SAVi Sustainable Asset Valuation

# A Sustainable Asset Valuation Assessment of Building and Transport Infrastructure Investment in the Shymkent–Tashkent–Khujand Economic Corridor

## METHODOLOGICAL NOTE FOR THE CENTER FOR DEVELOPMENT OF TRADE POLICY (QAZTRADE)

IISD International Institute for Sustainable Development

OECD

SIPA Sustainable Infrastructure Programme in Asia

On behalf of:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

IKI International Climate Initiative



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# 1.0 Overview

Plans have been developed to create both an International Center for Trade and Economic Cooperation (ICTEC) Central Asia and a trade and logistics centre between Kazakhstan and Uzbekistan to promote close and mutually beneficial trade relationships along the Shymkent–Tashkent–Khujand economic corridor. These infrastructure projects aim to include a modern and more efficient border crossing point for people, vehicles, and goods that will create jobs, increase trade and investment from the private sector, and foster economic cooperation, including in the tourism sector.

We carried out a Sustainable Asset Valuation (SAVi) assessment of the transport and building infrastructure in the economic corridor. The main objective of the integrated assessment is to gain insight and raise awareness of the impact of sustainable infrastructure on the efficiency of trade, energy efficiency and energy use, congestion, commuting times, number of accidents on the roads, $CO_2$ emissions, and employment creation.

This document served as a methodological background note for engagement with the Ministry of Trade and Integration and the Center for Development of Trade Policy (QazTrade). It provides definitions of sustainable transport and buildings, indicators to consider, the modelling approach proposed, and the resulting analysis.

# 2.0 Sustainable Transport

## 2.1 Introduction

### DEFINITION OF SUSTAINABLE TRANSPORT

Sustainable transport can be defined through three pillars: efficiency, equity, and environment (Transformative Urban Mobility Initiative, 2018). In this formulation, "efficiency" refers to the improvement of sustainable technologies and services, "equity" refers to supporting the mobility of users, and "environment" refers to reducing the negative impacts of mobility. One of the most comprehensive definitions is proposed by the High-level Advisory Group on Sustainable Transport for the United Nations (2016, p. 10):

> Sustainable transport is the provision of services and infrastructure for the mobility of people and goods—advancing economic and social development to benefit today's and future generations—in a manner that is safe, affordable, accessible, efficient, and resilient while minimizing carbon and other emissions and environmental impacts.

Defining and improving the sustainability of transport and trade in Kazakhstan is becoming increasingly relevant under new international policies, including the Carbon Border Adjustment Mechanism (CBAM) of the European Union (EU) (Gambaro et al., 2021). CBAM is a mechanism that will require importers to buy specific emission-related certificates for a price equal to what they would have paid if the goods had been produced within the EU, with the carbon intensity of EU production. However, if the importer can prove that the carbon intensity of local production is the same (or lower) than that of the EU, there would be no additional cost imposed for exports. It is, therefore, important that Kazakhstan start to decarbonize its production and trade sectors to gain competitiveness in the years to come. The CBAM will initially cover sectors like cement, iron, steel, and electricity, all relevant in the context of transportation projects. CBAM is particularly relevant because three of Kazakhstan's largest export markets are in the EU (Germany, Lithuania, and the Czech Republic), which account for a combined total value of USD 1,208,259,000.

### INDICATORS

In order to assess the sustainability of transport projects, indicators from the three dimensions of sustainability are crucial. In this context, the United Nations Economic Commission for Europe (UNECE) (2020) offers a list of indicators for this purpose, as shown in Table 1. Several of these indicators have been used to design the SAVi assessment for sustainable transport, in which indicators are divided into the following categories: economic, poverty and social, environmental, and risk to sustainability (Bassi et al., 2017b). It is worth noting that the list of indicators can be expanded/reduced depending on the requirements of the project.

**Table 1.** Environmental and socio-economic indicators suggested by UNECE to evaluate the sustainability of transport projects

| | Theme | Indicator |
|---|---|---|
| **Environmental indicators** | Global climate change | • Greenhouse gas (GHG) emissions from transport |
| | Air pollution | • Acidifying gases from transport<br>• Volatile organic compounds from transport |
| | Consumption of natural resources | • Consumption of mineral and oil products from transport<br>• Land coverage<br>• Need for additional new construction |
| **Social indicators** | Health | • Exposure to particulate matter from transport in the living environment<br>• Exposure to nitrogen dioxide from transport in the living environment<br>• Exposure to traffic noise<br>• Traffic deaths<br>• Traffic injuries |
| | Equity | • Justice of distribution of economic benefits<br>• Justice of exposure to particulate matter<br>• Justice of exposure to nitrogen dioxide<br>• Justice of exposure to noise<br>• Segregation |
| | Opportunities | • Housing standards<br>• Vitality of city centre<br>• Vitality of surrounding region<br>• Productivity gain from land use |
| | Accessibility and traffic | • Total time spent in traffic<br>• Level of service of public transport and slow modes<br>• Accessibility to city centre<br>• Accessibility to services<br>• Accessibility to open spaces |
| **Economic indicators** | Total net benefit from transport | • Transport investment cost<br>• Transport user benefits<br>• Transport operator benefits<br>• Government benefits from transport<br>• External accident costs<br>• External emission costs<br>• External greenhouse gas costs<br>• External noise costs |

Source: UNECE, 2020.

### LIFE-CYCLE APPROACH

Sustainable transport aims to limit environmental impacts through its life cycle, which involves the manufacture of materials as well as its construction, use, and decommissioning (Bassi et al., 2017b). The indicators for road and rail infrastructure are presented in Table 2.

**Table 2.** Life-cycle impacts considerations for roads and rail infrastructure

| Manufacture of materials | Construction | Use | Decommissioning |
|---|---|---|---|
| Cement/ asphalt manufacture | Energy sources for construction | Energy sources for use | Waste management (disposal, recycling, and reuse) |
| Metal manufacture | Waste management (disposal, recycling, and reuse) | Maintenance materials use | Land use (restoration) |
| GHG emissions | Construction impacts on the landscape and wildlife | GHG emissions | GHG emissions |
| | Land use (deforestation) | | |
| | GHG emissions | | |

Source: Authors.

## 2.2 Scenarios

Two main scenarios are proposed for the analysis of transport sustainability: one where existing road infrastructure is still used for trade activities and one where the road system is replaced by a rail system to improve the efficiency of trade.

1. **Business-as-usual (BAU) scenario:** This scenario assumes that traditional roads (grey infrastructure) and fossil fuel-based transport continue to be used. This represents a continuation of historical trends, with the possible worsening of negative climate change effects on trade volumes due to decreasing agricultural productivity (noting that climate change also affects productivity in the manufacturing sector). This scenario also includes the maintenance of the current road network and expansion based on growth projections.
2. **Sustainable infrastructure scenario:** This scenario proposes the expansion and strengthening of electrified rail as a sustainable transport option (green infrastructure). Sustainable transport infrastructure, and rail in particular, has certain advantages, such as transporting materials and goods faster than conventional roads, greater cargo capacity, cleaner energy (when electrified with renewable energy), lowered maintenance costs for roads, reduced congestion, and reduced number of accidents. The advantages can be summarized as follows:

- reduced energy use
- reduced use of raw materials
- lower operation and maintenance costs
- reduced emissions conditional to renewable energy use
- higher employment creation
- reduced time of transport, hence
    - reduction of food waste (post-harvest and distribution losses)
    - higher value of production, with agriculture products arriving at markets fresher and commanding a higher market price
    - lower cost per unit transported, making local farmers more competitive
    - higher income for farmers, with the potential to stimulate new investments and growing a different crop mix.

Rail transport in Kazakhstan has significant potential for expansion. Imports by rail are practically non-existent, while exports by rail represent only a small fraction (0.49%) compared to exports on roads. In terms of energy, although oil and coal account for 78% of Kazakhstan's domestic energy production, the country's potential for renewable energy generation is substantial. Kazakhstan currently produces 3% of its power from renewable energy, and 70% of all electricity production is generated from coal. However, the government aims to generate 15% of its electricity production from renewable energy sources by 2030 and 50% by 2050.

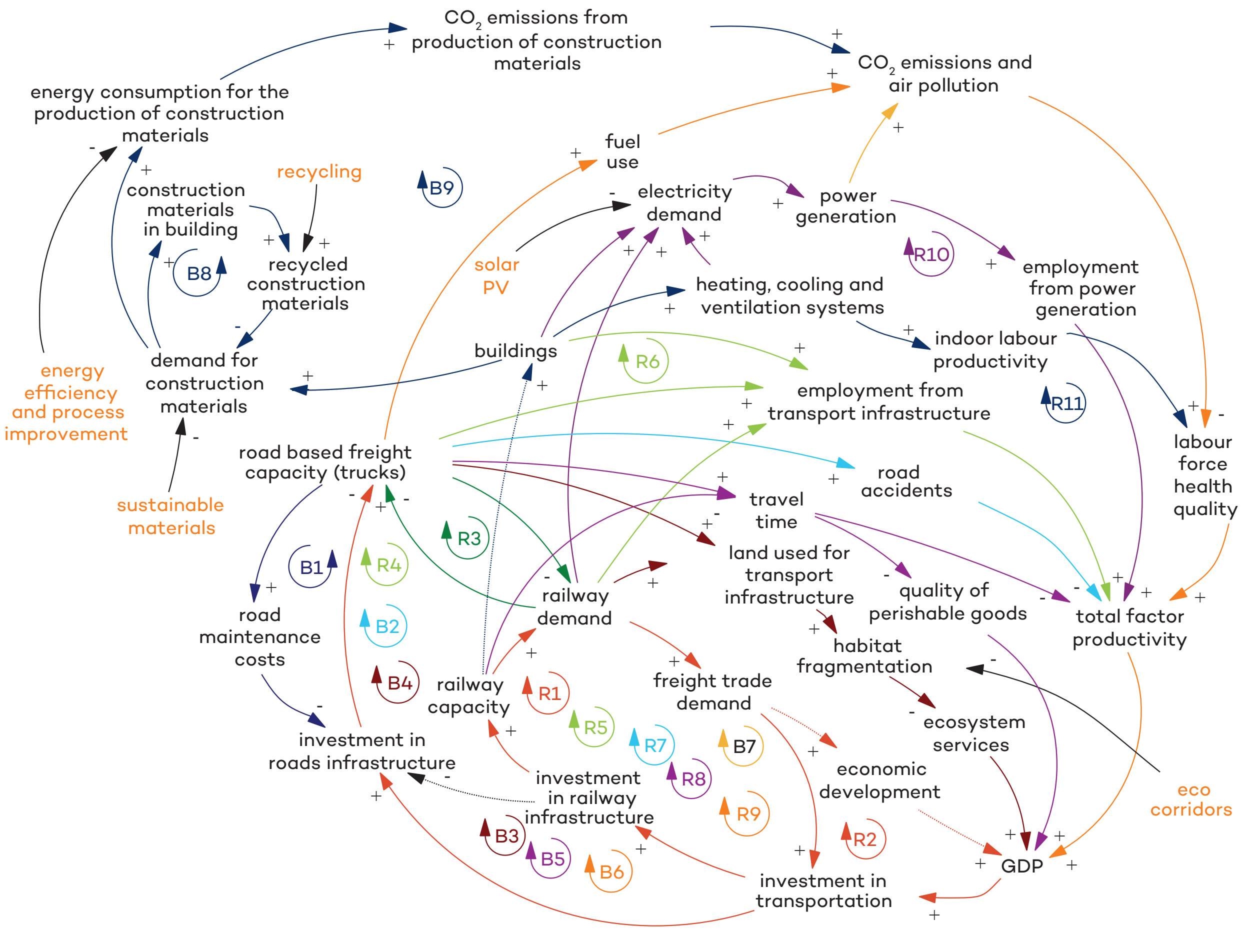
## 2.3 Sustainable Asset Valuation

The SAVi methodology allows the assessment of infrastructure projects considering risks usually overlooked in traditional valuations, making it possible to identify the monetary value of the environmental and socio-economic co-benefits of avoided costs. SAVi is based on systems thinking (Bassi & Pallaske, n.d.) and combines a set of different modelling tools: system dynamics modelling, multi-criteria analysis, spatial models, and project finance modelling. SAVi also provides scenario analysis and compares how the financial performance of an infrastructure project changes in relation to climate change and other drivers over time. SAVi thus considers different types of indicators (environmental, social, and economic) with a high level of customization, with additional financial indicators, informing decision-makers on the costs, avoided costs, and benefits of their projects. The SAVi methodology is designed to provide evidence of the risks, benefits, and climate impacts of infrastructure projects (Bassi et al., 2021). SAVi has been applied to various infrastructure projects and across sectors in more than 20 countries around the world.

A first step in the SAVi assessment will be to identify the impacts and underlying dynamics of a transport project, including driving forces and key indicators, summarizing them in causal loop diagrams (CLDs). CLDs show the interconnections of social, economic, and environmental components of the system, highlighting key dynamics and potential trade-offs emerging from the different scenarios considered in a SAVi assessment. The CLD is the starting point for the development of the mathematical stock and flow model that will simulate the BAU and sustainable scenarios. The CLD was validated through engagement with QazTrade.

Figure 1 provides an example of the CLD for the sustainable infrastructure scenario in Kazakhstan, which has direct connections with social variables such as accidents and employment, and indirect connections with economic variables such as consumption, GDP and demand, and direct impact on fuel use that will determine GHG emissions, affecting environmental performance.

**Figure 1.** CLD representing the advantage the sustainable infrastructure scenario in Kazakhstan




Source: Authors.

A SAVi assessment provides an integrated cost-benefit analysis (CBA) along with financial performance indicators that assist in comparing costs and benefits, including externalities, which are selected according to the characteristics of the infrastructure project and the objectives of the assessment, for BAU versus sustainable infrastructure options (such as roads versus rail).

Sustainable infrastructure investments must have environmental and social cohesion at their core, given the current challenges posed by both climate change and the COVID-19 pandemic. The “what-if” simulations based on the SAVi methodology are designed to inform decision-makers while considering those challenges.

The what-if scenarios are run to understand the socio-economic benefits that can be realized when public spending (also from sustainable recovery packages) is targeted at sustainable infrastructure. To do so, simulations are based on authoritative data and scientific analysis, incorporating different methods and models. For example, by using QGIS, a professional geographic information system application that supports the analysis of geospatial data, it is possible to prepare different land-use scenarios to link the different checkpoints, and thus calculate the total number of km of railroads that will need to be built/upgraded. Using this information, it would be possible to assess the total costs, avoided costs, and benefits using different multipliers expressed in USD/km.

The transport component of SAVi model includes both the vehicle fleet stock, the road network, and the rolling stock and rail network. Table 3 expands the variables and sectors that will be considered for the transportation component of the SAVi model applied to Kazakhstan's ICTEC project for both roads and rail infrastructure.

**Table 3.** Components of the SAVi roads and rail transport model

| Transport component of the SAVi model |
|---|
| • Vehicle fleet stock/rolling stock<br>• Cargo capacity<br>• Road/rail network construction<br>• Energy demand and emissions<br>• Climate change impacts on roads/rail<br>• Employment creation from construction and operation/maintenance<br>• Material use<br>• Construction and maintenance costs<br>• Pollution through the infrastructure life cycle and its health impacts<br>• Value of time lost/gained (and resulting damage to agricultural goods, for example)<br>• Land use (land clearing or deforestation)<br>• Accidents<br>• Congestion |

Source: Authors.

Finally, the model assesses the economic performance of the investments and generates a CBA that includes capital and maintenance costs, fuel costs, social cost of carbon, cost of noise, cost of urban effects from private vehicles, cost of air pollution, time-lost costs (e.g., value of time for operators in the transport sector and value of produce lost due to delays in authorizing border crossing), traffic accident costs, and more. It is important to highlight that the integrated CBA used in SAVi models already considers the costs of externalities, which are important based on the proposed indicators table (see Table 1).

# 3.0 Sustainable Buildings

## 3.1 Introduction

### DEFINITION OF SUSTAINABLE BUILDINGS

To be considered "sustainable," a building needs to demonstrate several socio-economic and environmental benefits. In some cases, the concept of "green buildings" is associated with sustainable buildings, in which green buildings are commonly focused on environmental outcomes. In terms of social impacts, because the average person spends the vast majority of time indoors, investing in sustainable buildings will provide benefits for people's health through indoor living environments that feature healthy air temperatures, humidity levels, noise levels, and air quality (International Energy Agency, 2021). In economic terms, sustainable buildings should offer several economic benefits, such as lower construction costs, cost savings (electricity, water, and heating) on tenant bills, higher property values, increased occupancy rates, and job creation (World Green Building Council, n.d.)

### INDICATORS

The indicators to assess the sustainable performance of buildings can be divided into the three dimensions of sustainability: environmental, social, and economic. Araújo et al. (2013) reviewed indicators for four European initiatives and selected the most relevant ones in the three categories (see Table 4). The authors sort the indicators into subcategories: energy and emissions, water, and materials and waste under the environmental dimension; human health and comfort along with process quality under the social dimension; and finally, life-cycle costs under the economic dimension.

**Table 4.** Building's sustainability indicators selected

| Dimension | Categories | Selected Indicators |
|---|---|---|
| Environment | Energy and emissions | Non-renewable primary energy |
| | | Renewable primary energy |
| | | GHG emissions |
| | Water | Water consumption |

| Dimension | Categories | Selected Indicators |
|---|---|---|
| | Materials and waste | Materials embodied energy |
| | | Ozone depletion potential |
| | | Acidification potential |
| | | Eutrophication potential |
| | | Photochemical oxidation potential |
| | | Reused and recycled materials |
| | | Responsible sourcing materials |
| | | Waste production |
| Society | Users' health and comfort | Indoor air quality |
| | | Lightning |
| | | Thermal comfort |
| | | Acoustic comfort |
| | Process quality | Integrated design project |
| | | Commissioning |
| Economy | Economy | Life-cycle costs |

Source: Araújo et al., 2013.

The indicators presented in Table 4 can be assessed by the SAVi model for buildings, and the list customized based on project needs. SAVi measures additional economic indicators related to the CBA, which considers not only direct costs and benefits but also the cost of externalities and risks (e.g., air pollution, noise pollution, climate resilience).

## LIFE-CYCLE APPROACH

All environmental, social, and economic impacts must be assessed throughout a building's life cycle, from the manufacturing of materials to the demolition phase (Bassi et al., 2017a). Because buildings are built using different products, materials, and technologies, it is necessary to evaluate the different individual components, as well as their integration into functional units to evaluate their sustainability. For example, the different technologies and methods and their costs and benefits can be considered for different individual components in buildings (see Table 5).

**Table 5.** Building life-cycle components included in the sustainability assessment

| Electricity generation and use | Water use | Material use | Heating/ cooling | Lighting |
|---|---|---|---|---|
| Solar photovoltaic–decentralized | Water heating systems | Portland cement | Efficiency of the heating/ cooling systems | Incandescent |
| Energy efficiency technologies and smart metering systems | Water reserve systems | Low-carbon or circular cement incorporating recycled materials | Renewable energy sources | LED |
| Energy use and GHG emissions | | Construction waste generation management | Energy use and GHG emissions | Energy use and GHG emissions |

Source: Authors.

Table 6 provides an example of measurement of GHG emissions, energy demand, water use, and solid waste during the life cycle of a typical house in Australia.

**Table 6.** Life-cycle impact category indicators of a case study house

| Impacts | Unit and % | Construction | Operation | Maintenance | Disposal | Total |
|---|---|---|---|---|---|---|
| GHG | Tonne $CO_2$ | 26.0 | 48.0 | 6.43 | -4.21 | 76.2 |
| | Percentage (%) | 34.0% | 63.0% | 8.43% | -5.52% | 100 |
| Cumulative energy demand | GJ | 380 | 560 | 127 | 13.0 | 1,080 |
| | Percentage (%) | 35.1% | 51.9% | 11.7% | 1.20% | 100 |
| Water use | kL ($H_2O$) | 1,940 | 65.4 | 1,090 | 0.29 | 3,100 |
| | Percentage (%) | 62.6 | 2.11% | 35.2% | 0.01% | 100 |
| Solid waste | Tonne | 3.86 | 1.63 | 4.95 | 70.3 | 80.8 |
| | Percentage (%) | 4.78% | 2.02% | 6.13% | 87.0% | 100 |

Source: Islam et al., 2015.

## 3.2 Scenarios

As in the transportation component, there are two main scenarios proposed for the assessment of sustainable buildings:

1. **BAU scenario:** The BAU scenario assumes the capital expenditure and operating expenses of conventional buildings without any sustainability aspects. The capital expenditure of conventional buildings is often cheaper than sustainable ones, but the operational costs over the lifetime of buildings can be significantly higher, as no technologies for resource or electricity use are put in place. There are also no avoided costs or added benefits in this scenario.
2. **Sustainable building scenario:** The sustainable building scenario assumes the construction of sustainable buildings and/or the retrofitting of conventional buildings. Sustainable buildings are designed to use energy more efficiently and rely on clean energy sources for lighting, cooking, heating, and cooling, which will reduce GHG emissions, the risk of carbon pricing, and impacts associated with air pollution (e.g., health impacts). This scenario also considers that the buildings use less water and have more sustainable waste management (recycling and reuse). It includes the building use as well as the building construction and decommissioning. In this scenario, we will also quantify the avoided costs or added benefits in terms of job creation, GHG and other emissions, and health benefits over the life cycle of the buildings.

## 3.3 Sustainable Asset Valuation

Different methods can be integrated into the SAVi assessment to evaluate sustainability indicators in buildings. For example, InVEST[1] (Integrated Valuation of Ecosystem Services and Tradeoffs) is a suite of spatial models used to map and value key ecosystem services (e.g., the contribution of green spaces to temperature regulation). With the systems thinking approach, the underlying dynamics of a specific building project can be defined, including driving forces and key indicators, and they can be summarized in CLDs, such as the one shown in Figure 2. The CLD shows that buildings have impacts on social variables, such as employment and indoor labour productivity, on environmental variables such as energy use, $CO_2$ emissions, and water use, and on economic variables, such as capital costs, operation costs, and labour income.

The SAVi model for buildings uses several interconnected modules to generate a systemic analysis: demand for construction ($m^2$ of building area required), employment from construction, energy demand and cost, $CO_2$ emissions, health impacts, heat generation technology, and rooftop solar photovoltaic technology. The model can be customized to include more modules that represent the dynamics in the context of sustainable buildings and sustainable transport in Kazakhstan. The CLD was validated through engagement with QazTrade. In the quantitative models, synergies were explored between sustainable transport and buildings by assuming full electrification of transport and of energy demand in buildings, using renewable energy.

1 https://naturalcapitalproject.stanford.edu/software/invest

Table 7 lists the main variables and sectors included in the SAVi model for buildings. The final list of indicators used for this assessment was determined and validated through engagement with QazTrade.

**Table 7.** Components of the general SAVi buildings model

| Buildings component of the SAVi model |
|---|
| • Demand for living space<br>• Employment from building construction and maintenance<br>• Energy demand and costs<br>• Emissions from buildings<br>• Health impacts<br>• Heating technologies<br>• Energy generation (small-scale capacity)<br>• Building costs<br>• Cost of externalities (e.g., GHG emissions) |

Source: Authors.

The SAVi assessment can also include climate data to understand how different climate change scenarios will affect the costs and benefits of the project, as well as spatial data retrieved from spatial models (such as InVEST). SAVi models use integrated world-class data on climate from the Copernicus Climate Change Service, which provides a single entry point for continuously updated climate data and products on the past, present, and future (International Institute for Sustainable Development, n.d.). All this information and data allows the structuring of CBAs such as the one shown in Table 8, which compares benefits, externalities, and costs for BAU versus a sustainable building scenario under different climate projections.

**Table 8.** Example of integrated CBA (buildings)

| | RCP 2.6 | |
|---|---:|---:|
| **Integrated CBA (ZAR)** | **BAU** | **Green** |
| **Project-related investment and costs** | | |
| Capital investment | 120,225,960 | 122,679,944 |
| O&M cost | 270,695,456 | 162,417,472 |
| Energy expenditure | 53,265,432 | 18,793,268 |
| *Boseline energy expenditure* | *65,679,268* | *31,207,104* |
| **Climate impacts on energy expenditure** | | |
| *Cost savings from solar PV* | *-12,413,836* | *-12,413,836* |

| | RCP 2.6 | |
|---|---|---|
| **Integrated CBA (ZAR)** | **BAU** | **Green** |
| **Climate impacts on solar PV performance** | | |
| Water expenditure | 6,056,209 | 6,056,209 |
| *Water expenditure from use in building* | *2,632,364* | *2,632,364* |
| *Irrigation water expenditure (outdoor)* | *3,423,845* | *3,423,845* |
| **Cllmate impacts on irrigation water expenditure** | | |
| **Subtotal (1): Project-related investment and costs** | **450,243,057** | **309,946,893** |
| **Externalities** | | |
| Costs of GHG emissions | 15,693,504 | 6,481,820 |
| *Baseline costs of GHG emissions* | *15,693,504* | *6,481,820* |
| **Climate impacts on cost of GHG emissions** | | |
| Discretionary spending | -4,569,268 | -4,569,268 |
| Costs of indoor air quality | 0 | 0 |
| Baseline costs of indoor air quality | | |
| **Cost of labour productivity lost due to heat stress** | | |
| **Subtotal (2): Externalities** | 11,124,237 | 1,912,552 |
| **Total net cost** | **461,367,293** | **311,859,445** |

Source: Authors.

**The results of the SAVi assessment of the ICTEC project are presented and discussed in the summary of results published jointly with this methodological note.**

# 4.0 Key Assumptions and Data Sources

**Table 9.** Assumptions and data sources of sustainable infrastructure in Kazakhstan

**Parameters for calculating added benefits and avoided costs**

| Added benefit or avoided cost | Indicator | Value | Data source |
|---|---|---|---|
| Investment costs | Capital cost per km of railway infrastructure | USD 14.18 million per km | Gillen et al., 1997 |
| | Railway network length | 60 km | Assumption |
| | Capital cost per train | USD 2.12 million per vehicle | Gillen et al., 1997 |
| | Total trains | 16 vehicles | Assumption |
| | O&M costs | USD 7.305 per vehicle-km | Gillen et al., 1997 |

**Parameters for calculating added benefits and avoided costs**

| Added benefit or avoided cost | Indicator | Value | Data source |
|---|---|---|---|
| Revenues from freight trade | Freight transported by railway after railway implementation | 421.6 tons by 2027 (based on the construction and adoption of the railway)<br>3.87 million tons by 2050 (with full adoption of the railway and a 60% shift) | The total number of tons transported on the road is assumed to be 4 million by 2023.<br>The growth rate of the freight transported by railway is assumed to be 1.5% per year.<br>The shift of freight transported from trucks to railways is assumed to be 60% after railway implementation. |
| | Freight transported by road (trucks) after railway implementation | 4.59 million tons by 2027 (based on the construction and adoption of the railway)<br>5.74 million tons by 2050 (with full adoption of the railway and a 60% shift, hence only 40% is transported in trucks) | The total number of tons transported on the road is assumed to be 4 million by 2023.<br>The growth rate of the freight transported by railway is assumed to be 2% per year.<br>The share of the total demand that will keep being transported by trucks is assumed to be 40% after railway implementation. |
| | Railway transport cost per ton | USD 90.8/ton of freight | Indian Railways Freight Services, 2023 |
| | Road transport cost per ton | Assumed at 80% of the cost of transport by railway: USD 72.64/ton | Indian Railways Freight Services, 2023 |

**Parameters for calculating added benefits and avoided costs**

| Added benefit or avoided cost | Indicator | Value | Data source |
|---|---|---|---|
| Income creation from railway employment | Railway construction rate | 2023: 15 km/year<br>2024: 15 km/year<br>2025: 15 km/year<br>2026: 15 km/year | Assumption: 15 km/year to complete 60 km of railway by the end of 2026 |
| | Construction jobs per km | 50 person/km | Bassi et al., 2019 |
| | Number of freight trains functioning | 16 trains | Bassi et al., 2019 |
| | O&M per train | 50 person/train | Bassi et al., 2019 |
| | Share of discretionary spending | 30% | Bassi et al., 2019 |
| | Salary per person | KZT 3.83/person/year | Take-profit, 2023 |

**Parameters for calculating added benefits and avoided costs**

| Added benefit or avoided cost | Indicator | Value | Data source |
|---|---|---|---|
| Income creation from building employment | $m^2$ of buildings under construction | 2024: 69 $m^2$<br>2025: 825 $m^2$<br>2026: 756 $m^2$ | Assumption |
| | Power generation jobs per building | 0.073235 person/$m^2$/year | von Anson et al., 2004 |
| | Total building floor area | 825 $m^2$ | Assumption |
| | O&M jobs | 0.000229358 person/$m^2$/year | International Facility Management Association, 2005 |
| | Salary per person | KZT 3.83/person/year | Take-profit, 2023 |
| | Share of discretionary spending | 30% | Bassi et al., 2019 |

**Parameters for calculating added benefits and avoided costs**

| Added benefit or avoided cost | Indicator | Value | Data source |
|---|---|---|---|
| Income creation from energy generation employment | Power generation capacity – solar large-scale | 2027: 0.02 MW<br>2030: 8.91 MW<br>2040: 10.33 MW<br>2050: 12.02 MW | Values autogenerated by the SAVi model based on both railway and building power generation needs. The technology to generate the power is assumed to be solar. |
| | O&M employment per MW of renewable capacity – solar large-scale | 2015: 0.7 person/MW/year<br>2030: 0.4 person/MW/year | Bassi et al., 2019 |
| | Power generation under construction | 2027: 0.00025 MW<br>2030: 0.01065 MW<br>2040: 0.01284 MW<br>2050: 0.01612 MW | Values autogenerated by the SAVi model based on both railway and building power generation needs. The technology assumed to generate the power is solar. |
| | Construction employment per MW | 2015: 13 person/MW<br>2030: 7.67 person/MW/year | Bassi et al., 2019 |
| | Salary per person | KZT 3.83/person/year | Take-profit, 2023 |
| | Share of discretionary spending | 30% | Bassi et al., 2019 |

**Parameters for calculating added benefits and avoided costs**

| Added benefit or avoided cost | Indicator | Value | Data source |
|---|---|---|---|
| Value added from freight trade | Additional freight trade vs BAU | 2030: 765,931 tons<br>2040: 1,384,544 tons<br>2050: 2,550,930 tons | Calculated by the SAVi model based on the total trips from both trucks and railway before and after the railway implementation |
| | Value added per ton of freight | USD 3,300/ton assuming uranium as the main traded good: 30 dollars per pound, market price of Uranium – USD 110/kg, 5% profit margin | Statista, 2023; Trading Economics, 2023 |
| Value of time saved | Time savings vs BAU | 2030: 2.06 million hours<br>2040: 2.70 million hours<br>2050: 3.60 million hours | Calculated by the SAVi model based on the total trips, the shift from road to railway, and the time spent on each trip. Travel speed, trucks: 50 km/hr, travel speed, railway: 80 km/hr. Average distance travelled per trip by truck or railway: 60 km |
| | Value per hour of time | USD 1.18 /hour | Ambarwati et al., 2017 |

**Parameters for calculating added benefits and avoided costs**

| Added benefit or avoided cost | Indicator | Value | Data source |
|---|---|---|---|
| $CO_2$ emissions from transport | Emissions per km (emissions factor trucks) | Trucks: 0.001056 tons of $CO_2$ per vehicle-km | Environmental Defense Fund, 2019 |
| | Average emissions per Tj of electricity generation (emission factor railway) | 0 tons of $CO_2$ per Tj for solar large-scale<br>92.5 tons of $CO_2$ per Tj for the BAU scenario (50% coal, 50% hydropower large-scale) | Energy Information Administration, 2020 |
| | Cost of emissions per ton | USD 31/ton = KZT 14,829.4/ton | Nordhaus, 2017 |
| $CO_2$ emissions from buildings | Buildings emissions intensity | 0.798 ton/(MWh) | Institute for Global Environmental Strategies, 2021 |
| | Energy consumption per $m^2$ | 0.18 MWh/$m^2$/Year | European Commission, 2021 |
| | Cost of emissions per ton | USD 31/ton = KZT 14,829.4/ton | Nordhaus, 2017 |
| Accidents | Cost of accidents per severity | USD 8,000/light accident<br>USD 101,000/severe accident<br>USD 764,000/deadly accident | Wijnen, 2021 |
| | Accident risk per 1,000 km | 4.66e-007 light accident/1,000 km<br>2.88e-007 severe accident/1,000 km<br>5.1e-008 deadly accident/1,000 km | Bassi et al., 2019 |

**Parameters for calculating added benefits and avoided costs**

| Added benefit or avoided cost | Indicator | Value | Data source |
|---|---|---|---|
| Fuel use | Avoided vehicle-km trucks BAU vs railway scenario | 2030: 3.92 million v-km<br>2040: 6.33 million v-km<br>2050: 5.40 million v-km | Calculated by the SAVi model based on trip demand and trip length for trucks |
| | Fuel consumption per vehicle-km – trucks | 0.24 ltr/km | Goel et al., 2016 |
| | Fuel price per litre in Kazakhstan | KZT 211.01/ltr | Global Petrol Prices, 2023 |
| Energy cost of buildings | Energy consumption in buildings | Conventional buildings: 150 MWh/year<br>Sustainable buildings (auto generation): 35 MWh/Year | Calculated by the SAVi model based on the energy consumption per $m^2$, climate impacts on energy consumption and on-site electricity generation. |
| | Energy consumption per $m^2$ | 0.18 $MWh/m^2$/Year | European Commission, 2021 |
| | Energy price | USD 140/(MWh) | Global Petrol Prices, 2023 |
| Capital costs of conventional energy | Construction rate of conventional (fossil fuel-based) energy capacity | 2027: 0.0166 MW/Year<br>2033: 0.00468 MW/year<br>2040: 0.00021 MW/year<br>2050: 0.00123 MW/year | Calculated by the SAVi model based on energy demand |
| | Capital cost per MW of diesel and fuel oil capacity | USD 630,000/MW | Bassi et al., 2019 |

**Parameters for calculating added benefits and avoided costs**

| Added benefit or avoided cost | Indicator | Value | Data source |
|---|---|---|---|
| O&M costs of conventional energy | Electricity generation rate of conventional (fossil fuel-based) energy capacity | 2027: 78.99 MWh/year<br>2033: 80.51 MWh/year<br>2040: 80.44 MWh/year<br>2050: 80.46 MWh/year | Calculated by the SAVi model based on energy capacity |
| | O&M cost per MWh of electricity generation | USD 30,000 /MW/year | Masson et al., 2020 |
| Capital cost of renewable energy | Capital cost per MW of renewable energy solar large-scale | 2019: USD 700,000/MW<br>2040: USD 400,000/MW | Bassi et al., 2019 |
| O&M costs renewable energy | O&M costs per MW/ year or renewable energy – solar large-scale | USD 8,862/MW/year | Bassi et al., 2019 |

# References


Ambarwati L., Indriastuti, A. K., & Kusumawardhani, P. (2017). Estimating the value of time and its application. *Open Science Journal, 2*(1). https://pdfs.semanticscholar.org/4449/d8abf90fb63b363b24cbd69fe26351e064ab.pdf

Araújo, C., Bragança, L., & Almeida, M. (2013). Sustainable construction: Key indicators. In L. Bragança, R. Mateus, & M. Pinheiro (Eds.), *Portugal SB13: Contribution of Sustainable Building to Meet EU 20-20-20 Targets* (505–512). Universidade do Minho. https://repositorium.sdum.uminho.pt/bitstream/1822/28942/1/Ara%c3%bajo_Bragan%c3%a7a_Almeida_SB13.pdf

Bassi, A. (2016). Moving towards integrated policy formulation and evaluation: The green economy model. *Environmental and Climate Technologies 16*(1). https://www.researchgate.net/publication/295181846_Moving_Towards_Integrated_Policy_Formulation_and_Evaluation_The_Green_Economy_Model

Bassi, A., Casier, L., Pallaske, G., & Uzsoki, D. (2019). *Sustainable Asset Valuation (SAVi) of the bus rapid transit project in Senegal: A focus on transport infrastructure*. International Institute for Sustainable Development. https://www.iisd.org/publications/report/sustainable-asset-valuation-savi-bus-rapid-transit-project-senegal

Bassi, A., Casier, L., Pallaske, G., & Uzsoki, D. (2021). *Sustainable Asset Valuation (SAVi) of Paterson Park's Building Infrastructure: City of Johannesburg (South Africa)*. Copernicus Climate Change Service.

Bassi, A., McDougal, K., & Uzsoki, D. (2017a). *Sustainable asset valuation tool: Buildings*. International Institute for Sustainable Development. https://www.iisd.org/system/files/publications/sustainable-asset-valuation-tool-buildings.pdf

Bassi, A., McDougal, K., & Uzsoki, D. (2017b). *Sustainable asset valuation tool: Roads*. International Institute for Sustainable Development. https://www.iisd.org/system/files/publications/sustainable-asset-valuation-tool-roads.pdf

Bassi, A. & Pallaske, G. (n.d.). *Introduction to systems analysis and system dynamics*. International Institute for Sustainable Development. https://www.iisd.org/savi/wp-content/uploads/2020/03/savi-academy-systems-thinking-dynamics-final.pdf

Energy Information Administration. (2020). *How much carbon dioxide is produced when different fuels are burned?* https://www.eia.gov/tools/faqs/faq.php?id=73&t=11

Energy Plan. (n.d.). *MARKAL/TIMES*. https://www.energyplan.eu/othertools/national/markaltimes/

Environmental Defense Fund. (2019). *The green freight handbook*. https://storage.googleapis.com/scsc/Green%20Freight/EDF-Green-Freight-Handbook.pdf

European Commission. (2021). *EU buildings factsheets: Ireland.* https://energy.ec.europa.eu/system/files/2016-11/irel_0.pdf

European Investment Bank. (2021). *The way forward: Investing in a cleaner and smarter transport system.*

Gambaro, E., de Bie, E., & Hamer, M. (2021). EU proposal for the Carbon Border Adjustment Mechanism. *National Law Review, XIV*(2). https://www.natlawreview.com/article/eu-proposal-carbon-border-adjustment-mechanism

Gillen, D., Levinson, D., Mathieu, J., & Kanafani, A. (1997). The full cost of high-speed rail: An engineering approach. *The Annals of Regional Science, 31*(2), 189–215 https://www.researchgate.net/publication/24053362_The_full_cost_of_high-speed_rail_An_engineering_approach/link/543fb4920cf21227a11ad1bb/download

Global Petrol Prices. (2023). *Kazakhstan gasoline prices, liter*, 25-Dec-2023. https://www.globalpetrolprices.com/Kazakhstan/gasoline_prices/

Goel, R., Mohan, D., Guttikunda, S. K., & Tiwari, G. (2016). Assessment of motor vehicle use characteristics in three Indian cities. *Transportation Research Part D: Transport and Environment, 44,* 254–265.

Guzzetti, M., Schlageter, A., Perera, O., & Wuennenberg, L. (2020). *Are investments in road infrastructure on Borneo a sustainable recovery strategy for Malaysia?* International Institute for Sustainable Development. https://www.iisd.org/savi/project/are-investments-in-road-infrastructure-on-borneo-a-sustainable-recovery-strategy-for-malaysia/

High-level Advisory Group on Sustainable Transport. (2016). *Mobilizing sustainable transport for development*. United Nations. https://sustainabledevelopment.un.org/content/documents/2375Mobilizing%20Sustainable%20Transport.pdf

Indian Railways Freight Services. (2023). *Expected freight charges*. https://www.fois.indianrail.gov.in/RailSAHAY/FrgtCalc

Institute for Global Environmental Strategies (2021). *IGES list of grid emission factors*. https://www.iges.or.jp/en/pub/list-grid-emission-factor/en?_ga=2.41471586.1931230525.1584950774-1946296047.1581946849

International Energy Agency. (2021). *World energy outlook 2021*. https://www.iea.org/reports/world-energy-outlook-2021

International Facility Management Association. (2005). *Estimated operations and maintenance staffing requirements*. https://www.fairfaxcounty.gov/budget/sites/budget/files/assets/documents/fy2010/lobs/presentations/appendix_a_fmd.pdf

International Institute for Sustainable Development. (n.d.). *C3S data*. https://www.iisd.org/savi/c3s-data/

Islam, H., Jollands, M., & & Setunge, S. (2015). Life cycle assessment and life cycle cost implication of residential buildings—A review. *Renewable and Sustainable Energy Reviews, 42*, 129–140.

Masson, M., Ehrhardt, D., & Lizzio, V. (2020). *Sustainable energy paths for the Caribbean*. Inter-American Development Bank. https://publications.iadb.org/en/sustainable-energy-paths-caribbean

Nordhaus, W. (2017). Revisiting the social cost of carbon. *PNAS, 11*(7), 1518–1523.

Reflex. (2021). *ASTRA*. REFLEX – Analysis of the European Energy System. http://reflex-project.eu/model-coupling/astra/

Statista. (2023). *Net profit margin of the top mining companies worldwide from 2002 to 2022, with a forecast for 2023*. https://www.statista.com/statistics/208725/net-profit-margin-of-the-top-mining-companies/

Stockholm Environment Institute. (2020). *LEAP 2020: SEI's flagship tool for low emissions analysis gets major upgrade*. https://www.sei.org/featured/leap-2020-major-upgrade-for-low-emissions-analysis-tool/

Take-profit. (2023). *Kazakhstan wages data*. https://take-profit.org/en/statistics/wages/kazakhstan/#:%20:text=What%20is%20average%20wage%20in,minimum%20was%2012890%20KZT%2FMonth

Trading Economics. (2023). *Uranium*. https://tradingeconomics.com/commodity/uranium

Transformative Urban Mobility Initiative. (2018). *Elements of sustainable mobility*.

United Nations Economic Commission for Europe. (2020). *A handbook on sustainable urban mobility and spatial planning*. https://unece.org/transport/publications/handbook-sustainable-urban-mobility-and-spatial-planning

Von Anson, M., Chiang, Y. H., & Raftery, J. (2004). *The construction sector in the Asian economies*. Routledge.

Wijnen, W. (2021). Socio-economic costs of road crashes in middle-income countries: Applying a hybrid approach to Kazakhstan. *IATSS Research, 45*(3), 293–302. https://www.sciencedirect.com/science/article/pii/S0386111220301023

World Green Building Council. (n.d.). *The business case for green buildings*. https://ukgbc.org/wp-content/uploads/2017/09/World-GBC-Business-Case-for-Green-Buildings.pdf

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