourism with an eco-tourism paradigm.
- **Initiate awareness and educational campaigns on climate risks** in tourism for businesses, institutions, and other stakeholders affected.

6.4 Institutionalizing CRVA

A CRVA connects available climate change scenarios with information on socio-economic systems. This is crucial for effective economic evaluation of adaptation options.

- **Decide on priority sectors for CRVA:** Select climate sensitive sectors that need to be addressed. Agriculture, forestry, water, energy, disaster risk reduction and health are perceived as the most climate sensitive sectors. However, we have seen that the sectoral growth of transport and tourism is also under pressure of climate change.
- **Adjust environmental law:** Define roles and responsibilities on the provision of sectoral CRVAs to inform the Ministry of Economy for economic evaluation by amendments to the environmental law. Sectoral CRVAs can be conducted by line ministries or their subordinated scientific bodies. In addition to defining the role for economic evaluation, also define responsibility for climate information provision. The latter can potentially be covered by Kyrgyz Hydromet.
- **Ensure cross-sectoral information exchange between sectoral CRVAs (expert workshops):** In practice it is very difficult to delineate sectoral impact. The climate impact chain of this CRVA shows that climate impacts flow along complex impact channels. Water sector is intertwined with the agriculture sector and the disaster risk sector with the transport sector. Unfortunately, sectoral expertise is divided into silos without mutual exchange. A successful CRVA needs to connect information on climate change, sectoral and environmental vulnerabilities and geographic exposure. For instance, the transport sector relies on information from the disaster risk reduction sector. This piloting CRVA has conducted expert workshops to bring together expert knowledge from different areas.
- **Ensure communication process between CRVAs of line Ministries and economic evaluation:** The working group on economic evaluation (MoE) relies on results of sectoral CRVAs to compute cost and benefits by using cross-sectoral economic models. This requires a communication framework. Economic evaluation can also be regarded as a service for line ministries to evaluate potential policy instruments.
- **Ensure inclusion of local stakeholders groups at the earliest possible stage**: Climate adaptation is happening mostly on the local level. The role of policy implementation on the national level is to facilitate the climate action implementation at the local level. Therefore, a CRVA needs to be informed by impacts on needs of, and the expertise of local stakeholders

from the beginning. Adaptation options are linked to very specific context conditions and are not effective without integration of affected groups and communities. The inclusion of stakeholder groups applies for assessing adaptation needs, as well as identifying, appraising, planning and implementing adaptation options.

- **Support of climate information providers:** CRVAs rely on the provision of climate information in the form of climate change scenarios. Most often climate information is only given for temperature and precipitation changes. However, sectorial CRVA demand for more specific climate parameters. For instance, ski resorts need average altitude increase of the snow reliability over several decades for investment decisions. This requires analytical skills to tailor such specific climate information. Unlike its Kazakh counterpart, the Hydrometeorological Agency under the MES of the Kyrgyz Republic lacks a research center. Increased generation and use of climate services is also a criterion for GCF funding.

6.5 Institutionalizing economic evaluation of adaptation options

An economic evaluation, as it is done now within the green economy modelling process, provides information on costs and benefits of different adaptation options. This economic modelling is cross-sectoral and includes a variety of non-climate risks and impacts. The results allow decision makers to prioritize, appraise and implement adaptation options.

- **Provide economic evaluation as an operational service:** Adaptation options should be identified, and their economic impact evaluated on a continuous basis to support decision-making. Demands for evaluation can come from line ministries that have selected adaptation options as policy instruments. The Ministry of Economy is a key player for this activity and the current green economy modelling process provides the foundation. However, every new adaptation option or assessed causality demands an update of the damage functions. Therefore, current sectoral green economy models need technical adjustment for each new input from a CRVA. This requires in-depth modelling capacities.
- **Ensure communication of results to inform political decision-making processes:** How can the forecast of the outcome of interventions reach all relevant sectoral and regional decision makers? One option is to set up a legislatory communication framework that enables sectoral (line ministries) and regional (provincial governments) decision makers to request the economic forecast of interventions on an operational basis. The requesting body will receive a report on possible scenarios after the environmental assessment. It needs to be noted that the systemic economic forecast in the current GE framework is intersectoral to a large extent. In other words, the forecasted outcome of one intervention is available for more than one sector. Hence, it is possible that results have a high value for more stakeholders than just the requesting body. An additional option for communication could be a coordinating body or a platform, which could disseminate this knowledge to other sectoral and regional stakeholders. The economic evaluation service should also be flexible enough to meet demands from governmental initiatives.

6.6 Technical capacity building

Raising awareness regarding the need to institutionalize CRVAs targets high-level governmental representatives, who are in the position to propose or implement institutional changes. However, the implementation of CRVAs and economic modelling relies on technical capacities. Therefore, high-level governmental representatives need the confidence that a) tested methodologies exist and b) technical experts are capable of applying the methods.

- **Capacity development for the methodology of CRVA:** A CRVA relies on context-specific expert knowledge of socio-economic as well as environmental and climatic aspects for the system under assessment (e.g. mountainous roads or summer tourism). Such context-specific expert knowledge is largely already available in Kyrgyzstan. For instance, the Ministry of Emergency Situations has very good insight into landslide risk along many road segments. It can also be assumed that extensive expertise about ecosystems exists among different state bodies. However, this knowledge has not been connected to design solutions. The added value of a CRVA is that it integrates knowledge from different fields. Therefore, capacity building does not need to focus on expert knowledge, but on establishing a methodology to integrate information on climate, exposure, vulnerabilities and their interaction. The results of this pilot CRVA are illustrated in the climate impact chains diagrams.
- **Capacity development for Trainers of CRVA methodology:** As shown above, methodological knowledge is distinct from expert knowledge. The CRVA relies on experts that conduct it, but the methodology itself can be disseminated by an institution specialized in education. For instance, a public academy that conducts trainings for Civil servants can provide CRVA trainers. International organisations can also be recruited to support the necessary training of trainers.
- **Capacity development for economic evaluation:** Capacity development is ongoing within the framework of the green economy modelling process. Local expertise must be developed to allow ongoing adjustments to the model, including the component quantification mechanisms and equations (for instance damage functions), as future data becomes available. Therefore, local experts need to be trained in all technical work. A quantified model is highly tailored to the Kyrgyz context and its political demands. It can be seen as a machine that needs constant maintenance and bug-fixes. A connection between the quantitative model and technical modelers is crucial for long-term application.
- **Capacity development for accessing and processing climate data in NetCDF format:** It needs to be stated that to our best knowledge, climate change scenarios in Kyrgyzstan have only been analyzed by international experts. It is obvious that data on future climate parameters cannot be collected by measurement but needs to be computed. This computation is done by a global climate modelling initiative (including China and Russia) coordinated by the Intergovernmental Panel on Climate Change (IPCC). This data is open and available, even downscaled (with higher resolution) and is freely available from the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) and the Coordinated Regional Climate Downscaling Experiment (CORDEX). All climate change scenarios from international experts are based on data that originates from the same open and free data. Why are climate change scenarios not generated in Kyrgyzstan, if the information is in open access? The data is in NetCDF (Network Common Data Format) format and requires capacities in script programming languages to access the data and to process further. Many other high-resolution data from international databases, e.g. crop-modelling results, are in NetCDF format as well. Hence,

technical capacity building on how to access and process NetCDF data would address a capacity bottleneck.

- **Capacity development for process-based computer models for slope instabilities:** Such models are used in Switzerland and can simulate the dynamic process of moving snow, earth and debris at specific sites. This allows the assessment of potential damages to existing assets and define zones and guidelines for land use management.

6.7 Next steps on CRVA in Kyrgyzstan

The knowledge on impact factors and channels, as well as adaptation options can be increased in some sectors.

- **Involve non-governmental institutions:** Share the insights of this piloting CRVA with existing institutions, for example, the Policy Center of the American University of Central Asia, Regional Mountain Centre of the Kyrgyz Republic and Camp Alatoo. These institutions already have extensive capacities on CRVAs and can support the adjustment of proposed measures (e.g. bioengineering) for the local context.
- **National Health sector:** The green economy modelling has not addressed the health sector. However, heat waves will increase and with it the critical issues of heat stress related morbidity and deaths. Vector-borne diseases may increase as well. A CRVA would clarify possible impact channels on public health and on the economy.
- **National Energy sector:** The CLD of the GE modelling process indicates drought, glacier melt, floods and landslides. However, adaptation options are not shown and the causal impact of changing water regimes on hydropower plants is not clear. Results of this CRVA on landslide mitigation can be applied for the energy sector as well.
- **Green industry:** The CLD of the GE modelling process acknowledges climate impacts on production sites without indicating options to mitigate these impacts. The degradation of resources within the agriculture sector potentially impacts the food production chain. A CRVA can clarify impact channels and response options.

6.8 Piloting bioengineering measures for road protection

A CRVA identifies adaptation options. The economic evaluations assesses the costs and benefits of these adaptation options. In other words, it forecasts the outcome of implemented measures. However, the proposed bio-engineering options need to be tested and adapted to the Kyrgyz context prior to their implementation. The feasibility of vegetation types needs to be determined with pilot projects. A pilot project that investigates the potential of bioengineering has following aspects:

- **Testing bioengineering techniques in local contexts:** The feasibility of concrete measures can be investigated further by an interdisciplinary team of local experts who know site-specific risks and conditions. The effect of different techniques and plants needs to be compared. Successful implementation of green engineering requires complete site investigations and knowledge of local hydrological, geographical, and topographical conditions. All implemented bioengineering measures as well as EbA “need to be part of an overall adaptation strategy” (GIZ EbA guidebook, 2018).

- **Assess potential of upscaling for bioengineering measures in all of Kyrgyzstan:** How many kilometers of critical roads are suitable for which bioengineering technique and vegetation type? Here the State Agency for Environmental Protection and Forestry (SAEPF) can be a key actor in coordinating the upscaling assessment in cooperation with the Department on Vegetation of the Ministry of Agriculture. An upscaling assessment can be scientifically supported by institutes of the National Academy of Science. Flora monitoring is already done by the Institute of Biology (National Academy of Science of the Kyrgyz Republic, 2019)). Additionally, it is engaged in the protection and rational use of economically significant species and ecosystems. The Scientific and Production Center for Forest Research named after P.A. Gan can play a key role in assessing the potential of protection forests exemplified by Switzerland and Japan.
- **Assess the damage potential of infrastructure and buildings:** In cooperation with the MES, process-based computer models identify hazard zones. To fully acknowledge the protective potential of vegetation, the value of all assets within hazard zones should be estimated. This methodology can be mainstreamed nationally at a later stage.

6.9 Tourism sector: some *additional* recommendations

In *addition* to the wealth of above recommendations, the following recommendations can support sustainable tourism development even *further*.

- **Integrate EbA measures into an overall adaptation strategy**. EbA measures always need to be part of an overall adaptation strategy. Link with national planning, e.g. with the NDC and with the National Biodiversity Strategy and Action Plan (NBSAP). Initiate EbA projects for implementation with the development partners.
- **Inform all climate-sensitive decisions with climate model data analysis:** For example, it should become mandatory to plan locations of skiing infrastructure with the aid of climate modeling data and climate information. Integrating climate modeling data on projected future snow cover and reliability in the upcoming decades is now crucial for more informed planning of skiing infrastructure in the future. They allow for more informed decisions on where and where not to plan new skiing bases. To this end, strengthen communication and collaboration with Kyrgyz Hydromet on using climatic data in tourism sector development plans, i.e. planning the location of ski bases, resorts, mountain trails and other tourism entities.
- **Diversify winter tourism offering in a sustainable way.** Learn from countries (e.g. see Section 4.3.) which have started to manage a decrease in snow cover and reliability for winter tourism. Diversification strategy can be guided by an eco-tourism paradigm.
- **Promotion of sustainable tourism, including ecotourism:** Visibly and credibly guide a diversification strategy for winter and summer tourism with an eco-tourism paradigm. Support the private sector in green tourism product development and placement.

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7. Annex

7.1. Full CRVA methodology with non-economically quantification

The entire methodology we used consists of nine modules (see Figure 7.1.). This pilot CRVA was too limited to cover all of them. Modules that focus on the quantification of impacts and risks were not covered in this report. Nevertheless, the quantification within the EURAC-GIZ methodology is not an economic one, but one that uses dimensionless indices. Since the Ministry of Economy requested an economic quantification, we propose to link the qualitative part of the CRVA with the systemic modelling approach of the GE Modelling exercise. It was clear since the beginning of the project that our particular assessments would perform three to four selected steps of this 9-step methodology. The steps we conducted are:

1) Preparing the assessment (scoping)
2) Developing the impact chains
3) Identifying adaptation options
4) Identifying indicators

Two steps that were partially conducted were identifying and selecting indicators and presenting outcomes. In **this specific CRVA case** the steps 3-8 can be done by the GE modelling process. This has 2 advantages:

1. Impact and risks are quantified as costs by the green economy modelling, instead as dimensionless indicators.
2. The green economy modelling process does allow the quantification of adaptation options. This is not covered by the CRVA method.

This pilot CRVA did not cover quantification steps due to a lack of time. The entire methodology would consist of nine steps (see Figure 7.1.). It was clear since the beginning of the project that our particular assessments would perform three to four selected steps of this 9-step methodology. Hence, **our CRVA does not quantify adaptation options and is therefore limited**. The reason the assessment was constrained to these steps was the time frame: Our assessment needed to be conducted in approximately four months time. For the assessment example used throughout the entire aforementioned Risk Assessment Guidebook, the authors recommend eighteen months for all nine steps.

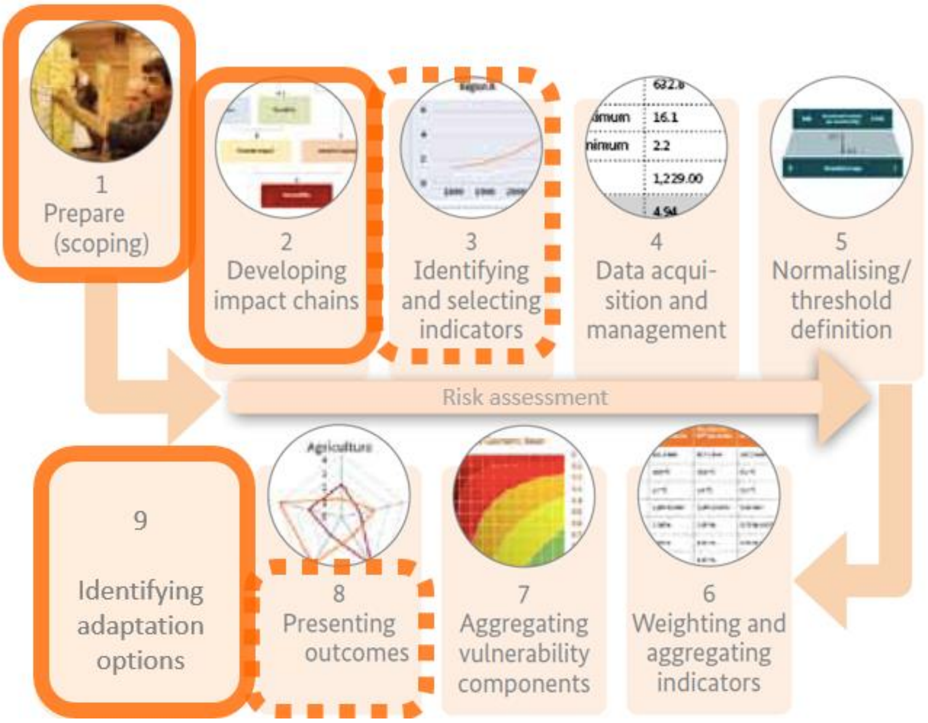

Fig. 7.1. *The nine steps of the entire CRVA methodology (GIZ, EURAC & UNU-EHS, 2018). The steps we took for these CRVA assessments are outlined in orange. Step 3 and 4 were partially taken. Therefore, they are outlined with a dashed line. Source of graphic: adopted from the Vulnerability Sourcebook, 2014 (GIZ) and the EbA Guidebook (2018).*

7.2. Indicators for factors within the transport sector

Table 7.1. Proposed indicators of factors for the climate impact chain within the transport sector

Component	**Factor**	**Potential indicator**	**Potential data source (today, future)**
Hazards	Heavy rain	days with > 20mm for slopes that put road infrastructure at risk	Today: Hydromet, but station data do not necessarily represent slope locations Future: Climate change scenarios (downscaled: NEX-GDDP, Cordex), less resolution: Climate change portal of the World Bank
Intermediate impact	landslides	Volume of earth (m^3)	Today: MES, CAIAG Future: process based modelling of landslides under changing climatic

			conditions
Intermediate impact	debris flows	Flow: Volume per time (m^3/s)	Today: MES, CAIAG Future: process based modelling of landslides under changing climatic conditions
Intermediate impact	avalanches	Flow: Volume per time (m^3/s)	Today: Kyrgyz Hydromet/MES Future: process based modelling of avalanches under changing climatic conditions
Vulnerability	Increased water flow	Exceedance probability for river discharge that exceeds protection facilities in place	Today: Kyrgyz Hydromet, MES, CAIAG, SAWR Future: Hydrological modelling
Vulnerability	Vegetation too degraded to stabilize slopes	Type of vegetation cover Vegetation condition index (satellite based)	SAEPF, Ministry of Agriculture, National Academy of Science, Statistical committee, environmental organisations, International providers of satellite information on vegetation indices (e.g. FAO)
Vulnerability	Overgrazing	density of livestock (number per ha)	SAEPF, Ministry of Agriculture, National Academy of Science, Statistical committee, environmental organisations, Statistical committee, environmental organisations
Vulnerability	Insufficient drainage	Drainage capacities Drainage type	Ministry of Transport and Roads

Vulnerability	Inappropriate road construction	Road construction without slope enforcement control (y/n per road segment)	Ministry of Transport and Roads, KSTCAU
Vulnerability	Lack of land use management	Pasture planning exists (y/n) Vegetation management exists (y/n) Erosion control (y/n)	SAEPF, Ministry of Agriculture, National Academy of Science, Environmental organisations
Vulnerability	Lack of finance	Available budget (KGS) for maintenance and slope stabilization	Ministry of Transport and Roads, KSTCAU, Kyrgyz Economic University
Exposure	Roads and bridges	Number of bridges and length of roads (km) within hazard zones	Ministry of Transport and Roads, KSTCAU

7.3. Indicators for factors within the tourism sector

Table 7.2. Proposed indicators of factors for the climate impact chains analyzed within the winter tourism sector

Component	**Factor**	**Potential indicator**	**Potential data source (today, future)**
Hazard	Mean temperature increase	Mean temperature	Today: Kyrgyz Hydromet Future: Climate change scenarios (downscaled: NEX-GDDP, Cordex), less resolution: Climate change portal of the World Bank
Hazard	Altitudinal increase of the snow line	Change in average altitude of snow line	Today: Kyrgyz Hydromet, CAIAG Future: Needs own methodology (model), and climate change scenario (downscaled: NEX-GDDP,

			Cordex data) to derive it
Hazard	Change in reliability of the onset and duration of the winter season	Change in standard deviation of onset of winter season based on criteria from skiing operators, e.g. amount of days where snow cover exceeds minimum thickness needed for skiing	Today: Kyrgyz Hydromet, CAIAG, based on criteria from skiing operators Future: Climate change scenarios (downscaled: NEX-GDDP, Cordex), less resolution: Climate change portal of the World Bank
Hazard	Change in average (climatic) duration of the winter season	Change in duration of winter season based on criteria from skiing operators, e.g. amount of days where snow cover exceeds minimum thickness needed for skiing	Today: Kyrgyz Hydromet, CAIAG, based on criteria from skiing operators Future: Climate change scenarios (downscaled: NEX-GDDP, Cordex), less resolution: Climate change portal of the World Bank
intermediate impact	Decrease in snow cover duration	Change in snow cover duration	Today: Kyrgyz Hydromet based on criteria from skiing operators; International providers of satellite information
intermediate impact	Decrease in the number of skiing tourists	Change in number of tourists per winter season	Skiing operator
Intermediate impact	Landslides	Volume of earth (m^3)	Today: MES, CAIAG Future: process based modelling of landslides under changing climatic conditions
Intermediate impact	Avalanches	Flow: Volume per time (m^3/s)	Today: Kyrgyz Hydromet/MES Future: process based modelling of avalanches under changing climatic conditions

Vulnerability	Lack of alternative sources of income from tourism in winter	Percentage of income from tourism in winter from skiing and snowboarding tourism	Survey
Vulnerability	Alternative sources of income from tourism in non-winter seasons,, i.e. a lack of diversity	Percentage of income from tourism from non-winter season tourism	Survey
Vulnerability	Lack of awareness and acknowledgement of climate risks	Aware of decreasing snow reliability (y/n)	Survey among skiing operator officials
Vulnerability	Vegetation too degraded to stabilize slopes	Type of vegetation cover Vegetation condition index (satellite based)	SAEPF, Ministry of Agriculture, National Academy of Science, Statistical committee, environmental organisations, International providers of satellite information on vegetation indices (e.g. FAO)
Vulnerability	Lack of finance	Ratio of available budget for managing climate risks to estimated costs for managing climate risks	Skiing operator; estimates costs would need to be assessed on a skiing operator by skiing operator basis
Exposure	Roads and bridges	Number of bridges and length of roads (km) within hazard zones of avalanches or landslides	Ministry of Transport and Roads, KSTCAU
Exposure	Slopes	Percentage of slopes length with snow cover for a sufficient amount of skiing degree days	Today: Respective skiing operator
Exposure	Operating infrastructure, including ski lifts and ski runs	Net monetary value of operating infrastructure	Respective skiing operator

Exposure	Skiing facilities such as hotels, restaurants, and catering	Net monetary value skiing facilities	Respective skiing operator
Exposure	Exposed ski resort employees and operators	Number of full-season job positions	Respective skiing operator

Table 7.3. Proposed indicators of factors for the climate impact chain analyzed within the summer tourism sector

Component	**Factor**	**Potential indicator**	**Potential data source (today, future)**
Intermediate impact	landslides	Volume of earth (m^3)	Today: MES, CAIAG Future: process based modelling of landslides under changing climatic conditions
Intermediate impact	avalanches	Flow: Volume per time (m^3/s)	Today: Kyrgyz Hydromet/MES Future: process based modelling of avalanches under changing climatic conditions
Vulnerability	Vegetation too degraded to stabilize slopes	Type of vegetation cover Vegetation condition index (satellite based)	SAEPF, Ministry of Agriculture, National Academy of Science, Statistical committee, environmental organisations, International providers of satellite information on vegetation indices (e.g. FAO)
Vulnerability	Lack of adaptive capacity of small tour	Number of tour operators /guest	Tourism Department under MCIT,

	operators Lack of knowledge and information on climate	house owners/tourism policy makers participating in the capacity building activities	international and bilateral development agencies that organize capacity-building activities
Vulnerability	Worsening sanitation	Number of ecologically-friendly toilets built	Tourism Department under MCIT, local self-government bodies, Universities
Vulnerability	Lack of adaptive capacity of small tour operators	Number of fast-growing trees planted	SAEPF, local self-government bodies
Vulnerability	Tourism season instability	Number of soft adventure offerings developed, tested and launched	Tour operators, community-based tourism (CBT) groups

7.4. Stakeholder maps

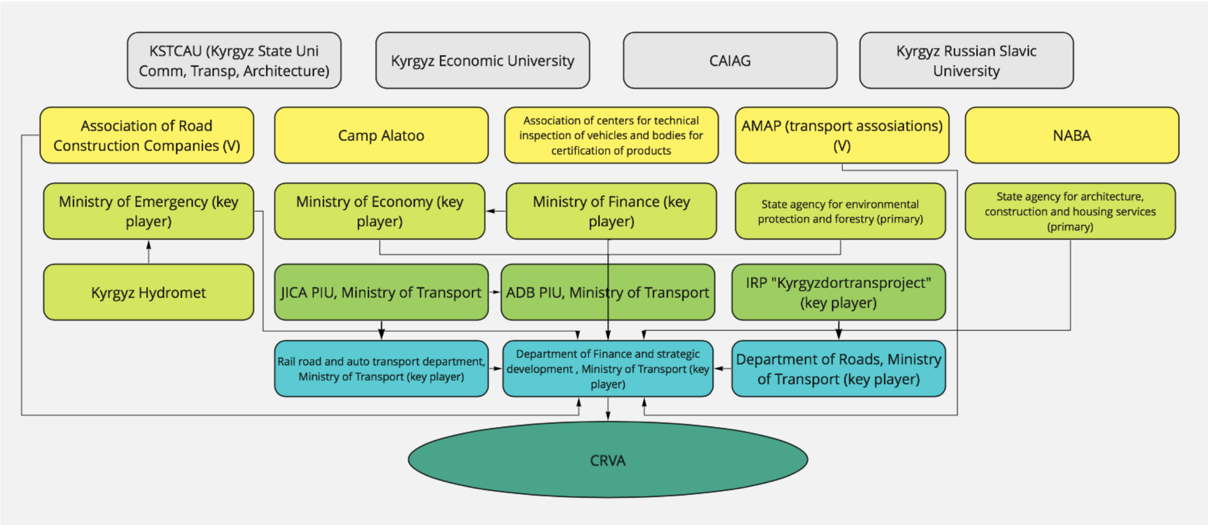

Figure 7.2. Stakeholder map, transport sector.

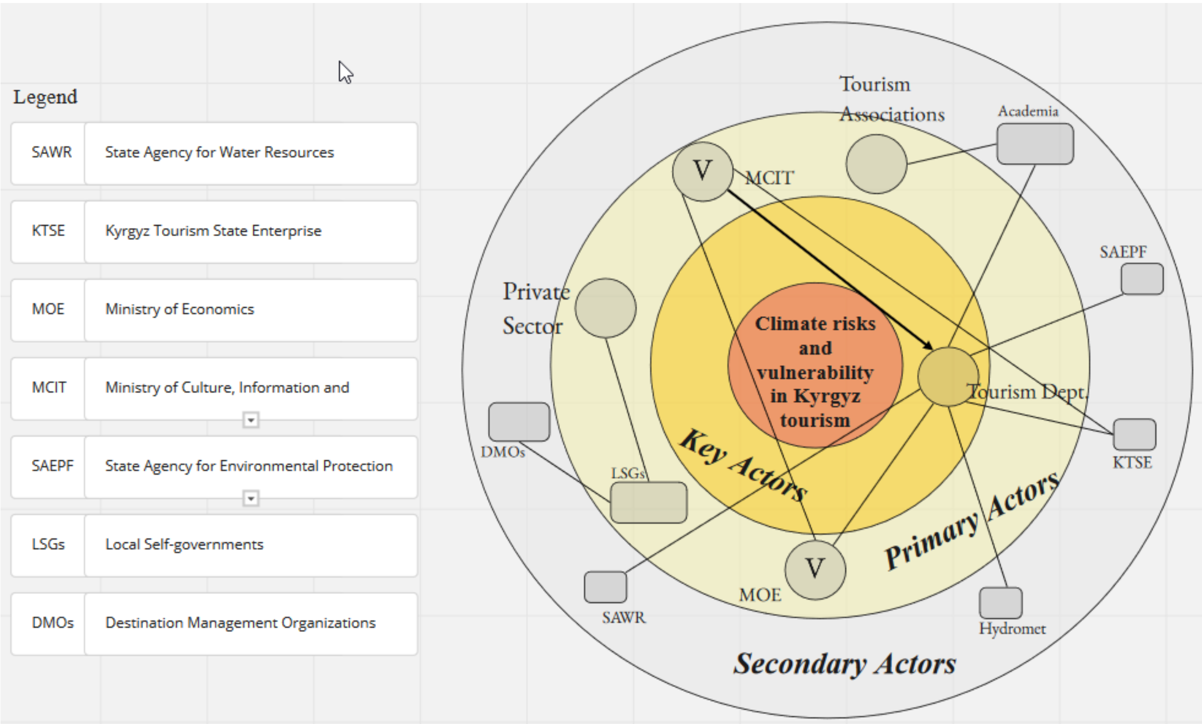

Figure 7.3. Stakeholder map, tourism sector.

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