Distr.: General
7 August 2020

English only

Economic Commission for Europe

Inland Transport Committee

Working Party on Transport Trends and Economics

Thirty-third session
Geneva, 7–9 September 2020
Item 4 (b) of the provisional agenda
Transport infrastructure data:
Benchmarking Transport Infrastructure Construction Costs

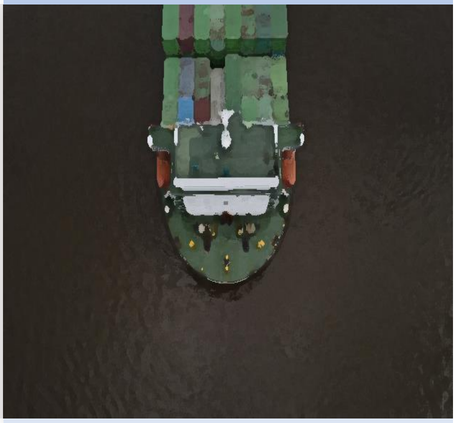
Benchmarking Study for Transport Infrastructure Construction Costs in the ECO region

Submitted by the secretariats of the United Nations Economic Commission for Europe (ECE) and the Economic Cooperation Organization (ECO)

Introduction

1. The attached report has been prepared by an A. Durrani (Reenergia) in the framework of a joint United Nations Economic Commission for Europe (ECE) – Economic Cooperation Organization (ECO) extrabudgetary project regarding the development of a transport infrastructure Geographical Information System (GIS) funded by the Islamic Development Bank (IsDB). The project compiles benchmarking data and practices from the following 10 ECO member States: Afghanistan, Azerbaijan, Islamic Republic of Iran, Kyrgyzstan, Kazakhstan, Pakistan, Tajikistan, Turkmenistan, Turkey and Uzbekistan, all of which are also participating in the UNECE Euro-Asian Transport Links initiative.

2. In the framework of the project, data has been collected on transport infrastructure construction costs covering road, rail, inland waterways and ports as well as intermodal terminals sectors. The data collected has been shared for analytical purposes with the ECE Group of Experts on Transport Infrastructure Construction Costs and is reflected, in part, in the final report of the Group.



Benchmarking Study for Transport Infrastructure Construction Costs

reenergia

UNECE

GLOSSARY: Terms and Definitions

ANNEXURES

LIST OF FIGURES

LIST OF TABLES

List of Acronyms

American Society of Civil Engineers	ASCE
Benchmark Indicative Asset Cost	BIAC
Bernard Williams Associate	BWA
Closed Circuit Television	CCTV
Container Freight Station	CFS
European Economic Interest Grouping	EEIG
Export Credit Guarantee Department	ECGD
Focus Group Discussion	FGD
Gross National Product	GNP
High Capacity Road	HCR
High Classified Road	HCR
Infrastructure and Port Authority	IPA
International Transport Forum	ITF
Key Informant Interviews	KII
Maintenance Performance Indicators	MPIs
Medium Capacity Road	MCR
Medium Classified Roads	MCR
National Corporative Highway Research Program	NCHRP
National Focal Point	NFP
PKP Polish Railway Lines	PKP PLK
Public Private Partnership	PPP
Transport Corridor Europe-Caucasus-Asia	TRACECA
United Nation Economic Commission for Europe	UNECE
Automated Vehicle Identification	AVI
Electronic Toll Connection	ETC
Global Positioning System	GPS
Intelligent Transportation Systems	ITS
Request for Information	RFI

Executive Summary

- *Benchmarking is a measure of effectiveness and expected performance and its' purpose is to find the "reasonably high expectation levels" and to strive to surpass those attributes.* The performance goals for benchmarks can be gauged in the broad dimensions of a) effectiveness b) reliability and c) cost.

- *The benchmarking of transport infrastructure construction costs is a critical step for having realistic construction costs and a stable investment program without unexpected cost increases*. The use of benchmarking of construction costs could also be useful for cost estimates as well as for control of projects' costs—which is why this study is an imperative step taken towards a much broader perspective by intending to benchmark the construction costs of transport infrastructures for eleven countries i.e. Albania, Afghanistan, Azerbaijan, Islamic Republic of Iran, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Turkey, Turkmenistan, and Uzbekistan.

- *The approach to tackling the data for this study was two-pronged—Primary Research via country engagement for data collection and secondary research.* The information gathered through these two approaches was then used for the benchmarking analysis.

- *A significant amount of rescheduling of activities had to be taken into account of changing circumstances*—including a force majeure. The study was completed after an extension of the deadline for two years due to unavoidable extenuating circumstances.

- *Terminologies and standard cost structure for each transport infrastructure category to draft the questionnaires were identified.* In order to prepare the questionnaires for the National Focal Points (NFPs) for primary research, terminologies which are commonly used in the ECE region for construction costs of inland transport infrastructure and a standard cost structure for each type of infrastructure for typical breakdown of costs in relevant categories and units of work were structured. This agreed list of terminologies was then used as a basis to draft the questionnaire to collect data and prepare the benchmarking exercise.

- *Apart from the data collection approaches used in this study, there are a number of other methods which involve technology,* such as a) Use of Point Sensors b) Use of Point to Point Sensors c) Wide Area Sensors.

- *A thorough questionnaire was designed for each inland transport mode.* This was done to ensure that all data pertaining to construction costs is encapsulated for a thorough analysis on benchmarking of transport infrastructure construction costs along the ECE region. The questionnaires for each inland transport mode were based on the ideas of experts monitoring work conducted on each transport mode. These questionnaires were reviewed by experts from UNECE and circulated to all NFPs.

- *The data sample received from the countries was sparse and carried limitations that impacted or influenced the interpretation of the research.* The data received from most countries was not enough for an in-depth analysis—which was a major setback. Most questionnaires were left unanswered—like the ones for ports, intermodal terminals and inland waterways while the questionnaires that were submitted were partially filled. Interpretation of the received findings led to the discovery that that there were few missing details in the questionnaires that inhibited the potential of a thorough analysis.

- *The limited data received from the questionnaire was analysed by comparing the construction costs per km*. Since the focus of the study was on the construction costs of the projects, the data was verified, organized, transformed, and extracted in an appropriate output form for subsequent use. A dataset of 140 projects could be perused—with most projects of roads and railways.

- *In order to analyse the data received for costing of transport infrastructures in different countries*—the construction cost data received in the questionnaire was converted to USD by using the UNECE "Market price exchange rate" tool. For countries which were not reflected in the tool, foreign exchange rate at the end of that fiscal year of 2016 was adopted. Once the errors were removed and the costs were standardized to 2016—all construction cost data was turned into 2016 USD prices by using the GDP Deflators. It must be noted that the GDP Deflator value to turn the cost into 2016 USD prices for the costs reflecting 2019 and 2020 prices were calculated using the average of previous two years. Furthermore, it was pertinent to study the factors that had a direct as well as indirect effect on the construction costs. For that purpose, a summary of input costs was tabulated, and the received data was analysed with the help of the said factors.

- *For the road and railways' analysis, different input costs that have a direct/indirect effect on construction of roads were studied.* Costs of labour (per month), cement bag (per 50kg bag), iron (USD/Ton), concrete (USD/Ton), power cost (USD/unit), wood (USD/40kg) and fuel (USD/litre) were tabulated and normalized to 2016 by using the GDP Deflator Index. The study of these costs showed that input costs for construction of roads in Turkey are found to be highest while the input costs for construction of roads for Kyrgyzstan are found to be comparatively lower. For rail infrastructure, direct input construction costs in Turkey are the highest while the direct input construction costs in Afghanistan are comparatively the lowest.

- *For roads class type, the data was analysed for MCR Primary Roads and HCR Motorways.*

- *For MCR Primary Roads,* it was observed that Tajikistan has comparatively higher final output cost of construction per km than Kazakhstan, Kyrgyzstan and Afghanistan whereas it has comparatively lower direct input costs for construction of roads; implying that there may be various indirect costs affecting the total construction costs of roads in Tajikistan including financial charges relevant to licensing, tender, consultancy, and other price related contingencies. Similarly, final construction costs for MCR Primary Roads in Turkey are estimated to be lowest, while the data for direct input costs indicates that Turkey has the highest direct input costs for the materials used in the construction of roads. This leads to the conclusion that even though the input costs of Turkey are highest as compared to the other countries, it still manages to employ its resources efficiently, thus constructing the road with lowest absolute costs.

- *Data for HCR Motorways was received from Azerbaijan and Turkey only—therefore the analysis was limited.* Turkey had comparatively lower cost of constructing HCR Motorways-Expressways despite having highest construction costs based on the key inputs and due to data limitations explained earlier, Azerbaijan could not be compared to the other countries.

- *The road work types analysed were a) New Construction; b) Reconstruction; c) Resurfacing by Strengthening; d) Reconditioning; e) Expansion (Capacity Improvement).*

- *For new construction of roads*, Turkey has the lowest construction costs; irrespective of having the maximum input costs—implying that the administrative, transaction, and agency costs remain relatively lower in Turkey as compared to other countries. Furthermore, it was seen that Uzbekistan has comparatively higher direct input costs and likewise has comparatively second highest output costs associated with construction of new roads.

- *For roads reconstruction,* it was seen that despite having higher direct input costs, Kazakhstan manages to lower its final costs for reconstruction of roads due to efficient management of the resources. Whereas, Turkmenistan has comparatively lower direct input costs but still have higher output costs. This abnormality entails a significant impact of certain indirect factors that integrally inflate the overall reconstruction costs of roads in Turkmenistan. In addition to this, for Turkey it was seen that regardless of having highest input costs for construction of roads; it has second lowest final costs for reconstruction of existing roads while Azerbaijan not only have higher final costs but also comparatively higher direct input costs for construction of roads per km.

- *For road reconditioning,* it was observed that Turkey, despite having the highest direct-indirect input costs, has the lowest reconditioning costs as compared to the rest of the countries. Moreover, due to data constraints, Azerbaijan could not be compared to other countries, thus leaving the data inconclusive.

- *For road resurfacing by strengthening,* it was observed that while the output costs for resurfacing in context of Uzbekistan are higher as compared to Turkey, the direct input costs of construction in Uzbekistan are relatively lower which shows that certain key factors affect the overall road infrastructure implementation costs.

- *Analysing the data for road surface type, Asphalt,* showed that Turkmenistan records the highest final construction costs for asphalt roads whereas it has been ranked average in the input cost summary. Tajikistan and Kazakhstan seem to have swapped their positions and portrays a different picture when compared to their input costs. While Tajikistan manages to reduce its final output costs, Kazakhstan has a number of indirect factors that heavily influence its output costs. Moreover, a similar trend is observed for Turkey, which irrespective of having the highest input costs for construction of roads, has lowest output cost for asphalt roads.

- *Rail infrastructure construction cost analysis was carried out for each rail characteristic i.e.* New construction, Renewal and Upgrade.

- *For new construction of rails*, it was observed that Turkey is the most expensive country to build new railways infrastructure. This is due to the fact that Turkey has comparatively higher labour costs, fuels costs and the power costs. Azerbaijan follows a similar trend.

- *For renewal of rail infrastructure*, Azerbaijan has higher direct input costs while on the other hand, Turkmenistan has comparatively lower output costs than Azerbaijan which reinforces the analysis of having comparatively lower direct input costs.

- *For railway infrastructure upgradation,* Uzbekistan has the highest output costs while Turkmenistan has the lowest output costs. Kazakhstan, despite being above Tajikistan in input costs, manages to employ its resources efficiently and subsequently reduce its output cost for the upgradation of the rails. Whereas, Tajikistan, despite having third lowest labour costs, seems to have involved other factors and indirect costs which increases its' total actual construction costs.

- *Analysing the data for electrified lines* showed that Turkey has comparatively higher final construction costs than Turkmenistan and corroborate the fact that Turkey has higher direct input costs for the construction of the rails. Turkmenistan, on the other hand, has the lowest final construction costs when constructing the electrified rails. Moreover, for non-electrified lines i.e. Azerbaijan is the costliest country to build non-electrified rails when compared to the other countries whereas the direct input costs for construction in Azerbaijan are comparatively lower than Turkey. It was observed that this situation changes for Turkey as it has lower final construction costs when compared to Azerbaijan but has comparatively higher direct input costs. This shows that Azerbaijan has some hidden costs involved when it comes to building non-electrified rails.

- *When comparing the data of the construction costs per km for the rails having the velocity less than 120 Km/h*, it was observed that Azerbaijan has higher direct input costs than Tajikistan. The same is reflected in the final construction costs as the factors that may directly or indirectly affect the construction costs of the projects are higher in Azerbaijan than in Tajikistan. When comparing the data for construction costs per of the rails having the velocity more than 120 Km/h but less than 160 Km/h, it was seen that Turkey, despite having higher input costs like labour costs, power costs and the fuel costs, has lower final output costs than Uzbekistan. Whereas, Uzbekistan having comparatively lower direct input costs, is ahead of turkey when it comes to final construction costs for the rails with 120<V≤160-line speed design.

- The scope of this study is just the tip of the iceberg and if explored in more depth, could pave a way for more avenues to branch out in transport infrastructure benchmarking.

- *Another round of primary data collection should be conducted for quality improvement.* The data targeted for this study holds tremendous potential to become a ground-breaking study, if given the opportunity to re-conduct the survey to gather more data.

- *In order to add meat around the bones of the study—Key Informant Interviews (KII) are an imperative tool.* Conducting KIIs [virtually or in person, depending upon the situation at hand] will be the most important tool for the analysis as this allows the stakeholders from each country to reference the different projects—significant, recent, ongoing and proposed; which would result in a coherent and more in-depth benchmarking analysis.
- *Revamping the Questionnaire is pertinent to develop the bigger picture.* Adding more fields to the original questionnaire draft will add more weightage to the analysis.

- *It will be a promising prospect if the scope of Transport Infrastructure Benchmarking is explored beyond costing.* It would be interesting to see the results if the transport infrastructure of the eleven countries are benchmarked in terms of their operations, functions and performance.

- *Meeting with the experts before the regional workshop* would help identify key facets of the study that could be taken up for more further research and to devise a way forward for the data currently at hand.

Chapter 1: Background and Objectives

1.1. Background of the Mission

Benchmarking of transport infrastructure construction costs is a critical step for having realistic construction costs and a stable investment program without unexpected cost increases. The use of benchmarking of construction costs could also be useful for cost estimates as well as for control of projects' costs.

For this purpose, United Nations Economic Commission for Europe (UNECE) brought together a group of experts in order to benchmark the construction costs of transport infrastructures for eleven countries i.e. Albania, Afghanistan, Azerbaijan, Islamic Republic of Iran, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Turkey, Turkmenistan, and Uzbekistan.

Figure 1 Map of Countries

Originally, the project was divided into three components. The first component dealt with the preparation of the list of potential investment projects and their prioritization as well as the establishment of a GIS database with transport networks. The second component dealt with review and analysis of the received data and responses collected. It also included missing data gaps to be identified, and then revising the questionnaire to collect the specific responses missing from existing data and conducting the appropriate analysis. The third component was based on good practices for financing transport infrastructure.

1.2. Objectives of the Study

The transport infrastructure targeted for this study were:

a) Road
b) Railways
c) Waterways
d) Ports
e) Intermodal terminals

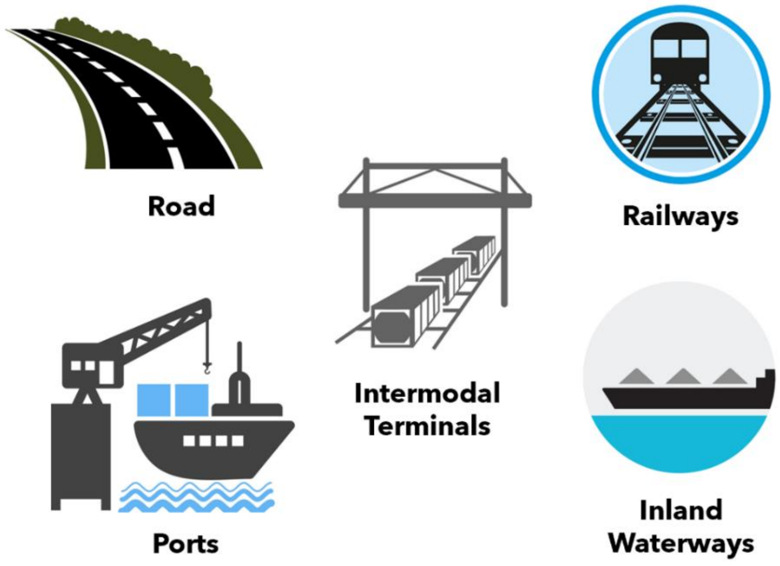


Figure 2 Targeted Transport Infrastructure

For our study, originally the main objectives of the study covered:

1. Identifying models, methodologies, tools, and good practices for evaluating, calculating, and analysing construction costs of inland transport infrastructure.

2. Identifying and listing the terminologies used in the UNECE region for construction costs of inland transport infrastructure;

3. Collecting and analysing data in order to prepare a benchmarking of transport infrastructure construction costs along the ECE region for each inland transport mode.

4. Organization of a regional workshop presenting the findings from the study.

1.2.1. Resetting the Project Objectives in 2020

The project started in 2018 and had a clear set of objectives, however, due to unavoidable extenuating circumstances; the project pushed from four months to two years; the objectives of the study were re-defined as follows:

1. Providing a Literature review on various benchmarking definitions, theories, concepts, methodologies, and best practice approaches used worldwide.

2. Conducting a Benchmarking analysis by identifying and listing the terminologies used as well as the analysis of the data submitted by the NFPs.

3. Providing the experience on transport infrastructure cost benchmarking in the region.

4. Organization of a regional workshop presenting the findings from the study.

1.3. Limitations of the Study

This project started in 2018, with the intention of wrapping it up in four months. However, with time, it was subjected to a number of factors which stretched the project delivery timeline to over 2 years where eventually, in 2020, the COVID-19 pandemic struck and put a final nail in the coffin of the hopes of delivering the project with the original objectives set out for it.

1.3.1. Force Majeure: The Pandemic

In Early 2020, there was an outbreak of COVID-19, also known as *Corona Virus* or *SARS-CoV-2*[1]—a highly contagious virulent disease which permeated every aspect of the daily life and brought everything to a standstill.

This pandemic served to be major hurdle for the study completion, and it was mutually decided to reset the project objectives in a way which is more suitable to the post-pandemic scenario and enabled the team to deliver the study efficiently.

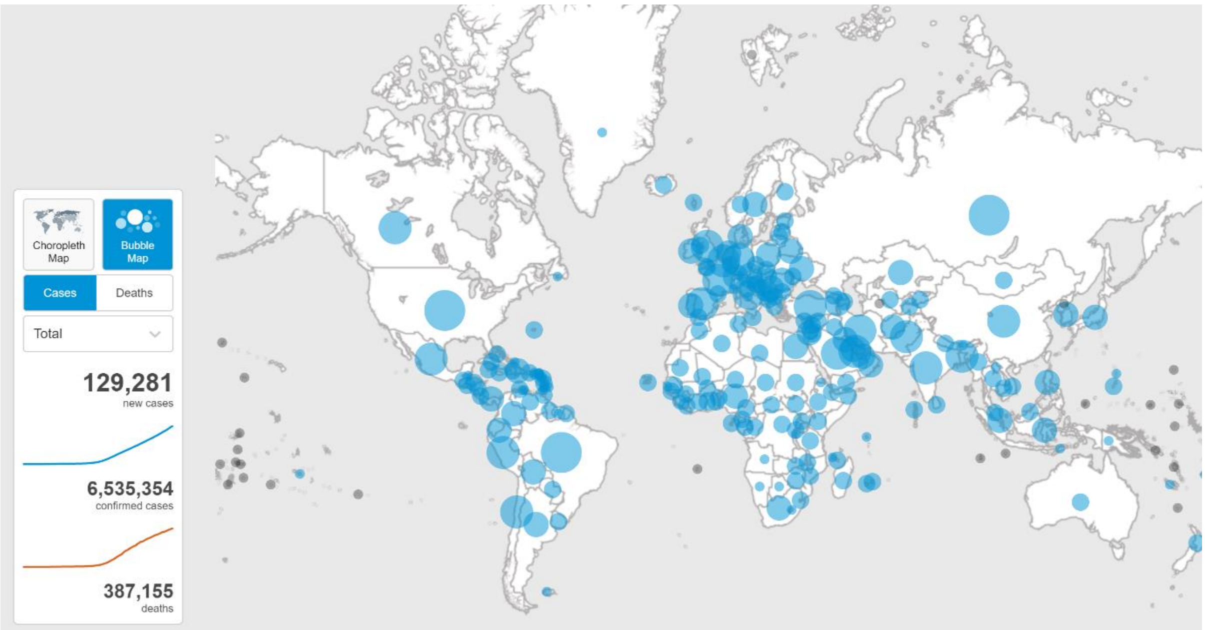


Figure 3 Snapshot of the WHO Coronavirus Disease (COVID-19) Dashboard - Taken on 5th June 2020

1.3.2. Coordination

One of the most important deliverables of the study was collecting and analysing data in order to prepare the benchmarking of transport infrastructure construction costs along the ECE region for each inland transport mode. This aspect of the study required extensive coordination between relevant stakeholders i.e. the Economic Cooperation Organization (ECO) Secretariat, Governments focal points, National consultants, Islamic Development Bank experts and the UNECE secretariat. However, there were some unforeseen circumstances which led to the change of team of the representatives of the ECO secretariat, which contributed to pushing the timeline of the project farther than it was originally planned. Furthermore, reaching out to the NFPs served as a real challenge to the ECO team members as the data had to be collected from eleven countries, and it took a long time to collect the data from eleven focal points.

1.3.3. Responses

An important part of the project study revolved around coordinating with the relevant stakeholders of the project as well as the stakeholders in each country. A questionnaire was prepared for each transport category and distributed to NFPs of each country's Government in order to collect all relevant benchmarking data. However, there were subsequent delays in receiving the responses from the NFPs and even though the questionnaires were circulated and recirculated in different rounds, the data received in response was sparse.

[1] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it

Chapter 2: Approach and Methodology

For benchmarking and analysing the transport infrastructure costs, the approach for this study included; (a) Primary Research i.e. Country engagement for data collection and (b) Secondary Research. The information gathered through these two approaches was then used for the benchmarking analysis.

Apart from the data collection approaches used in this study, there are a number of other methods which involve technology, such as a) Use of Point Sensors b) Use of Point to Point Sensors c) Wide Area Sensors. These methods are explained further in the report.

2.1. Terminologies for Benchmarking the Inland Transport Infra Costs

In order to prepare the questionnaires for the NFPs for primary research, terminologies which are commonly used in the ECE region for construction costs of inland transport infrastructure were identified and a standard cost structure for each type of infrastructure for typical breakdown of costs in relevant categories and units of work were structured. This agreed list of terminologies was then used as a basis to draft the questionnaire to collect data and prepare the benchmarking exercise.

2.1.1. Road Terminologies

The terminologies for Road were derived after a thorough perusal of National Cooperative Highway Research Program (NCHRP) reports, AASHTO M 146, ASTM D8 and more. The glossary for the terminologies is attached to this report.

2.1.2. Rail Terminologies

The terminologies for Railways were carefully compiled as per the definitions defined by the experts of PKP Polish Railway Line with the help of Directive (EU) 2016 of the European Parliament and of the Council, University of Birmingham and Network Rail Railway Lexicon Mk 24, Eurostat, International Transport Forum (ITF), and more. The glossary for the terminologies is attached to this report.

2.1.3. Inland Waterways Terminologies

For Inland Waterways, the terminologies were derived after careful consultation of the National standards of member countries of the Working Party on Inland Water Transport, UNECE resolution No. 30 on Classification of European Inland Waterways, International Association of Marine Aids to Navigation and Lighthouse Authorities, Illustrated Glossary for Transport Statistics, American Society of Civil Engineers (ASCE) and more. The glossary for the terminologies is attached to this report.

2.1.4. Ports Terminologies

The terminologies for Ports were drafted after consulting the Illustrated Glossary for Transport Statistics, American Society of Civil Engineers (ASCE) and more. The glossary for the terminologies is attached to this report.

2.1.5. Intermodal Terminals Terminologies

For intermodal terminals, the terminologies were derived after consulting the World Review of Intermodal Transportation Research, Policy Options for Intermodal Freight Transportation and more. The glossary for the terminologies is attached to this report.

2.2. Drafting Questionnaires for Benchmarking the Inland Transport Infra Costs

A thorough questionnaire was designed for each inland transport mode to ensure that all data pertaining to construction costs is encapsulated for a thorough analysis on benchmarking of transport infrastructure construction costs along the ECE region. The questionnaires for each inland transport mode were based on the ideas of experts monitoring work conducted on each transport mode.

Once the questionnaires were drafted, they were reviewed by assigned experts from UNECE and then redrafted as per the comments received. The questionnaire for road infrastructure was reviewed by General Directorate of Turkish Highways; rail infrastructure by PKP Polish Railway Lines (PKP PLK); Ports questionnaire by the Port Authority of Gdynia S.A. and the intermodal terminal infrastructure by Euro platforms EEIG.

Regarding the scope of work and elements of infrastructure important to construction, all categories related to documentation were removed – feasibility studies, administrative fees and designs. However, each questionnaire of each transport mode had a section on social and economic factors covering the investment budgets, infrastructure investments, design costs, GNP and more.

Furthermore, two alternative options were accepted for providing data through the questionnaires i.e. a) Provision of normalized data for 2016 or, b) Provision of specific inland transport infrastructure project data. Each country was also requested to provide socio-economic indicators for each category.

2.2.1. Country Engagement

The team primarily coordinated with the Economic Cooperation Organization in Tehran, Islamic Republic of Iran in order to engage with the national focal points/consultants for Governments involved in the project from Albania, Afghanistan, Azerbaijan, Islamic Republic of Iran, Kazakhstan, Kyrgyzstan; Pakistan, Tajikistan, Turkey, Turkmenistan and Uzbekistan. This engagement was virtual through the entirety of the project, where the NFPs provided the data in the form of questionnaires pertaining to road, rail, inland waterways, ports and intermodal terminals infrastructure construction costs.

Before the questionnaires were circulated to the countries, a relevance checklist was shared with all NFPs to establish a better understanding of the type of infrastructure the Governments of each country were dealing with. A sample of the relevance checklist is attached in Annex F. The relevance checklist was circulated in three different rounds; however, no conclusive data was received—which led to the decision of circulating all the questionnaires to all the countries.

2.2.2. Road Questionnaire

The questionnaire for Road Infrastructure drafted was reviewed by the General Directorate of Turkish Highways and embodies the following categories;

2.2.2.1. Social and Economic Indicators

The social and economic indicators for Road infrastructure covered;

1. The length of roads [including single carriageway and double carriageway]
2. Lengths of bridges and tunnels
3. Annual investment budget of roads
4. Annual road investment by PPP and as percentage of GNP
5. Annual constructed roads in length [including single carriageway and double carriageway]

2.2.2.2. Construction Costs of Bridges and Tunnels

The construction costs of different types of bridges and tunnels were requested to be provided in USD 2016 prices and excluded design costs, land acquisition costs and value-added cost.

2.2.2.3. Construction costs of Asphalt and Concrete roads—Single Carriageway and Double Carriageway

The Road questionnaire was systemically designed around: 1) Road Surface Type
2) Road Class Type 3) Road Work Type

1) <u>Road Surface Type:</u>

The questionnaire dealt with two types of road surfaces:

a) Asphalt

b) Concrete

2) Road Class Type:

The Road classes were divided into:

a) High Capacity Roads (HCR): Motorways-Expressway
b) Medium Capacity Roads (MCR): Primary Roads and Secondary Roads

3) Road Work Type:

The questions for the type of road work were based on;

a) Resurfacing
b) Resurfacing by Strengthening
c) Pavement Replacement
d) Reconditioning
e) Reconstruction
f) Expansion (Capacity Improvement)
g) New Construction

A sample of the Road Questionnaire is attached as Annex A.

2.2.3. Rail Questionnaire

The data on new construction of rail, upgrade or renewal projects was requested between the years 2007-2016, excluding design costs, land acquisition costs and value-added costs. The questionnaire was reviewed by PKP Polish Railway Lines (PKP PLK) and was based on the following themes:

1) Type of Work

The questionnaire for Rail has been divided into three types of work:

a) Construction
b) Upgrade
c) Renewal

2) Type of Lines

The types of lines were specified as:

a) Electrified
b) Non-Electrified

3) Categories of Speed

Furthermore, the number of categories of speed were adjusted to each type of work. The speeds defined were as follows:

a) V<120
b) 120<V≤160 km/h
c) 160<V≤200 km/h
d) 200<V≤250 km/h
e) V>250 km/h

A sample of the Rail Questionnaire is attached as Annex B.

2.2.4. Inland Waterways Questionnaire

The questionnaire for inland waterways covered the construction costs for various aspects of land expropriation, mobilization, engineering works, canal excavation & dredging (including transportation and disposal), construction of outer protection boundary of sea filling areas, canal bank & bottom protection, imperviousness of canal, auxiliary structures at entrances of the canal, emergency and waiting mooring basins, streams connections, road along both sides of canal, canal operation and maintenance structures and the construction of yacht and logistic harbour(s).

A sample of the Inland Waterways Questionnaire is attached as Annex D.

2.2.5. Ports Questionnaire

The Ports questionnaire was divided into three types of work i.e. Construction, Upgrade, and Renewal. The costs pertaining to different aspects of hydrotechnical infrastructure, quay(s); road rail, sewage, electricity and heating infrastructure; terminals; Loading/unloading and safety infrastructure, warehouses, cold storage, storage yards, office buildings, conveyor (grain silo), liquid fuel containers and fire safety were captured in the questionnaire. The questionnaire for ports was reviewed by the Port Authority of Gdynia S.A.

A sample of the Ports Questionnaire is attached as Annex C.

2.2.6. Intermodal Terminals Questionnaire

The questionnaire for intermodal terminals was reviewed by Euro platforms EEIG and covered the costs of land adaptation, intermodal terminals, truck parks, container freight station (CFS), internal roads, pavements, conduits, roads installation, cables, portable water supply, power supply, rain drainage, facilities complex, dark water treatment, telecom supply, warehouse, fire prevention, green areas, CCTV and access control.

A sample of the Intermodal Terminal Questionnaire is attached as Annex F.

2.3. Data Analysis Methodology

The questionnaires were circulated for five transport infrastructures, as explained above.

A quick summary of the questionnaires with usable data received from each country is summarized below:

List of Countries	Rail	Road	Inland Waterways	Intermodal Terminals	Ports
Albania					
Afghanistan		✓			
Azerbaijan	✓	✓			
Iran					
Kazakhstan	✓	✓			
Kyrgyzstan		✓			
Pakistan	✓	✓		✓	
Tajikistan	✓	✓			
Turkey	✓	✓			
Turkmenistan	✓	✓			

List of Countries	Rail	Road	Inland Waterways	Intermodal Terminals	Ports
Uzbekistan	✓	✓			

Table 1 Summary of Questionnaires with Usable Data Received per Country

As seen in the table above, even though the questionnaires were circulated in numerous rounds; the data received was scattered and sparse. Which is why, the analysis was limited and could not be as coherent as it was expected.

2.3.1. The Data Statistics

A dataset of 140 projects could be perused—with most projects of roads and railways. Out of the eleven countries; Afghanistan, Azerbaijan, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Turkey, Turkmenistan and Uzbekistan were the countries who contributed data for the road questionnaire while the Rail projects comprised of data from Azerbaijan, Kazakhstan, Tajikistan, Turkey, Turkmenistan and Uzbekistan only. Pakistan was the only country that provided a couple of lines on the data of intermodal terminals while no country provided data for Waterways or Ports.

2.3.2. Approach for Data Analysis

The results of the questionnaire turned out to be useful to gain insights into the difference observed in construction costs per km. Since the focus of the study was on the construction costs of the projects, the data was verified, organized, transformed, and extracted in an appropriate output form for subsequent use.

2.3.2.1. Data Reverification

After ensuring the integrity of the data, a comprehensive data verification strategy was applied to ensure that the data is free from any human or logical errors. The project details shared in the questionnaires were reverified using desk research to remove any typo errors or any misrepresentations.

2.3.2.2. Removing the Blanks

As mentioned earlier, the data received was sparse and scattered. The first challenge was to bring the data to a readable format which could later be analysed. For that purpose, all the projects with missing construction costs and project lengths were removed from the final dataset, as they did not serve any purpose to the study.

2.3.2.3. Standardizing the Cost Unit

Different countries gave their costs in their National Currencies, for example Afghanistan and Kazakhstan. Since all values were to be handled in USD, all construction costs were then converted to USD. This was carried out using the UNECE “Market price exchange rate” tool[2]. For countries which were not reflected in the tool, foreign exchange rate at the end of that fiscal year of 2016 was adopted.

2.3.2.4. Data Normalization

Once the errors were removed and the costs were standardized to 2016—all construction cost data was turned into 2016 USD prices by using the GDP Deflators[3]. The GDP price deflator was used as it presents a more accurate portrait of an economy where currency values may be in flux.

$$\text{GDP Price Deflator} = (\text{Nominal GDP} \div \text{Real GDP}) \times 100$$

Using the UN GDP Deflators, changes in prices over several periods were measured. The implicit price deflator value was divided by 100 and then in order to bring the prices to the prices of the year 2016, the costs of the concerned projects with the result was divided. However, for the data reflecting 2019 and 2020 prices an average value from the previous two years were used for GDP Deflator.

[2] https://w3.unece.org/PXWeb2015/pxweb/en/STAT/STAT__20-ME__6-MEER/30_en_MECCExchPPPsNEWY_r.px/
[3] unstats.un.org/unsd/amaapi/api/file/15

2.3.2.5. Compilation of Data

Once the data was normalized to 2016— it was combined into a single spreadsheet and analysis was carried out to determine differences between the construction costs per km across the countries.

2.3.2.6. Delving into the Data

In order to better appreciate the meaning of the results obtained in the course of this study, data for the construction projects were compared with the different factors influencing the construction costs including the direct input costs of the construction in order to a) Determine why some countries report more costs of constructions and b) determining the factors that affect the construction costs in varying degrees.

2.3.2.7. Data Limitations

The data sample received from the countries was sparse and carried limitations that impacted or influenced the interpretation of the research in the following capacities:

Data Sparsity

The data received from most countries was not enough for an in-depth analysis—which was a major setback. Most questionnaires were left unanswered—like the ones for ports, intermodal terminals and inland waterways while the questionnaires that were submitted were partially filled. For example, most road questionnaires were partially filled and breakdown project costs like the costs of bridges and viaducts, tunnels, pedestrian crossings etc. were left out. Such cases left no room to analyse the data in any way. Furthermore, the sample size was very constricted and could not offer much synthesis. For example, only 2 road projects for Kyrgyzstan and Turkmenistan were provided which led to inconclusive results.

Missing Links and Data Access;

Interpretation of the received findings led to the discovery that that there were few missing details in the questionnaires that inhibited the potential of a thorough analysis of the results like lane width, international standards etc. This served as a challenge because there is limited data available on open sources for such aspects and even fewer research studies on construction costs' benchmarking that could help a thorough analysis.

2.4. Exploring More Data Collection Methods on the Performance of Transport Infrastructure—Use of Technology

Intelligent Transportation Systems (ITS) are being widely used to better manage and improve the existing transportation infrastructure of a country. Through use of sophisticated data collection technologies for example electronic transponders and global positioning system (GPS) and traffic models systems, we can easily improve the efficiency of existing transportation models, maximize capacity, minimize delays and improve reliability of transportation system.

Accurate traffic data and knowledge of existing traffic congestions are important for supporting a variety of transportation related decisions which affect the transportation related operations and ultimately cause delays. There are various advanced sensor technologies for collection and representing real time travelling data and thus provide means to improve the overall transportation operation.

2.4.1. Use of Point Sensors

Point Sensors includes inductive loop sensors, radar/infrared/microwave/ ultrasonic sensors, video image detection system and weigh-in-motion (WIM) which are normally installed at fix position usually at major intersections to collect traffic data. These are also highly accurate and low maintenance machines.[4]

2.4.2. Use of Point to Point Sensors

Through use of these technologies' vehicles can be detected at multiple locations of route. This also support re-identification and tracking facilities, which can provide point to point travel times, route choice fractions and paths.

Technologies in this category include:

a) Automated Vehicle Identification (AVI) systems
b) Vehicle Identification without driver (cooperation)
c) License Plate Recognition system

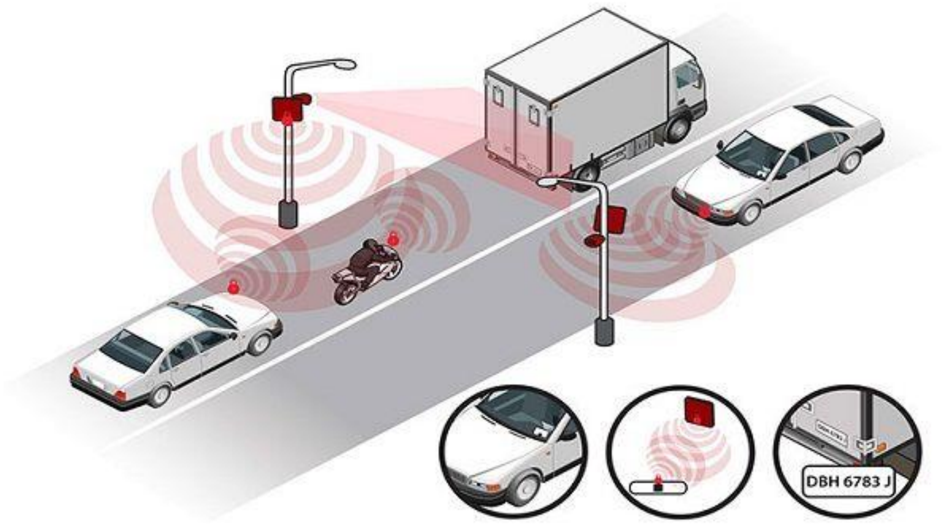


Figure 4 Automated Vehicle Identification (AVI) systems[5]

2.4.2.1. Electronic Transponders

Electronic Transponders are mainly used as secondary transmitter in the Electronic Toll Connection (ETC), which is a wireless system used to collect toll fee. Electronic transponders are installed on the windshields of vehicles gets triggered when they received radio signals from the ETC, and it transmits back an identification number of the vehicle. Electronic Transponders are mainly used in AVI system in order to expedite the whole process to E-ticketing at ETC.

These transponders can also provide a path for data collection via when linked with a software the transponder-equipped vehicles could become a travel-time probe fleet.

---

[4] A Synthesis of emerging data collection technologies and their impact on traffic management applications, https://link.springer.com/article/10.1007/s12544-011-0058-1

[5] Know the Future of Automatic Vehicle Identification (AVI) Systems Market, North India Herald.

2.4.3. Wide Area Sensors:

Aforementioned technologies are mainly limited to collect data only related to in-land transportation therefore wide area sensors is used to expand range of in term of other modes of transportation. These sensors include electronic transponders and global positioning system (GPS). These sensors have potential to provide traffic data for real time monitoring, traffic congestion information, best route selection and traffic predictions.[6]

2.4.3.1. Global Positioning System (GPS):

GPS technology is widely used by various transportation agencies including city planning organization, transportation department in governments and transportation engineering consultants. Both private and public sectors use GPS for vehicle navigation system and fleet tracking system. Some of the major applications of GPS in transportation systems can be identified as follows.

A. Vehicular Travel Analysis:

Basic determination of vehicular locations is essential pre-requisite for hosting an intelligent transport system which is truly relevant for freight and public transport operations. GPS placed in vehicle can be used to collect specific traffic movement data at pre-set time intervals. Upon analysis, it can be understood where the vehicles experienced congestion and through traffic modelling and various tools, one can create useful performance statistics to alleviate traffic congestion. In depth vehicular travel analysis can provide some useful information for example arrival time information, in-vehicle navigation, intelligent speed adaption and advance driver assistance system.

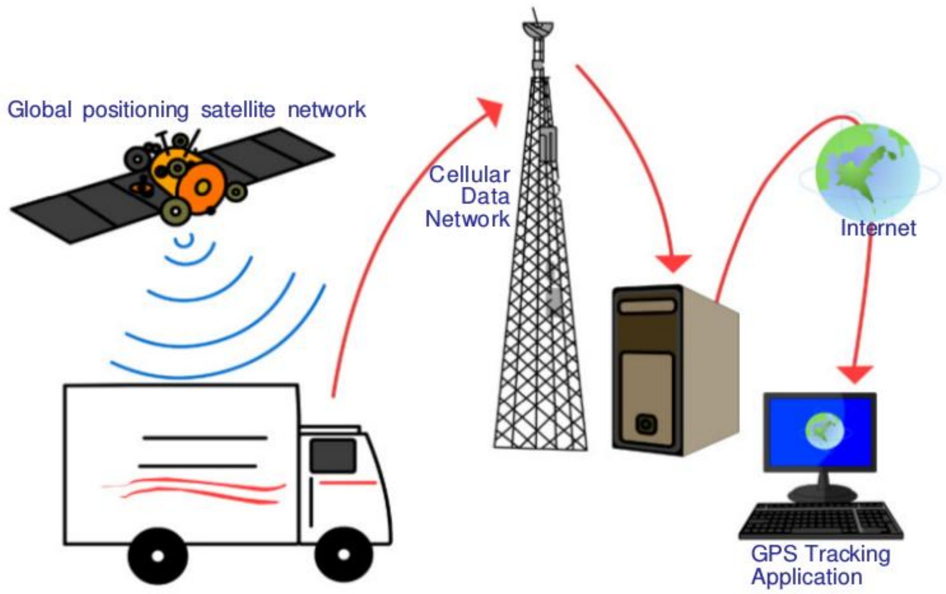


Figure 5 GPS Tracking System for Data Collection on Traffic Congestion and Travelling Time[7]

B. Traffic Monitoring:

Traffic congestion is one of the critical problems worldwide in many urban. To identify causes of congestion and road strength, Road Capacity Manual (RCM) can be generate based on degree of services, capacity ratio and travel time measurements. GPS placed in a vehicle can automatically record all the relevant which is necessary for generating RCM.

[6] GPS Applications in Transportation System, Teesta Dey Junior Research Fellow Department of Geography, University of Calcutta
[7] GPS system, BITS.Pvt. Ltd

Chapter 3: Benchmarking Studies

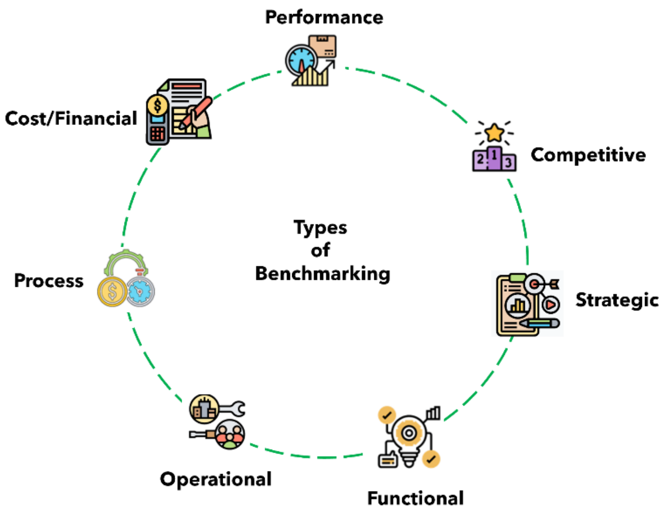
3.1. Benchmarking - At a Glance

Benchmarking is a systematic comparison of relating key performance metrics and business processes with the industry's best practices to create new standards or to improve processes. It is a measure of effectiveness and expected performance. Commonly the dimensions measured for benchmarking include *quality, time, and cost.*[8] In order to conduct a thorough benchmarking activity, a specific indicator is used to generalize the overall performance in order to be compared with the high rates metrics. The concept of benchmarking is an imperative everyday strategic tool to assess the existential performance dynamics and appraising with the available optimal options to improve overall performance.[9] A vastly used approach for benchmarking involves garnering optimal options in a peer group for a profound comparative analysis and the viewpoint of optimization through effective benchmarking of processes and cost has become a popular procedure in project implementation.

3.2. Key Concepts & Types of Benchmarking

The purpose of benchmarking is to find the "reasonably high expectation levels" and strive to surpass those attributes.

The popular theories of benchmarking mainly delineate the prevailing kinds of performance appraisals that imperatively impact overall activities of organizations. As per the prevalent theories, the process of benchmarking can either be internal or external mainly depending on the nature of organization and processes. Executive Agency should consider both external and internal benchmarking. External benchmarking can be done by identifying the best private sector corporations that develop civil engineering style plans and then working towards those quality plans. Internal benchmarking can done by identifying the best organizational division, without regard to function, and then working towards those attributes.



The major types of benchmarking are as follows[10]:

- Process Benchmarking
- Performance Benchmarking
- Competitive Benchmarking
- Strategic Benchmarking
- Functional Benchmarking
- Operational Benchmarking
- Cost/Financial Benchmarking

3.2.1. Cost/Financial Benchmarking

Cost benchmarking is a method to compare the cost competitiveness against those of similar counterparts.[11] The nature of benchmarking depends upon the nature of procedural processes. In the infrastructure development sector, the benchmarking of cost and financials is undertaken to enhance the competitiveness of the project under

[8] https://en.wikipedia.org/wiki/Benchmarking
[9] https://www.ukessays.com/essays/management/overview-of-benchmarking-theory-management-essay.php
[10] https://www.isixsigma.com/methodology/benchmarking/understanding-purpose-and-use-benchmarking/
[11] https://www.everestgrp.com/2013-10-the-three-foundational-elements-of-cost-benchmarking-sherpas-in-blue-shirts-12216.html/

implementation with a view to mitigate additional burden due to excessive cost and improve its score in the all-inclusive Cost-Benefit Analysis.

3.3. Significance of Cost Benchmarking

The key models of finance and economics clearly indicate the importance of undertaking a comprehensive financial analysis with greater stress on cost evaluation. Thus, the significance of cost benchmarking becomes an imperative tool to evaluate key processes having the inclusion of cost and profitability in the public-private spheres. Cost Benchmarking is the measurement, refinement, and analysis of one's cost incurred in performing any activity as compared to the cost incurred by the optimal peer group.

It defines the competitiveness of pricing and highlights the areas where the competitiveness of pricing can be improved. Cost is the major concern while pursuing infrastructure related projects especially related to physical infrastructure mainly the transportation infrastructure. However, with the development of the intellectual capabilities, the processes of benchmarking have also geared up with technology.

The transnational connectivity through various modes of transportation available is an explicit example of the implausible growth of benchmarking conceptions related to process, performance, operational, strategic, and cost benchmarking.[12]

It becomes hard for governments and private agencies to accurately estimate the cost of building infrastructure projects that leads to variation in budgeting and implementation procedures. The variation in cost is vast depending upon nature of project and implementation environment; however, the cost benchmarking aims at normalizing the spread of estimated cost and adjusting it to an optimal benchmark level. Since transportation development embodies diverse variables of costs that fluctuate throughout the project's lifetime, it makes the overall cost comparisons highly tedious.

3.3.1. Cost benchmarking in infrastructure projects—the context of the Basic Economic Problem

The basic intuition behind pursuing the cost benchmarking exercise in infrastructure projects is to level up the basic economic doctrine that highpoints the weight of scarcity of resources and the highly imperative concept of opportunity cost.[13] With constrained capital and physical resources, it is very important to optimize different components of the infrastructure development. For this purpose, Cost benchmarking is a helpful tool which can help optimize the cost components and enhance the overall project implementation.

3.4. How Benchmarking is Conducted

The process of benchmarking[14] includes a thorough consideration of existing performance indicators and further comparing them with the industry's optimal option with the need to add value. The procedures adopted for benchmarking may vary amongst organizations, but the intrinsic intuition and concept remains the same as defined below.[15]

[12] https://dynamicbusiness.com.au/topics/workplace/managing-blogs/a-beginners-guide-to-cost-benchmarking-12032013.html
[13] https://www.philadelphiafed.org/education/teachers/publications/intersections/2006/spring/opportunity-cost#:~:text=Scarcitypercent 20percent E2percent 80percent 94percent 20Thepercent 20conditionpercent 20thatpercent 20exists,whenpercent 20apercent 20choicepercent 20ispercent 20made.
[14] Boxwell's Benchmarking for Competitive Advantage (1994)
[15] https://www.lucidchart.com/blog/8-steps-of-the-benchmarking-process

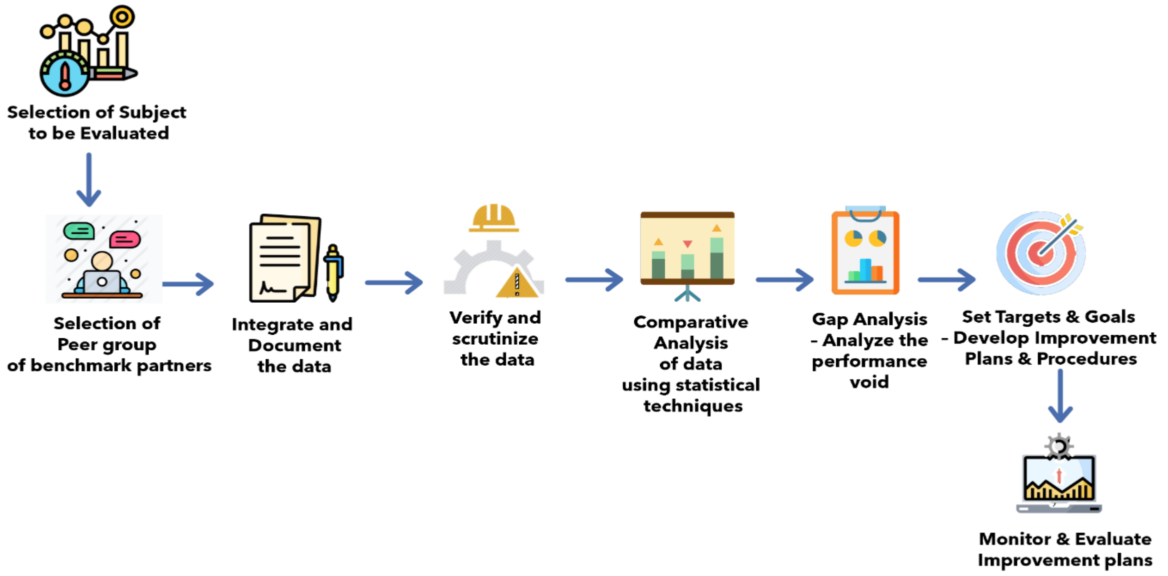


Figure 6 Standard Benchmarking Procedure

Setting the targets for performance enhancement is relatively simpler as compared to effectively pursuing the improvement procedures. Thus, the process of benchmarking substantively considers the importance of commitment and fastidious efforts in actualizing the set targets. Moreover, it must also be kept into consideration that the procedures for bridging the performance gaps must symbolize enriched knowledge, better-quality practices, and upgraded processes.

Benchmarking—A Self Driven Mechanism

The entire process of benchmarking follows a self-driven approach as the progressive process embodies motivational backups at all stages of planning, analysis, integration, and action.[1]. The crucial part is to identify the bottlenecks if any, and to devise a strategy to overcome them. However, it must be kept into consideration that benchmarking entirely depends on the selected benchmark partner as the entire evaluation drives around the traits and abilities of the benchmark partner. Once, the data collection and the comparatively analysis between the subject and its peer group is efficiently done, the process gains momentum itself and follows a self-driven trajectory.

3.5. Best Practice Approach for Benchmarking

Benchmarking is not just about the data; rather the implications of culture and broader circumstances must be taken into account when the results are viewed. The best practice must demonstrate through evidence that it embodies potential to yield a better, quicker, and cheaper result. Moreover, it must also ensure that the organizational objectives are achieved in much more effective way than any other secondary practice. However, utilization of best practices somehow faces immense impediments with regard to key constraints across management, data collection & analysis, integrating responses, and pursuing drafted agenda.

An overall research shows that the best practices involve prudency in setting up the benchmarking process, analysing the pros and cons of each implication at every stage, and adopting meticulous measures while surveying, and analysing data.

The best practice approach of benchmarking includes:

3.6. Benchmarking Transportation Cost – Analysis of Case Studies

There are different components of costs for different modes of infrastructure projects of Road, Rails, Ports, Airports, Inland Waterways, Pipelines, and Terminals. The costs include Capital costs, operational costs, and fixed/variable costs. Moreover, the case studies define certain key drivers for infrastructure development costs that include Life Expectancy, Linear/Non-Linear Depreciation costs, Time span, Maintenance costs, and Interest Rate.

Likewise, certain parameters also affect the costs that include economic development of the country, availability of natural resources, quality of construction, type of topography, and other environmental factors. A profound research shows that different modes of transportation have different approach towards cost accounting, thus different cost analysis and benchmarking mechanism.[16]

3.6.1. Case Study 1: Benchmarking of use of Construction (Costs) Resources in the Member States i.e. France, Spain, Italy, Germany, UK, Ireland, Belgium, Netherlands, Finland, Denmark, Czech Republic, Poland and Hungary. (Pilot Study)

This pilot study was conducted by Bernard Williams Associate s (BWA) and was called "Benchmarking of Construction Costs in the Member States" commissioned by ECDG Enterprise and Industry Construction Unit."[17]

Project Stages

The project had six stages.

In Stage 1, literature review was conducted and collected in the form of a report. Stage 2 – Once the project commenced, the reports were reviewed, and a 'snowball' process generated an exceptionally large number of 'leads' which led to relevant material being discovered. Stage 3 was the stage where the reports were collected. Stage 4 was the stage of conducting FGD where the attendees were requested to advise the researchers of any relevant projects being carried out in their own countries. This helped produce leads to more significant research projects like those available for public consumption. Stage 5 was classifying the reports and papers which were then developed using an alpha -numerical reference system · Stage 6 – having assembled and classified the material the next stage was to distil from the material relevant information regarding names and contact details of researchers who might be able to assist the project in some way; assessment of the quantity and quality of

[16] https://www.unece.org/fileadmin/DAM/trans/doc/2014/wp5/7_Mr_Tsamboulas_WP5_workshop_8Sept2014.pdf
[17] http://ec.europa.eu/DocsRoom/documents/5141/attachments/1/translations/en/renditions/native

information available in respect of each of the 'short -listed' countries and analysis of material in the context of its potential use within the 'First Strike' Benchmarking activity.

Project Outcome

The project undertook a review of related construction industry studies carried out over the past 20 years (at both European and national levels) and drew conclusions from the studies identified as to the relative efficiency of resource usage between different member state's construction industries. Furthermore, it identified the various factors that affect resource usage in the construction process and based on the factors, drew a conclusion as to the impact that these factors have on the efficiency of resource usage. A survey of the representative sample of public and private construction industry stakeholders was also conducted in order to ascertain their views as to the findings of the preceding areas of work.

The project delivered a number of important innovative elements:

a) The quality and reliability of the data and the findings were subjected to extensive due diligence
b) The case study highlighted a number of problems encountered and suggested how they might be addressed in future projects
c) Numerous excellent contacts were made with stakeholders of all categories in most countries, although the team's rigorous attempts to forge contacts with Spain and Italy proved to be generally unrewarding.
d) There was generally considerable enthusiasm for the project and the prospect of involvement in any further developments.

3.6.2. Case Study 2: Benchmarking tunnelling costs and production rates in the UK

A case study undertaken by Infrastructures and Port Authority – IPA titled: *Benchmarking tunnelling costs and production rates in the UK* [18] has been analysed to embody the aspect of cost benchmarking with regard to project development with excessive focus on tunnelling costs across UK and rest of the world.

Cost Benchmarking – Comparison of Project Costs

In this paper the concept "benchmarking", or more accurately "cost benchmarking", defines the collation of actual costs from accomplished projects in order to forecast likely outturn costs for the upcoming projects. However, the study further recognises that benchmarking has more sophisticated potential application beyond cost estimates. Throughout the study, the process of benchmarking has required obtaining cost figures for similar projects both in the home country and other, comparable, countries, which are then plotted on a graph against key factors that impact cost; for example, tunnelling costs are often plotted against tunnel diameter or length.

Project Scope

The IPA's benchmarking methodology, being developed with support from the private sector seeks to compare cost, schedule, benefit, and performance. It intends to do so by breaking down the total project into common assets or components, which might in themselves be comparable to similar assets from other projects. Furthermore, the IPA top down BIAC benchmarking methodology was tested and proven as a concept.

Study Constraints

The case study highlights a number of complications in estimating the costs of major economic infrastructure (rail, road, energy, water projects). Firstly, there is often a limited number of similar projects or similar tasks to enable reliable unit costs to be established. Secondly there are a number of variables, including ground conditions, tunnelling method, length, diameter and access arrangements, which make any direct comparison

[18] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/762006/CCS207_CCS1118018748-001_Benchmarking_tunnelling_costs_and_production_rates_in_the_UK_Web_Accessible.pdf

difficult or impossible. Thirdly, owing to the long duration of infrastructure projects the costs available at completion are usually a number of years in the past. This is compounded by the fact that the project may have been tendered or contracted in very different economic conditions to those prevailing when the benchmarking exercise is carried out.

Unavailability of data for Public Sector Projects

According to the case study, the data is rarely readily available and for public sector projects as there are no universally recognised metrics, notably for performance. Therefore, the result is that any data used for benchmarking is often, sparse and not always suitable for robust comparison.

Best Practices Approach

The case study provides a detailed viewpoint with regard to the embodiment of effective methodologies in undertaking the cost-benchmarking exercise. The issue of unavailability of data has been successively highlighted in the case study in order to delineate the importance of reliable data for an overall credible benchmarking exercise. Moreover, the study further takes into account precise estimates of cost components, tunnel measurements, and relevant infrastructure costs estimates to minimize errors and uncertainties.

3.6.3. Case Study 3: Study of Banverket and Jernbaneverket

A relevant case study of Banverket (the Swedish Rail Administration) and Jernbaneverket (the Norwegian National Rail Administration) has been analysed to embody key conceptions of transport related cost benchmarking.[19]

Pursuance of Benchmarking Process – Collection, Comparison & Analysis of Data

The results from the two case studies have been compared and analysed. The benchmarking data for the railway infrastructure have been further retrieved, classified, and analysed for best practice improvement. The case study involves improvement in the prevailing railway infrastructure by utilizing Maintenance Performance Indicators (MPI), hence linked with the benchmarking approach. The MPI approach has been used as a tool for considering improvement in the railway infrastructure. Moreover, each railway infrastructure is unique due to its geographical locations and constraints, besides the organization, management, and other resources. Thus, the study takes into account all sorts of cost relevant to maintenance of the railway tracks and utilizes key benchmarking methodologies to appraise the endeavours with the peer group railways.

Implementation of Best Practices approach

The case study symbolizes the implementation of best practice approach in pursuing the benchmarking processes. The content analysis of the case study delineates that meticulous measures have been taken in selection of peer group for comparison and further data collection is done while keeping in mind the reliability perspective of the data. Similarly, the study outlines the effective implementation of MPI as defined above with a view to enhance the existing infrastructure of railways.

Miscellaneous factors to be considered for a successful Benchmarking exercise

The case study further includes additional significant factors that need to be accounted while assessing and evaluating a project with the lens of benchmarking. This includes taking into consideration key notions of culture, topography, climate, governmental system, economic growth, environmental regulations, political economy perspective, and cost of material (inputs). Furthermore, it stresses on considering all the key factors that directly or indirectly impacts the overall project implementation while undertaking the benchmarking exercise.

[19] https://www.emerald.com/insight/content/doi/10.1108/14635770910948240/full/html

3.6.4. Case Study 4: Sustainable benchmarking of a public transport system using analytic hierarchy process and fuzzy logic: A Case study of Hyderabad, India

In order to further include the perspective of transportation related cost and process benchmarking, another relevant case study titled: *Sustainable benchmarking of a public transport system using analytic hierarchy process and fuzzy logic: A Case study of Hyderabad, India* [20], is analysed as it also gives an insight to the infrastructure related benchmarking in the public sector transport facility.

Overview of the study

The project aims at conducting a substantial and sustainable benchmarking of public transportation system in Hyderabad, India as it habituated across the globe. It further aims at developing a comprehensive mode-specific benchmarking framework for the urban bus system. The study has managed to include a number of evaluators and indicators, while multi-criteria decision-making techniques including 'analytic hierarchy process' and 'direct weighting' is used. Moreover, the study has estimated a performance index for the urban bus system in the city and compared it with the other cities of India, and with certain other parts of the world.

Exercising Procedural/Process Benchmarking

The benchmarking of processes, quality, time, and cost has been undertaken in the study in order to evaluate the existing urban bus system of Hyderabad with other prevailing urban bus systems. The benchmarking exercise further provided key policy level and technical recommendations for the existential bus system for a better management and improved user interaction, and experience.

Utilizing Best Practices Approach

The case study has utilized imperative research techniques that directly and positively impact the benchmarking activity. The comparison of urban bus systems has been undertaken while taking into consideration the best practices approach and considering the importance of reliable and accurate data. Moreover, the performance index has been also calculated while utilizing imperative mathematical and statistical tools, thus further compared with other prevailing urban bus systems in India.

3.7. Benchmarks and Performance Goals

Benchmarking in the construction industry is conducted in the context of evaluating[21]: a) partnering performance b) project duration c) safety management d) contractor selection e) information technology evaluation. Over the years, numerous countries like United Kingdom, Chile, Denmark, Australia, and more have established a performance benchmarking system for their construction industries.

Ideally, the performance goals can be gauged in the broad dimensions of a) effectiveness b) reliability and c) cost. However, it is important to note here that there are many more detailed concerns that fall within these principal dimensions.

3.7.1. Performance Goals—Measures of Effectiveness

Effectiveness is defined as the system's ability to provide the services as per the community's expectations. It is generally described in terms of a) its capacity and delivery of services, b) the quality of services delivered, and c) the system's compliance with regulatory concerns, and the system's broad impact on the community.

Some indictors defined as performance goals as a measure of effectiveness in the transportation systems include:

A. Output
   Vehicle movements

[20] https://link.springer.com/article/10.1007/s12469-019-00219-8?shared-article-renderer
[21] Palaneeswaran and Kumaraswamy, 2000; Li et al., 2001; Yasin, 2002; Mohamed, 2003; Stewart and Mohamed, 2004; Costa et al., 2006

Seat-miles
Route closures (hours), breakdown
Technical productivity
Operating cost per passenger
Percent of bridges with weight restriction noise emission targets
Average fuel consumption

B. Utilization
Mode split
Trip purpose distribution
Passenger-miles

C. Access/coverage
By jurisdiction
Special segments (e.g., mobility impaired)
Contingency
Emergency response capability
Severe weather response experience

D. Consumer Safety
Accident events
Value of losses
Fatalities per capita total, or per annual user

E. Satisfaction
Level of service
Average speed
Space per passenger
On-time service
Fare, cost to use
Ride quality

3.7.2. Performance Goals—Measures of Reliability

Reliability is described as the likelihood that infrastructure effectiveness will be maintained over an extended period of time or the probability that service will be available at least at specified levels and times during the design life of the infrastructure system.[22] Performance measurement must unavoidably deal with uncertainty. Uncertainty can be in the form of a natural phenomenon with which infrastructure must contend and the characteristics (e.g., material strength, pipe condition, worker health) of the infrastructure itself. Added uncertainty comes from the inadequacies of data. Finally, assessing performance when changes in the system are being made requires forecasting of future conditions, which introduces more uncertainties. Reliability is a measure of these uncertainties.

Some of the indicators to measure a system's reliability are:

A. Deterministic

Engineering safety factors
Percentage contingency allowances

[22] National Research Council. 1996. Measuring and Improving Infrastructure Performance. Washington, DC: The National Academies Press. doi: 10.17226/4929

Risk class ratings

B. Statistical, probabilistic
Confidence limits
Conditional probabilities (Bayesian statistics)
Risk functions

C. Composite (typically deterministic indicators of statistical variation)
Demand peak indicators
Peak-to-capacity ratios
Return frequency (e.g., floods)
Fault-tree analysis

3.7.3. Performance Goals—Measures of Cost

Measuring infrastructure costs is often a complex financial exercise that goes well beyond simply recording expenditures for facilities construction, operations, and maintenance. Consideration must generally be given to the initial construction or replacement cost of facilities (also called investment or capital cost) and the recurring expenditures for operations and maintenance that will be required throughout the system's service life. Measures of cost generally reflects such factors as the source of funds (i.e., who pays), timing of expenditures, and relative preferences for short-or long-term commitments.

Factors that influence the cost measures are:

A. Investment, replacement, capital, or initial cost

Planning and design costs
Construction costs
Equity
Debt

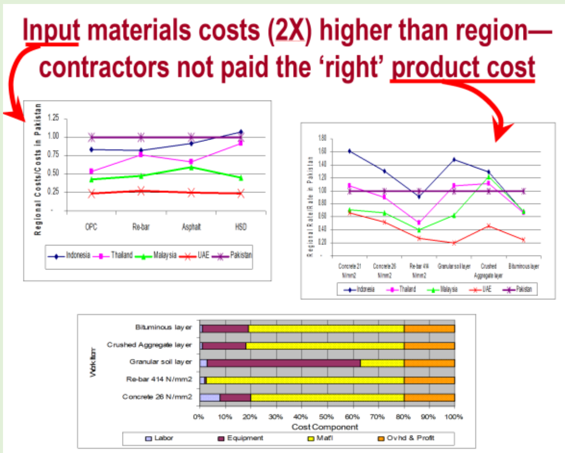
B. Recurrent or O&M cost

Operations costs
Maintenance costs
Repair and replacement costs
Depreciation costs
Depletion costs

C. Timing and source

Timing of expenditure
Discount and interest rates
Exchange rates and restrictions (e.g., local versus foreign currency)
Sources of funds, by program (e.g., federal or state, taxing authority)
Service life

The need for setting up performance goals as measures of cost can be seen from comparison that the market cost of construction materials in Pakistan are not only the highest in the region, but compared to the UAE, the cost of basic materials is 3 to 4 times higher in Pakistan. This indicates a need for planners to review in detail the cost structure of construction materials and see how the basic costs can be made more competitive.



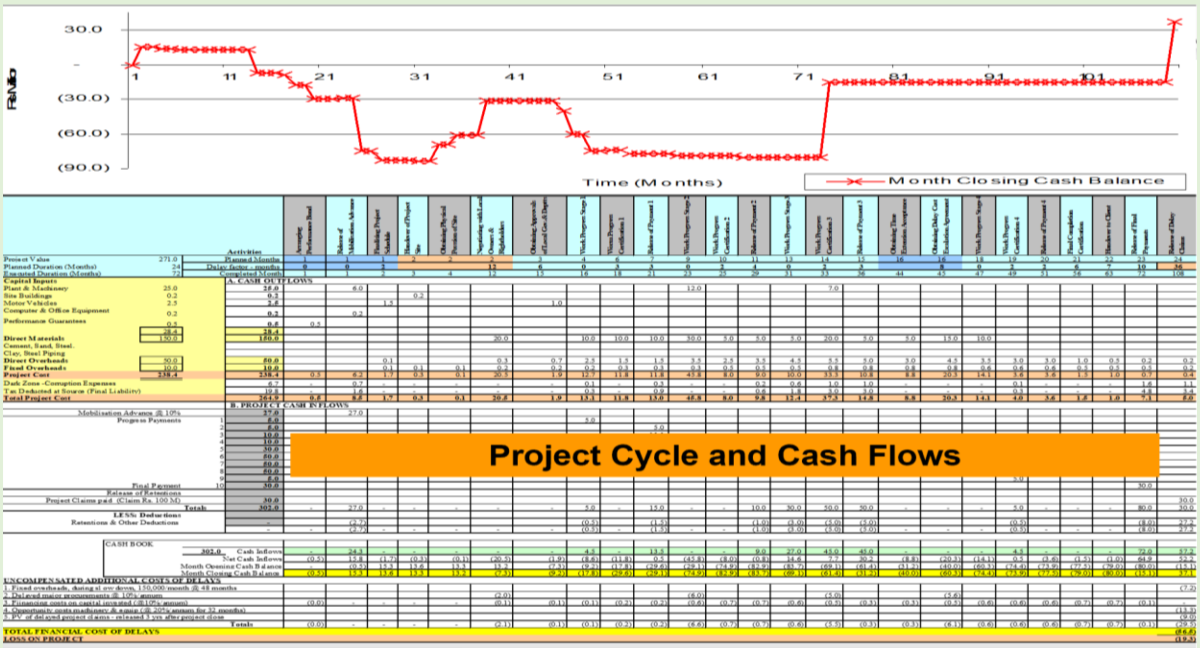
The major portion of a contractor's rate is the cost of materials and machinery. Considering that basic cost of materials, including the cost of fuel is about 200 percent higher as compared to other countries, the contractors' unit rates in Pakistan in US$ (PPP) terms may not actually be as high as they seem. Although the professional salaries in Pakistan are on an average 2 to 3 times lower than the salaries offered in regional countries, these do not contribute as significantly and would have less of an impact on the total rate of an item. The rates in fact could, therefore, be considered to be quite competitive. However, when adverse effects of other variables like old, inefficient equipment, systematic weaknesses and inefficiencies, corruption, transparency issues are also considered, the rates despite being "competitive" may well in fact be unworkable. The contention that rates are low and do not allow for profits and for providing better salaries to professionals and workers may very well be true, but for all the wrong reasons!

Conducting a De Soto Analysis on a complete Procurement cycle of an Infrastructure Construction in Khyber Pakhtunkhwa

A De Soto analysis was conducted on the complete procurement cycle of a water storage infrastructure in Khyber Pakhtunkhwa in order to assess the economic and financial impact.

The figure below shows the analysis on the complete procurement cycle starting from the prequalification and start up pre-requisites till the release of the performance guarantee. Running the analysis on the procurement cycle helped identify the core processes zones, the outer processes zones and the unofficial processes zones (coined as 'Dark zones'—meaning that the Business "Dark Zones"—such as corruption & enforcement agencies—are making risk management impossible). The figure depicts not only the main stages that were involved during the life cycle of the project, but also highlights the time and relative effort as compared to the expected norms, the business processes where major delays occur and the different zones where such processes reside.

From this study, it was concluded that it took thrice as much time than the planned duration of the project and the cost of the total project was two times the actual cost of the project (Corruption alone costing more than 10-15 % of project value).



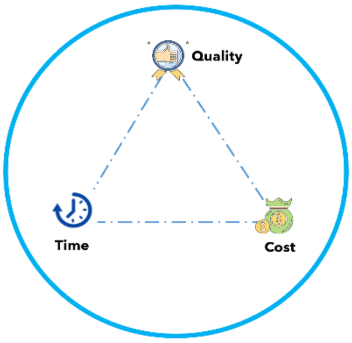
It is pertinent to note here that while many companies use key performance indicators (KPIs) to gauge and compare performance in terms of meeting strategic and operational goals, the construction industry as a whole lacks objective benchmarks, or a way to measure excellence across the industry.[23] One of the primary reasons for the absence of benchmarking and performance goals in the construction industry is the lack of centralized data necessary to establish standards. The lack of data and subsequent inability to measure the infrastructure system and its performance in many cases limits the system's susceptibility to effective management[24].

[23] Farook Hamzeh, Glenn Ballard & Iris D. Tommelein (2012) Rethinking Lookahead Planning to Optimize Construction Workflow. Lean Construction Journal 2012 pp 15-34

[24] National Research Council. 1996. Measuring and Improving Infrastructure Performance. Washington, DC: The National Academies Press. doi: 10.17226/4929

3.8. Construction Costs and the Variability Factor

A project has a definite starting and finishing time and it must meet certain specified objectives. Broadly these objectives are required to be achieved by meeting three fundamental criteria i.e.: (i) the project must be completed on time (ii) the project must be accomplished within the budgeted cost and (iii) the project must meet the prescribed quality requirements. These criteria can be graphically represented by well-known project triangle.[25]



The unique nature of constructions projects means that construction activities often face both duration and cost variability. Since these variables cannot be fully eliminated, thus it can create huddles in completing the project on time and within budget.

Cost is one of the most important considering throughout the project management cycle and can be regarded as on the vital parameter of a project and driver of success. Variations in construction cost are nearly inevitable elements and have so dominant that a project cannot be success executed without changing the design drawing and whole construction process.

From the planning through construction, there are certain steps and processes that should be properly followed to ensure a desirable output. Following the planning phase, when the project is entered into the design and feasibility phase, schematic designs are created where considering the structural, electrical and other relevant system.[26]

Certain engineering efforts are poured in in term calculating estimate critical loads and selection of material, component sizes, compositions of raw materials and other elements. In case of construction of large infrastructures, software simulations are created to perfect replica, which is later subjected to various load configuration to the calculate critical conditions and tolerance limits for the structure. It is also pertinent to consider using value engineering reviews early in the project time.

Once the detailed design is approval later stage of construction is performing various essential tests and inspection of construction site. The results of these test are intended to assist the Engineers and other decision maker in deciding whether or not particular material and work is satisfactory and likewise the whether the infrastructure can sustain the external factors in long terms.

For example, in case of construction of road and Highways following types of engineering effort/ standard tests are conducted prior to the actual construction:

a) Sampling tests of soil, concrete, cements, bitumen and bricks to analysis moisture content and Atterberg limits etc.
b) Various type of strength tests of soil including California Bearing Test and Dynamic Cone Penetrometer Test
c) Strength test of cement and concrete
d) Test for Bitumen and Bitumen materials
e) Steel reinforcement test.[27]

[25] Lester, A. (2013). Project Management, Planning and Control: Managing Engineering, Construction and Manufacturing Projects to PMI, APM and BSI Standards, Sixth Edition, ButterworthHeinemann Imprint, 592 Pages.
[26] https://www.letsbuild.com/blog/6-stages-of-a-project-in-construction
[27] Standard test procedures, Government of the People's Republic of Bangladesh, Ministry of Communications Roads and Highways Department, access via: http://www.rhd.gov.bd/Documents/ConvDocs/Standard%20Test%20Procedures.pdf

Thought these aforementioned tests increase cost of construction but they provide all the relevant information which is critical for decision making at very earlier stages of construction thus reducing the overall variability of whole process.

3.8.1. Impact of design errors on overall costs of construction

Design errors are an unavoidable and important issue which have negative impact on the project management efficiency and effectiveness. These errors lead to rework, cost overruns, schedule delays and unsafe environment which at the end affects the overall cost of constructions.[28]

In reality, owner, designer, contractor and other stakeholders have difference interests in the design and these conflicting interests lead to design errors. One major reason behind these errors is that a greater emphasis is normally being placed on the issue of time and cost and as a result, quality is not being prioritized properly.[29]

The design error can lead to 80 to 90 percent of failures in civil engineering projects. Moreover, these design errors can incur additional cost of around 14.3 percent of total project value.[30] Therefore, the cost of construction related to design errors tend to the greater than costs of mitigation efforts in term of additional designing.

Since the quality of the project depends on the conformity between objectives and requirements, it can only be achieved through proper communication of the scope of work to the designer at design phase. When more efforts are put in during the design phase it will lead to a quality of product. Results and recommendations from the testing and surveys should be reflected in detail designs of the project.

[28] Error Begat Error: Design Error Analysis and Prevention in Social Infrastructure Projects, access via: https://www.sciencedirect.com/science/article/abs/pii/S0001457511000480?via%3Dihub

[29] Effects of design errors on construction Project, Access via: https://www.ijser.org/researchpaper/EFFECTS-OF-DESIGN-ERRORS-ON-CONSTRUCTION-PROJECTS.pdf

[30] Evaluating the impact level of design errors in structural and other building components in building construction projects in Cambodia, access via: https://www.sciencedirect.com/science/article/pii/S1877705815031434#:~:text=Design%20errors%20are%20unavoidable%20in,coordination%20process%2C%20and%20human%20mistakes.

Chapter 4: Data Analysis and Experience

4.1. Country Profiles

4.1.1. Afghanistan

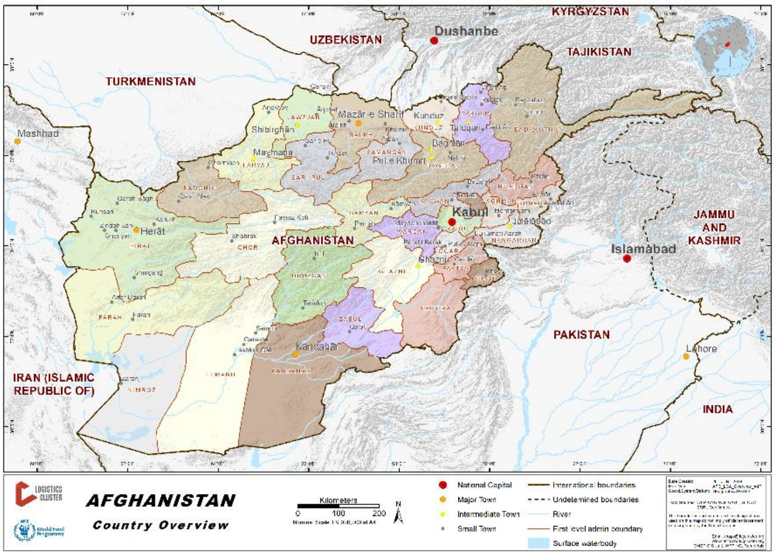


Figure 7 Afghanistan Country Overview

Afghanistan is an Islamic Republic, located in South and Central Asia, which enhances its geostrategic significance. However, the country has a mountainous and rugged terrain and is landlocked from all sides. The country has a multi-ethnic population combined with rich cultural and religious history. Afghanistan has been struggling economically as well as politically due to smooth governance mechanisms mainly because of weak administration and lack of efficient governance system. The country's GNP as per the 2019 estimates stood at USD 20.45 billion with a per capita GNP equivalent to USD 550. On an average, the population of Afghanistan has been 38.9 million in 2020, which is almost a 2.33 percent increase. The surface area of the country has been estimated to be equivalent to 652,230 square kilometres with an average population density equivalent to 59 persons per square kilometre. The country embodies immense potential to alleviate from the existing troublesome situation and emerge as a robust economy in the coming years.

Terrain: Afghanistan is a landlocked mountainous country with numerous highland regions having rugged terrain. The plateaus and hilly terrain demarcate the borders with the neighbouring countries. The Hindu Kush mountains, running Northeast to Southwest of the country provide a dynamic view, while the north-eastern part of the country embodies some of the most fertile soil.

Climate: Even though the country has four diverse climatic seasons; spring, summer, autumn, and winter; majority regions of Afghanistan experience a stringently dry continental climate with extremely hot summers and cold winters. Rainfall is a scarce phenomenon in the country, mainly occurring in the highland regions.

4.1.2. Azerbaijan

Figure 8 Azerbaijan Country Overview

Rich historical heritage and diverse cultural embodiment defines Azerbaijan. The modern republic has a profound history of development and has absorbed the modern macroeconomic doctrines, which makes Azerbaijan an economically dominant Central Asian state. The most recent data of 2018 estimates define the country's aggregate GNP at USD 40.26 Billion with a per capita national income equalling USD 4,050. The population estimates of 2020 show that the aggregate average population has been equivalent to 10,132,528. Moreover, the accumulated surface area of the country is 86,600 square kilometres, while the population density works out to be 123 persons per square kilometre from the 2020 data estimates. Azerbaijan has a robust industrial base with escalating tourist inflow that further enhances its overall economic outlook.

Terrain: Azerbaijan is characterized by a widely diverse variety of landscapes. As per the estimates, more than two-fifths of the country comprises up of lowlands, while an almost half region lies in a moderately high-altitude region. The rest of the regions are mountainous having a highly rugged terrain and challenging access.

Climate: The climate of Azerbaijan can be defined as continental influenced climate with warm summers and stringently cold winters. The dynamic and diverse landscape of the country defines the similarly diverse climatic conditions with the overall temperature following a geographical pattern. Majority of the rainfall occurs in the winter. However, the mountain region embodies a frosty climate with regularly occurring snowfall and dry cold.

4.1.3. Kazakhstan

Figure 9 Kazakhstan Country Overview

The Republic of Kazakhstan is situated in the heart of Eurasia having enriched traditional and cultural history. Kazakhstan is the largest country in Central Asia, while the ninth largest in the world. The 2020 data estimates the aggregate surface area of Kazakhstan levelling 2,724,901 square kilometres with a population density of 7 persons per square kilometres. The population estimates of 2020 shows an average population of 18,760,016, which is relatively higher as compared to other Central Asian states. The country is rich in mineral resources with excessively arable lands, thus contributing positively towards the vigorous outlook of the economy. According to 2018 data, the Gross National Product (GNP) of Kazakhstan stood at USD 147.57 Billion, while the per capita GNP was USD 8,080.

Terrain: Kazakhstan has an immensely diverse topographic and landscape fragmentation. There is considerable topographical variation within the country. The country embodies some of the highest peaks of the region, while some parts of the country are quite below the sea level. Majority of the peaks are covered with intense snow year-around, while their run-off is the main source of Kazakhstan's main freshwater rivers, streams, and lakes.

Climate: The climate of Kazakhstan is quite similar to other Central Asian states and is rendered continental with peaking summers and acutely cold winters. The climatic variation in the country is ranges from arid climatic conditions in the lowlands, while the highlands signify a totally different climate. Despite the nation's relatively low precipitation rates and immensely arid geography, spring floods that can occasionally be brought on by heavy rainfall and melting snow, are not unusual in the Northern and Central regions of the country. Thus, these issues mainly contribute towards ongoing climatic tribulations and overall environmental degradation across the country.

4.1.4. Kyrgyzstan

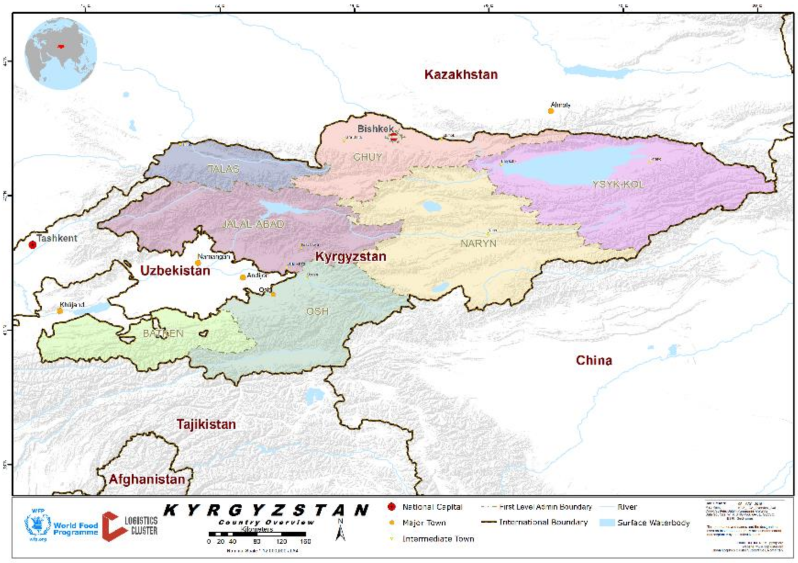


Figure 10 Kyrgyzstan Country Overview

The Republic of Kyrgyzstan is a modern Central Asian state having a profound historical and cultural heritage. A rugged mountainous terrain mainly defines the boundaries with other Central Asian states; whereas the country's internal terrain is fundamentally mountainous as well. According to the economic indicators from the year 2018, the GNP in dollar terms is equivalent to USD 7.70 billion, while adjusting the figure as per the population defines the GNP per capita that works out to be USD 1,220. The population data from 2020 delineates Kyrgyzstan as a moderately populated country with an estimated population of 6,524,195. Moreover, the approximate surface area of the country is estimated to be equivalent to 199,950 square kilometres. While, relating the population and the surface area indicators, the population density works out to be 34 persons per square kilometre.

Terrain: The terrain of Kyrgyzstan is mainly characterized by huge mountain regions covering an almost 65 percent of the national territory. The mountains of Kyrgyzstan are geologically young, so sharply uplifted peaks separated by deep valleys mark the physical terrain. The country also embodies considerable glaciation, while only few valleys are defined as flat that fosters large-scale agriculture. Due to huge peaks, the country is well watered by the descending streams. However, the country lies in an earthquake prone region that has significant threat from the natural calamity.

Climate: The climate of Kyrgyzstan is generally continental, as the country has no nearby access to an ocean. The overall climate is quite sunny over the year, with an average rainfall occurring 70 days a year. Though the summers get immensely hot, however, the mountains remain colder even in the hottest months. Likewise, the winters are snowy and cold everywhere across the entire country, especially at the higher elevations. Days tend to be warmer than nights, but the general climate of Kyrgyzstan is quite pleasant, with four explicitly defined seasons including spring, summer, autumn, and winter.

4.1.5. Pakistan

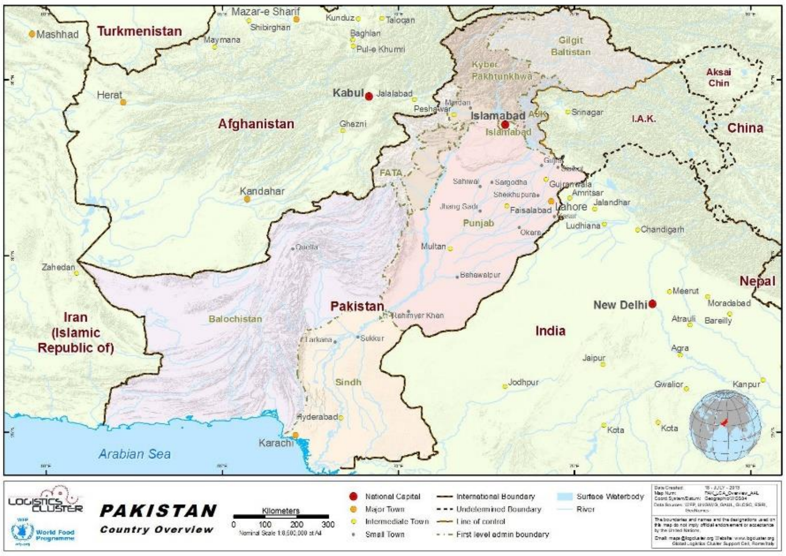


Figure 11 Pakistan Country Profile

Pakistan, an Islamic Republic located in the South Asian hemisphere of the globe, is an imperative state in the global perspective due to its pivotal geostrategic location as well as its significant contribution in the context of global political economy. With a relatively volatile macroeconomic outlook, Pakistan has a Gross National Product (GNP) of USD 337.06 billion, whereas the per capita GNP works out to be USD 1,590, as per the 2018 data. The population growth has been a major challenge for the country as the 2020 data shows the overall population figure of 220,892,340. The topography of the country is immensely dynamic with diversified topographic outlook. According to the 2017 data estimates, the surface area of the country is 796,100, while the average population density works out to be 287 persons per square kilometres, based upon the 2020 estimates.

Terrain: Pakistan has an immensely dynamic terrain followed by diversified landscapes filled with remarkable depiction of nature's exquisiteness. The country due to its pivotal geostrategic location has a significant footprint in the regional as well as global political economy. Pakistan is fragmented into three major geographic regions including northern highlands, the Indus River plain, and the Balochistan plateau. The northern highlands contain the numerous mountain ranges with some of the world's highest peaks. Likewise, the plain region embodies immensely fertile lands with remarkably high potential for agriculture, while the region also has some of the largest desert areas of the world. Pakistan has a stretched and imperatively critical opening to the sea in its South with potential of active sea-trade related economic activities.

Climate: The trend of climatic conditions for Pakistan is quite much related to the diversity of its landscape. The country has four diverse climatic seasons including spring, summer, autumn, and winter. The onset and duration of these seasons vary somewhat according to the location. Moreover, the climate varies from tropical to temperate, with extremely arid conditions in the coastal South of the country. Rain in some parts of the country is a rare phenomenon, while the highlands and certain areas experience often spells of rain. The heavy rain spell is characterized by the Monsoon Season that brings heavy rainfall and intense floods in the plain regions. Thus, the diversity of landscapes and climate in Pakistan allows a wide variety of plantation and fosters a remarkable potential of agriculture.

4.1.6. Tajikistan

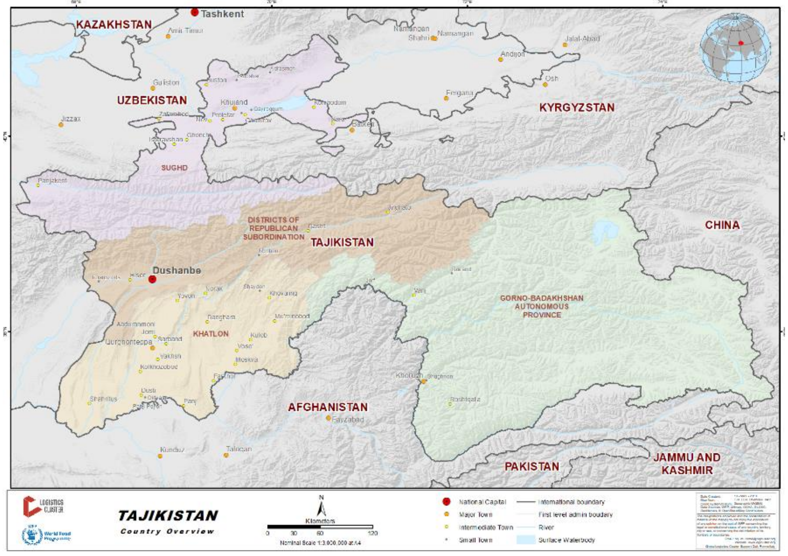


Figure 12 Tajikistan Country Profile

Tajikistan is a modern Central Asian republic having an immensely rich cultural history. The country is home to multi-cultural people from diverse nationalities, thus portraying a remarkable depiction of cultural diversity and peaceful multi-ethnic human habitat. The economic outlook of Tajikistan has been feeble as compared to the other Central Asian states. The imperative reasons for the crumbling economic outlook have been quite relative to availability and usability of resources, internal & external pressures, and weak macroeconomic management. The 2018 data shows the GNP of Tajikistan as USD 9.20 billion, while the per capita GNP is equivalent to USD 1,010. The cumulative population from the 2020 estimates is 9,537,645 spread over the total surface area of 143,000 square kilometres. The population density from the aforementioned data of 2020 works out to be 68 persons per square kilometre.

Terrain: Tajikistan mainly comprises of immensely eye-catching ranges of mountains that follow a trajectory throughout the entire country, forming borders with the other Central Asian states. More than half of the country lies above an average altitude of 3,000 meters. Even the lowlands are quite above the normal sea level. Thereupon, it is imperative to note that the entire country majorly embodies a mountainous terrain with insignificant portion of plains and low altitude portion of land.

Climate: Tajikistan's climate is continental, subtropical, and semiarid, with some desert areas. However, the climate changes drastically according to the elevation and geographical locality. The temperature across the hilly regions drop sharply and keep alike for even more than 100 days a year. In the subtropical regions the temperature is moderately high with overall arid climatic conditions. These areas are good for farming and agricultural activities. Moreover, rainfall is quite high in the highlands with reduced rainfalls in the lowlands.

4.1.7. Turkey

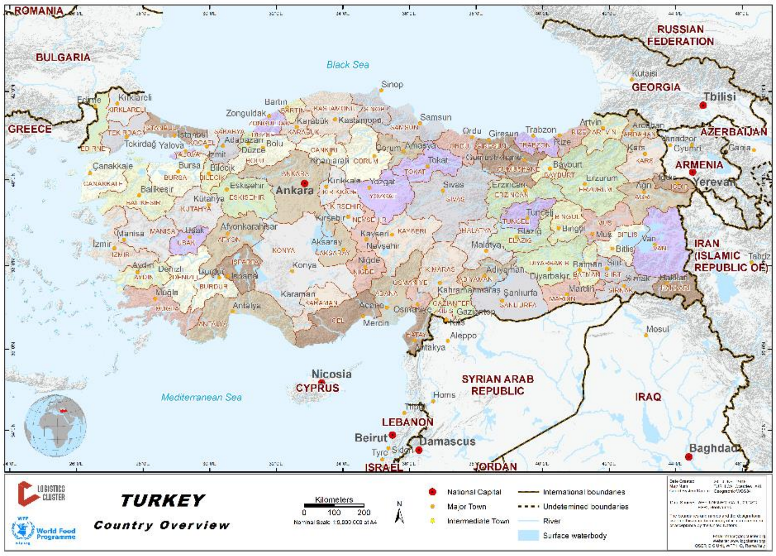


Figure 13 Turkey Country Profile

A country embodying a stretched historic and cultural significance, the present-day Turkey is a modern republic with profound heritage, enriched resources, and a weighty footprint in the global political economy. The strategic and unique bi-continental location of Turkey further enhances its significance in the region as well as across the wider world. Turkey has a stable macroeconomic outlook with a GNP of USD 2.332 Billion as per the 2020 estimates. According to the 2020 data, the population of Turkey is 84,339,067. The dynamic geographical state has an estimated surface area of 769,604 square kilometres with a population density of 110 persons per square kilometre. Due to a firm macroeconomic outlook and improving resource utilization, Turkey envisages a growing trajectory towards sustainable economic growth with enhanced welfare of its populace.

Terrain: Turkey is immensely famous due to its diverse landscape and terrain. The bi-continental geographic location of the country defines its dynamic terrain, while its stretched openings with different seas delineates its coastal outlook. The maritime borders are vastly stretched with neighbouring countries. Likewise, the landscape of the country is quite unique, with strong contrasts ranging from Thrace to the Caucasus, including coastal regions as well as Anatolian steppes. This diversity directly has an impact on the overall climatic conditions. One of the most significant reasons of the huge influx of tourists is the diverse terrain of Turkey. The country embodies scenic beauty due to eye-catching mountainous region, while one can experience one of the most breath-taking plain and desert regions in Turkey as well.

Climate: The diversity of terrain relates much with the diversity of climatic conditions in the context of Turkey. The coastal regions have dynamic weather ranging from extremely hot summers and dry winters. Rainfall is spontaneous and a frequently occurring phenomenon in Turkey's context. However, the climate varies with the geographic location of the regions as the plain regions have some of the most severe climatic conditions. However, the exceeding global temperatures have somehow changed the optimal climate of the country, as the country is prone to significant flooding and abnormal spells of rain and snowfall.

4.1.8. Turkmenistan

Figure 14 Turkmenistan Country Profile

Turkmenistan is a culturally rich Central Asian state embodying dynamic topographic terrain with a surface area levelling 488,100 square kilometres, including 80 percent of dessert land. The country is rich in natural resources including oil and natural gas, while the agricultural output is also relatively higher compared to its neighbouring countries. According to the statistics of 2018, the country's GNP equals USD 40.76 billion, while the per capita GNP works out to be USD 6,967 with the population of 6,031,200 as per the 2020 estimates. Moreover, the population density of Turkmenistan as per 2020 indicators works out to be equivalent to 13 persons per square kilometre. The country embodies significant developmental potential to alleviate its socio-economic standards and enhance its competitiveness in the global perspective.

Terrain: The terrain of Turkmenistan consists of flat to rolling sandy deserts, the mountainous ranges, with its dunes rising to the south. Likewise, the Caspian Sea washes the Western shores of this mostly arid country. The country has some gigantic patches of desert that delineates the diversity of landscape and terrain. However, the country lies on tectonic plates that are mainly prone to earthquakes and similar geological variations,

Climate: Turkmenistan has a cold climate that is severely continental. The summers are quite stretched, hot, and dry, while the winters are mild and dry, occasionally cold and damp in the north. The precipitation is slight across the entire country mainly occurring in the plain regions of the country. The country experiences almost constant winds northerly, north easterly, and westerly.

4.1.9. Uzbekistan

Figure 15 Uzbekistan Country Profile

The republic of Uzbekistan gained independence from the Soviet Union in 1991 and emerged as a modern Central Asian state. Uzbekistan is a resource-rich, doubly landlocked country having a cumulative population of 33,469,203 million, as per the 2020 estimates. The country has been under stress due to macroeconomic imbalances mainly due to crumbling economic indicators and rising disparities due to inflation, unemployment, and public debt. According to 2017 data, the Gross National Product (GNP) of Uzbekistan has been USD 66.5

Billion, while the per capita GNP has been equivalent to USD 2,020. The economic indicators of Uzbekistan are moderate as compared to its neighbouring Central Asian states. Moreover, the estimated surface area of the country is 448,798 square kilometres with a population density of 79 persons per square kilometre.

Terrain: Uzbekistan is one of the largest Central Asian states and the one having borders with all the four Central Asian states. The landscape of the country is immensely diverse ranging from flat regions; desert topography that comprises 80 percent of the country’s territory, while the mountainous peaks in the east provides an umbrella to the widespread national territory. The majority of the highest peaks have scarce water availability with no major lakes flowing in between. Moreover, Uzbekistan lies over earthquake prone region with frequently occurring seismic activities. The mountain areas of the country are especially prone to earthquakes.

Climate: Uzbekistan's climate is categorized as continental, with hot and dry summers, and cool winters. Summer temperatures often surpass 40 degrees Celsius, while the winter temperatures average about −2 degrees Celsius but may fall as low as −40 degrees Celsius. Likewise, most of the country also is immensely arid with lower average annual rainfall occurring mostly in winter and spring. Between July and September, little precipitation falls, essentially impeding the growth of vegetation during that period of time. Therefore, the country has an extreme climatic condition depending on the nature of its topography and landscape.

4.2. Road Infrastructure Cost Analysis

4.2.1. Country Statistics for Road Infrastructure

The road infrastructure statistics for each country were gathered via the questionnaire that was prepared and sent out to the NFPs. Countries like Afghanistan, Kyrgyzstan and Tajikistan provided additional information which has been reflected below.

4.2.1.1. Afghanistan

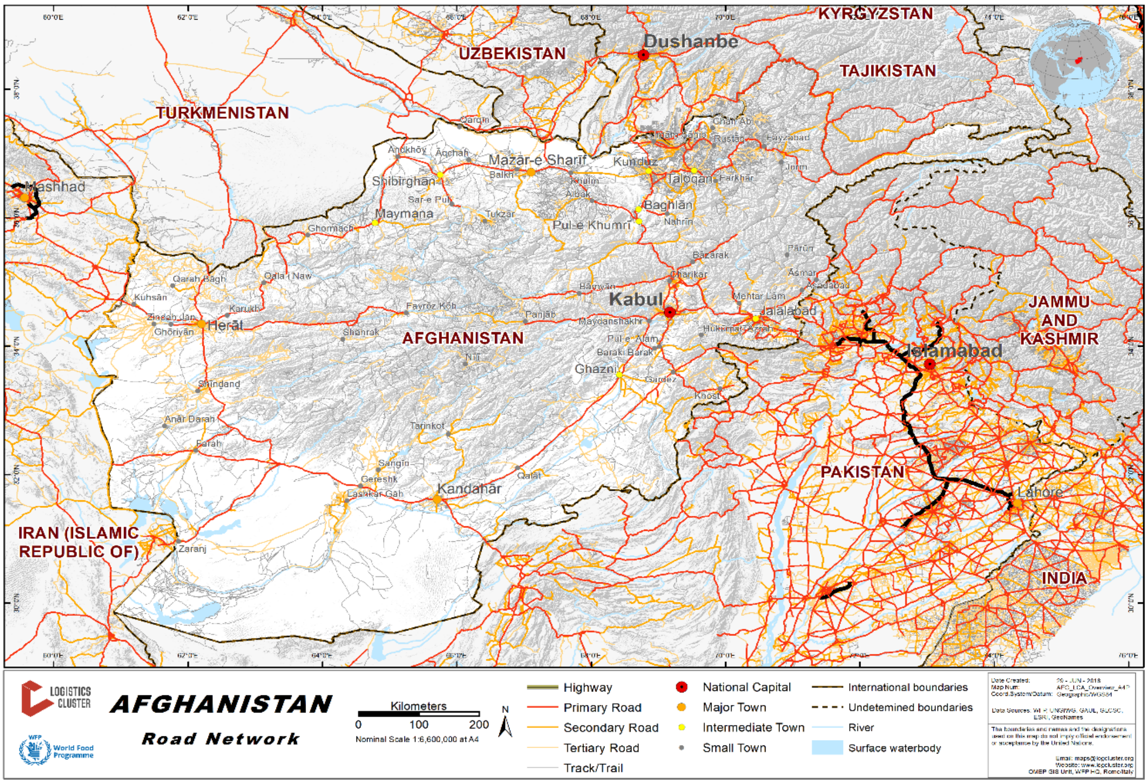


Figure 16 Road Network of Afghanistan

Description of Afghanistan's primary roads and main bridges is reflected as a summary in the tables below:

Legs	Distance (km)	Road surface condition	Terrain	Weather Limitations	Gross Tare Weight	Classification
Herat-Kandahar	593	Asphalt	Flat	All weather	40 MT Max	Good
Herat-Islam Qala	123	Asphalt	Flat	All weather	40 MT max	Good
Herat-Torgundi	120	Asphalt	Flat	All weather	40 MT max	Good
Herat-Farah	280	Asphalt	Flat	All weather	40 MT max	Good
Herat-Ghor/Bhadghis provincial road	368 / 153	Murram	Mountainous, steep, narrow	Partially constrained by snow, rain and mud	20 Mt during summer & winter	Poor road quality

Table 2 Description of Afghanistan's Primary Roads

Main bridges in Afghanistan
Afghanistan-Iran Bridge (Zaranj, Nimroz province)
Afghanistan-Tajikistan Bridge (Sherkhan Bandar, Kunduz Province)
Afghanistan–Uzbekistan Friendship Bridge (Hairatan, Balkh Province)
Bar Shultan Bridge (Kunar Province)
Saw Bridge (Kunar Province)
Guryak Bridge (Kunar Province)
Khan Kunar Bridge (Kunar province)
Pashad Bridge (Kunar Province)
Behsud Bridge (Jalalabad, Nangarhar Province)
Lal Pur Bridge (Jalalabad, Nangarhar Province)
Kandahar-Helmand Bridge (Bagh-e-Pol) Kandahar Province
Kandahar-Urozgan Bridge (Kandahar Province)
Malan Bridge (Pol-e-Malan) (Herat, Herat Province)
Tajikistan-Afghanistan Bridge (Vanj-Jamarj-e-Bala) 216m

Table 3 Main Bridges of Afghanistan

The data from 2016 shows that the total length of single carriageway of primary and secondary Medium Classified Roads (MCR) has been equivalent to 3,371 km and 4,892 km, respectively. The cumulative length of other Single Carriageways in the country has been equivalent to 11,364 km. Moreover, by the end of year 2016, the total length of bridges and tunnels in Afghanistan has been 4.4 km and 2.7 km, respectively. Likewise, the data from the average of years 2012-2016 shows that the cumulative length of annual constructed roads has been equivalent to 18 km. The average data further delineates that the length of annual constructed single carriageway roads in Afghanistan has been equivalent to 18 km, while the cumulative length of annually constructed bridges has been equivalent to 58 m.

Length of roads (end of 2016) (km)	Medium Classified Roads (MCR)-primary roads	Single Carriageway	3,371
Length of roads (end of 2016) (km)	Medium Classified Roads (MCR)-secondary roads	Single Carriageway	4,892
Length of roads (end of 2016) (km)	Other Roads	Single Carriageway	1,1364
Length of Bridges (end of 2016) (km)			4.4
Length of Tunnels (end of 2016) (km) (**)			2.7
Annual constructed roads in length (km) (Average of the last five years (2012-2016))			18
Annual constructed single carriageway roads in length (km) (Average of the last five years (2012-2016))			18
Annual constructed bridges in length (m) (Average of the last five years (2012-2016))			58

Table 4 Summary of Statistics for Road Infrastructure in Afghanistan

4.2.1.2. Azerbaijan

Figure 17 Road Network of Azerbaijan

The data from fiscal year 2016 shows that the total length of Single and Double Carriageway of Primary – Medium Classified Roads (MCR) is equivalent to 18,994 km and 4,641 km, respectively. The total length of Single Carriageway apart from the category of MCR and HCR equals 13,354 km. Moreover, the data further outlines that the cumulative length of HCR Motorways per 1000 square kilometres in 2016 is equivalent to 18,824 km, by the end of 2016. The budgetary allocation from the fiscal year 2016 shows an annual investment budget on roads of USD 1,758,086. The annual budget allocation on the roads for the fiscal year 2016 works out to be 0.09 percent of the GNP. However, the average data from the years 2012-2016 delineates that the 110 km of roads have been constructed annually in Azerbaijan.

Length of Roads (km)	Medium Classified Roads (MCR)-primary roads	Single Carriageway	18,993.6
		Double Carriageway	4,640.6
	Other Roads	Single Carriageway	14,353.6
HCR_Motorways per 1000 km² (end of 2016)			Total: 18,824
Annual investment budget of roads (USD) (2016 Fiscal Year)			1,758,086
Annual Investment Budget of Roads as Percentage of GNP (percent) (2016) (Including yearly PPP investments)			0.09
Annual constructed roads in length (km) (Average of the last five years (2012-2016))			110

Table 5 Summary of Statistics for Road Infrastructure in Azerbaijan

4.2.1.3. Kazakhstan

Figure 18 Road Network of Kazakhstan

The estimates from 2016 delineate the total length of High Classified Motorways (HCR) in Kazakhstan has been equivalent to 490 km. While the estimated length of Single Carriageway of Primary – Medium Classified Roads (MCR) has been equivalent to 96,353 km. Likewise, the cumulative length of Single Carriageway of Secondary MCR and another road category has been 87,029 km and 9,324 km, respectively. Moreover, the total length of bridges by the end of year 2016 has been equivalent to 7.1 km. The share of MCR Primary Roads and MCR Secondary Roads per 1000 square kilometres in 2016 has been equivalent to 5 km and 9 km, respectively. Likewise, the annual budget figures for 2016 shows that cumulative investment on roads has been equivalent to 31,913 KZT, while annual road investment by PPP from 2012-2016 has been USD 380,000. Thus, the overall investment budget of roads as a parentage of GNP for the year 2016 works out to be 5 percent including yearly PPP investments.

Length of roads (end of 2016) (km)	High Classified Roads (HCR)-motorways		490
	Medium Classified Roads (MCR)-primary roads	Single Carriageway	96,353
	Medium Classified Roads (MCR)-secondary roads	Single Carriageway	87,029
	Other Roads	Single Carriageway	9,324
Length of Bridges (end of 2016) (km)			7.11
HCR_Motorways per 1000 km² (end of 2016)			0
MCR_Primary Roads per 1000 km² (end of 2016)			5
MCR_Secondary Roads per 1000 km² (end of 2016)			9
Annual investment budget of roads (USD) (2016 Fiscal Year)			31,913 KZT
Annual Road Investment by PPP (Average of the last five years (2012-2016) (USD)			380,000
Annual Investment Budget of Roads as Percentage of GNP (percent) (2016) (Including yearly PPP investments)			5

Table 6 Summary of Statistics for Road Infrastructure in Kazakhstan

4.2.1.4. Kyrgyzstan

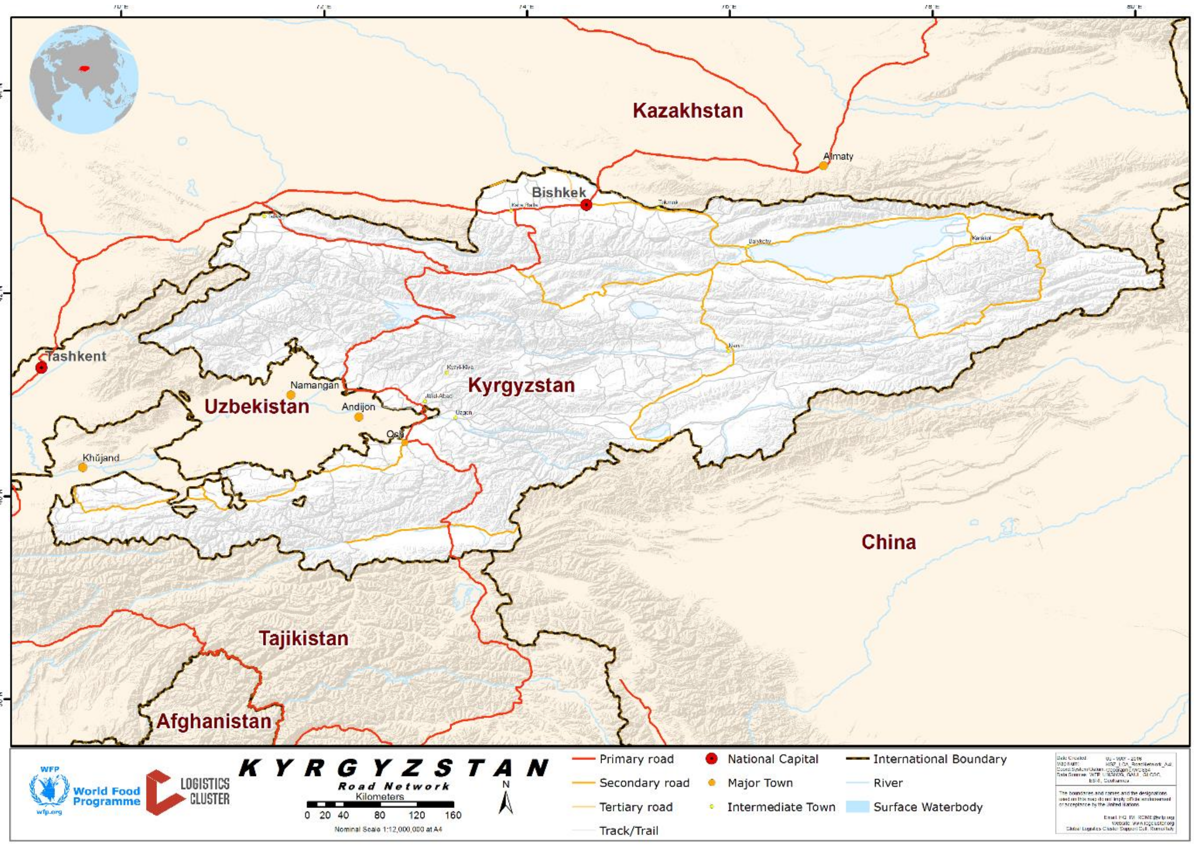


Figure 19 Road Network of Kyrgyzstan

Apart from the data that was analysed for the study, a number of interesting pointers were shared by the Kyrgyz focal point regarding the road infrastructure in Kyrgyzstan, which has been summarized as under:

During the time period of independence of Kyrgyzstan, the development of roads and of automobile sector of the Kyrgyz Republic has received loans amounting to USD 2.355 million by Ministry of Transport. Rehabilitation and reconstruction of the Kyrgyz roads and highways such as: Bishkek-Osh, Osh-Saryaghash, Sarytash-Irkeshtam, Bishkek-Naryn-Torugart, Osh-Batkent-Isfahan, Suusamyr-Talas-Taraz and Bishkek-Georgievka have been completed as of this date.

In the course of implementation of the Road Strategy of the country, the presently ongoing projects are a) Construction of automobile road "North-South" Phase 1 and Phase-2 b) Interconnection of CAREC Corridors 1 and 3" c) Rehabilitation of road segment "Epkin-Bashkuugandy" d) Rehabilitation of "Bishkek-Osh" road segment e) Phase-4 road segment "Bishkek-Kara Balta" and "Jalal Abad-Madaniat" rehabilitation project f) Phase-1 of Programme of roads improvement in the direction of Central Asia – PUDPS CA-1 (Tup-Kegen) and g) Project "Improvement of mainstream roads of international significance".

Ongoing is the implementation of the rehabilitation projects on automobile roads i.e. a) sh-Batken-Isfan b) Bishkek-Naryn-Torugart and c) Suusamyr-Talas-Taraz".

In the framework of the implementation of the aforementioned projects, the overall length of the constructed automobile roads and also of road links that are currently under construction has reached 2390.3 kilometres. Of this length, the length of constructed roads equals to 2079.5 kilometres. Under current construction are 310.8 kilometres of road. Added to the above data, the bridges, tunnels and overpasses have been constructed on the "North-South" highway. Road construction technical equipment have been purchased based on the financing by grants.
Large donors involved in the development of road infrastructure of Kyrgyzstan have been and are EXIM Bank of China, Asian Development Bank, World Bank, Islamic Development Bank and other international financial development institutions.

Furthermore, according to the data from the fiscal year 2016, the estimated length of bridges by the end of the year is equivalent to 145.61 m, while the average annual budgeted investment on roads by PPP appears to be USD 62,900,000. Likewise, the data further shows that the length of average annual construction of Single Carriageway roads is estimated to be 123 km and the average constructed length of bridges over 2012-2016 works out to be equivalent to 14 m.

Length of Bridges (end of 2016) (M)	145.61
Annual Road Investment by PPP (Average of the last five years (2012-2016) (USD)	62,900,000
Annual constructed single carriageway roads in length (km) (Average of the last five years (2012-2016))	123
Annual constructed bridges in length (m) (Average of the last five years (2012-2016))	14

Table 7 Summary of Statistics for Road Infrastructure for Kyrgyzstan

4.2.1.5. Pakistan

Figure 20 Road Network of Pakistan

According to the 2017 data, the total length of High Classified Roads (HCR) motorways is equivalent to 12,000 km, while the total length of Single Carriageway of Secondary - Medium Classified Roads (MCR) is equivalent to 10,849 km. The data from the fiscal year 2016 shows that the total length of bridges and tunnels by the end of fiscal year is equivalent to 1.6 km and 24 km, respectively. Moreover, the annual budgetary allocation data from the fiscal year 2016 shows that the annual investment budget of roads has been USD 5 billion. Similarly, the average data from years 2012-2016 shows that the length of annual constructed roads is 100 km, while the annual constructed Single Carriageway roads is equivalent to 30 km. Likewise, the average data further shows that the length of annual constructed tunnels is equivalent to 0.5 km over the years 2012-2016.

Length of roads (end of 2016) (km)	High Classified Roads (HCR)-motorways		12,000
	Medium Classified Roads (MCR)-secondary roads	Single Carriageway	10,849
Length of Bridges (end of 2016) (km)			1.63
Length of Tunnels (end of 2016) (km) (**)			24
Annual investment budget of roads (USD) (2016 Fiscal Year)			5,000,000,000
Annual constructed roads in length (km) (Average of the last five years (2012-2016))			100
Annual constructed single carriageway roads in length (km) (Average of the last five years (2012-2016))			30
Annual constructed tunnels in length (km) (Average of the last five years (2012-2016))			0.5

Table 8 Summary of Statistics for Road Infrastructure in Pakistan

4.2.1.6. Tajikistan

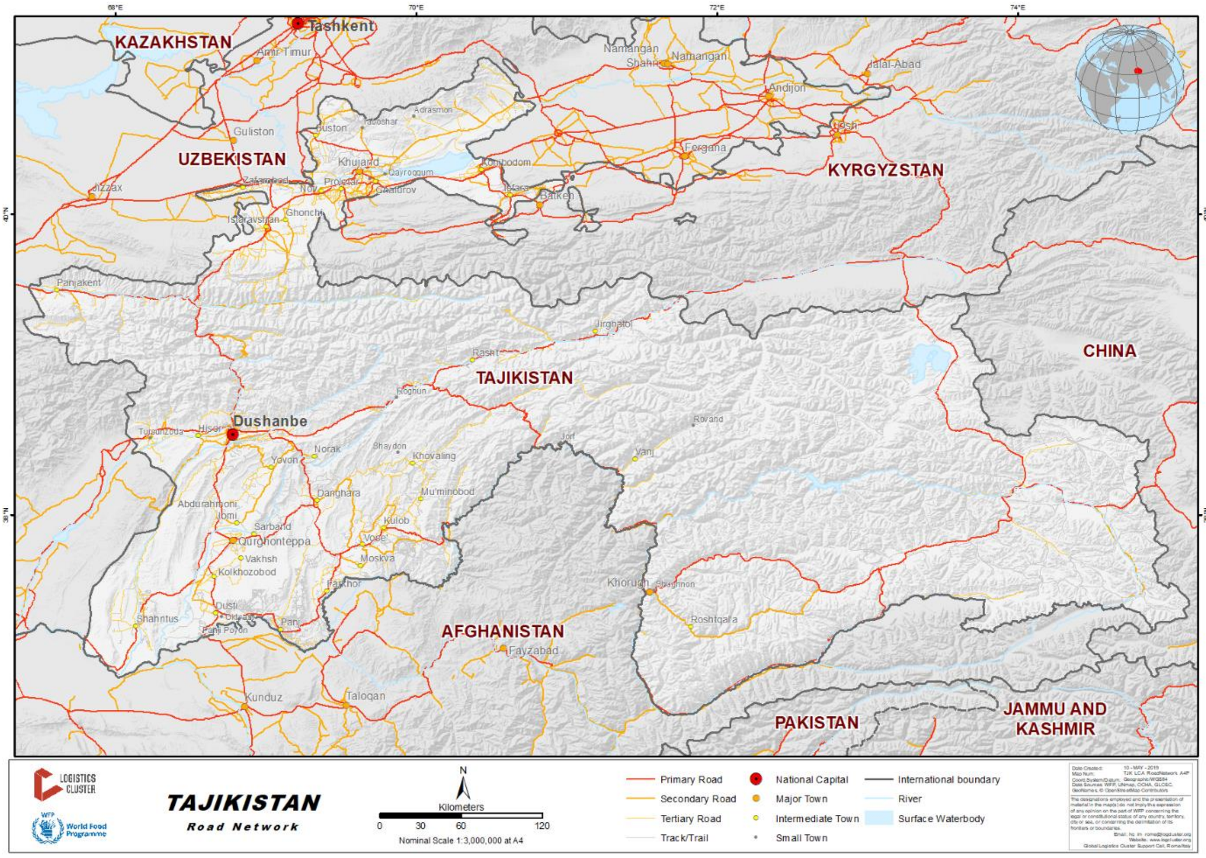


Figure 21 Road Network of Tajikistan

87 percent of cargo and 62 percent passenger transportation are carried by road transport in Tajikistan[31]. Furthermore, according to the data estimate of 2016, the total length of Single Carriageway of Primary-Medium Classified Roads (MCR) in Tajikistan is equivalent to 27,224 kilometres. Similarly, the 2016 estimates further a show that by the end of the year the total length of tunnels in the country has been equivalent to 31 km. The estimated share of HCR Motorways, MCR Primary Roads, and MCR Secondary Roads per 1000 square kilometres has been 13,612 km, 4,732 km, and 8,880 km, respectively. Moreover, the annual investment budget on roads by the end of fiscal year 2016 has been quite low equivalent to USD 375, which is 0.03 percent of the country's overall GNP. Likewise, the data outlines that the total length of roads constructed from an average of 2012-2016 has been 70 km, while the cumulative length of bridges constructed on an average has been equivalent to 25 m.

[31] Tajik Focal Point Data

Length of Tunnels (end of 2016) (M) (**)	31,000
HCR_Motorways per 1000 km² (end of 2016)	13,612
MCR_Primary Roads per 1000 km² (end of 2016)	4,732
MCR_Secondary Roads per 1000 km² (end of 2016)	8,880
Annual investment budget of roads (USD) (2016 Fiscal Year)	375
Annual Investment Budget of Roads as Percentage of GNP (percent) (2016) (Including yearly PPP investments)	0.03
Annual constructed roads in length (km) (Average of the last five years (2012-2016))	70
Annual constructed bridges in length (m) (Average of the last five years (2012-2016))	25

Table 9 Summary of Statistics for Road Infrastructure in Tajikistan

4.2.1.7. Turkey

Figure 22 Road Network of Turkey

According to 2017 data, the length of High Classified Roads (HCR) motorways is 2,542 km, while the length of Single and Double Carriageway of Primary Medium Classified Roads (MCR) equals 11,316 km and 19,970 km, respectively. Likewise, the estimated length of Single and Double Carriageway of Secondary Roads of MCR network is 32,015 km and 1,498, respectively. Moreover, the data further shows that the approximate length of Single Carriageway in the category of other roads is equivalent to 175,429 km.

Furthermore, the data from the fiscal year 2016 shows that the total length of the bridges by the end of the fiscal year equals 520,934 km, while the approximate length of tunnels is 345,841 km. The estimated figure for the HCR Motorways per 1000 square kilometre in the country is accounted to be 3 km per 1000 square/km by the end of fiscal year 2016. While the length of MCR Primary Roads per 1000 square kilometres and MCR Secondary Roads per 1000 square kilometres is 40 km per 1000 square/km and 44 km per 1000 square/km, respectively.

Furthermore, the annual budgetary spending from the national exchequer in the fiscal year 2016 on roads have been equivalent to USD 6,080,901,283, while the average annual road investment by PPP (2012-2016) is equivalent to USD 1,657,913,741. Likewise, the annual investment on roads as a percentage of GNP in 2016 works out to be 1 percent with the inclusion of yearly PPP investments.

Moreover, the length of annual constructed roads on an average (2012-2016) is equivalent to 1,761 km. The length of annual constructed Single and Double Carriageway over the period of 2012-2016 comes out to be 794 km and 967 km, respectively. Similarly, the length of annual construction of tunnels and bridges is equivalent to 39.34 km and 26.39 km, respectively. Likewise, the data from 2016 delineates that the Design Cost as a Percentage of Construction Cost is equivalent to 4 percent for the overall development of road infrastructure.

Length of roads (end of 2016) (km)	High Classified Roads (HCR)-motorways		2,542
	Medium Classified Roads (MCR)-primary roads	Single Carriageway	11,316
		Double Carriageway	19,790
	Medium Classified Roads (MCR)-secondary roads	Single Carriageway	32,015
		Double Carriageway	1,498
	Other Roads	Single Carriageway	175,429
		Double Carriageway	-
Length of Bridges (end of 2016) (km)			520.93
Length of Tunnels (end of 2016) (km) (**)			345.85
HCR_Motorways per 1000 km² (end of 2016)			3
MCR_Primary Roads per 1000 km² (end of 2016)			40
MCR_Secondary Roads per 1000 km² (end of 2016)			44
Annual investment budget of roads (USD) (2016 Fiscal Year)			6,080,901,283
Annual Road Investment by PPP (Average of the last five years (2012-2016) (USD)			1,657,913,741
Annual Investment Budget of Roads as Percentage of GNP (percent) (2016) (Including yearly PPP investments)			1
Annual constructed roads in length (km) (Average of the last five years (2012-2016))			1,761
Annual constructed double carriageway roads in length (km) (Average of the last five years (2012-2016))			794
Annual constructed single carriageway roads in length (km) (Average of the last five years (2012-2016))			967
Annual constructed tunnels in length (km) (Average of the last five years (2012-2016))			39.34
Annual constructed bridges in length (km) (Average of the last five years (2012-2016))			26.39
Design Cost as Percentage of Construction Cost (percent) (end of 2016 Prices)			4

Table 10 Summary of Statistics for Road Infrastructure in Turkey

4.2.1.8. Turkmenistan

Figure 23 Road Network of Turkmenistan

As per the 2016 data estimates, the length of the Single Carriageway of the Primary Roads of Medium Classified Roads (MCR) is equivalent to 13644 km, while, the length of its Double Carriageway equals 1100 km. Likewise, the data for the year 2016 shows the total length of bridges in the country is 22000 km. Furthermore, the data defines that the MCR-Primary Roads per 1000 square kilometres is equivalent 49 per 1000 square/km. According to the budgetary estimates of the fiscal year 2016, the annual investment budget on Roads stood at USD 450,000. The 5 years average figures of the year 2012-2016 shows that the annual lengths of constructed roads have been 12 km. While the average figure of the length of annual single carriageway constructed (2012-2016) shows an average annual construction of 12 km. Similarly, the average benchmark figure of the length of annual constructed bridges (2012-2016) delineates that 5 km bridges have been constructed in a year.

Length of roads (end of 2016) (km)	Medium Classified Roads (MCR)-primary roads	Single Carriageway	13,644
		Double Carriageway	1,100
Length of Bridges (end of 2016) (km)			22.00
MCR_Primary Roads per 1000 km² (end of 2016)			49
Annual investment budget of roads (USD) (2016 Fiscal Year)			450,000
Annual constructed roads in length (km) (Average of the last five years (2012-2016))			12
Annual constructed single carriageway roads in length (km) (Average of the last five years (2012-2016))			12
Annual constructed bridges in length (km) (Average of the last five years (2012-2016))			5

Table 11 Summary of Statistics for Road Infrastructure in Turkmenistan

4.2.1.9. Uzbekistan

Figure 24 Road Network of Uzbekistan

The data from the year 2016 shows that the total length of High Classified Roads (HCR) and Single Carriageway of Primary Medium Classified Roads (MCR) are equivalent to 44 km and 42 km, respectively. While, by the end of year 2016 the total length of Single Carriageway of other roads have been estimated to be 4 km in the entire country. Likewise, the cumulative length of bridges by the end of 2016 is approximately equivalent to 262 m. The budgetary allocation from an average estimate from 2012-2016 in the form of annual investment on roads by PPP has been USD 2.42 billion, which works out to be equivalent to 29 percent of the country's overall GNP including other PPP investments.

Length of roads (end of 2016) (km)	High Classified Roads (HCR)-motorways		44
	Medium Classified Roads (MCR)-primary roads	Single Carriageway	42
	Other Roads	Single Carriageway	2
Length of Bridges (end of 2016) (M)			262
Annual Road Investment by PPP (Average of the last five years (2012-2016) (USD)			2,419,000,000
Annual Investment Budget of Roads as Percentage of GNP (percent) (2016) (Including yearly PPP investments)			29

Table 12 Summary of Statistics for Road Infrastructure in Uzbekistan

4.2.2. Analysing the Data Received for Costing of Road Infrastructure in Different Countries

In order to analyse the limited data of road received from different countries, it was pertinent to study the factors that had a direct as well as indirect effect on the construction costs of the road. These costs were normalised to 2016 by using the GDP Deflator Index. A summary of input costs was tabulated as Table 13.

The data in this table reflects the sum of these individual factors and is arranged in a descending order starting from the highest cost to the lowest cost. This clearly shows that direct input costs for construction of roads in Turkey are found to be the highest while the input costs for construction of roads for Kyrgyzstan are found to be comparatively lower.

Country	Labour Cost	Cement	Iron	Concrete	Fuel	Total Direct Input Costs (USD)
	per month	per Bag (50kg)	USD/Ton	USD/Ton	USD/Litre	
Turkey	468.75	2.97	638.88	3.09	1.05	1114.74
Uzbekistan	139.50	4.18	821.64	4.32	1.10	970.73
Azerbaijan	171.90	4.44	654.03	4.99	0.62	835.98
Pakistan	166.00	3.65	521.74	3.97	0.53	695.89
Kazakhstan	87.83	4.34	589.82	4.23	0.48	686.69
Turkmenistan	156.00	3.15	508.06	2.99	0.46	670.67
Tajikistan	25.32	3.93	596.81	4.12	0.58	630.77
Afghanistan	78.64	3.56	518.00	3.02	0.49	603.71
Kyrgyzstan	13.26	2.63	494.05	2.73	0.47	513.14

Table 13 Summary of Input Costs for Road Infrastructure in USD

Note: This data is collected from different sources as the data could not be extracted from a single source. Also, it is important to understand here that the factors shown in the table above are just some of the factors that may directly or indirectly affect the construction costs of the projects.

The data extracted from the questionnaires was compared to the input costs derived, and for each road class type, surface type and work type—the results deduced were as follows.

4.2.2.1. Analysis on the Road Class Types

The road class types defined in the questionnaires were three i.e. a) Medium Capacity Roads (MCR) - Primary Roads b) MCR-Secondary Roads and c) High Capacity Roads (HCR) Motorways-Expressways;

However, the data received from different countries could only be analysed on two fronts i.e. MCR Primary Roads and HCR Motorways. Based on the sparsity of data, the analysis for the remaining road types and countries remained inconclusive.

A. Medium Capacity Roads (MCR) Primary Roads

Medium Capacity Roads such as Primary Roads are not access controlled. They are usually toll-free roads. They may be double or single carriageway highways. The geometric and physical capacity of this type of roads are medium. They are also main arterials and principal roads of national highways system of countries. The applied speed limits on this road are lower than on High Capacity Roads (HCR).

When the data of this road class type i.e. MCR Primary Roads is compared with different countries that provided the relevant data, it was observed that:

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Turkmenistan	3,593,750	3,554,934	3,516,119	1,200
Tajikistan	2,395,446	1,398,579	583,929	817
Kazakhstan	2,553,191	1,231,685	4,118	1,545
Kyrgyzstan	987,048	697,779	408,509	124
Afghanistan	2,490,854	626,895	234,615	281
Turkey	1,314,653	353,272	8,461	8,237
All Countries	3,593,750	1,310,524	4,118	12,204

Table 14 Road Data Comparison for MCR Primary Roads

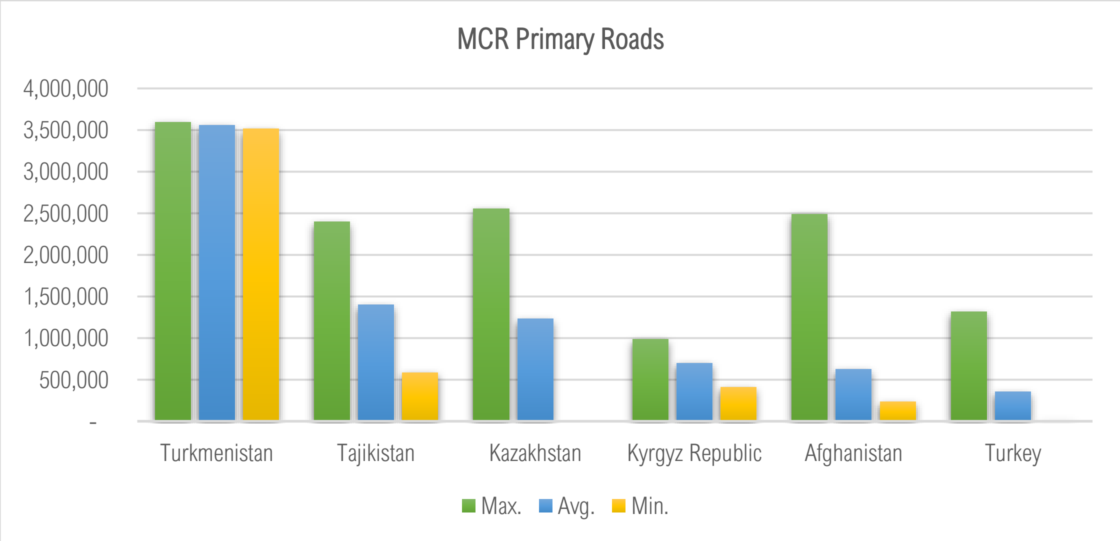


Figure 25 Road Data Comparison for MCR Primary Roads

The maximum, average and minimum final costs of construction per km of MCR Primary Roads in different countries has been arranged in a descending order from the highest average construction cost per km to the lowest average construction cost per km. When this data is compared with the factors that may directly or indirectly affect the construction costs of the projects, i.e. Table 14, it can be seen that Tajikistan has comparatively higher final output cost of construction per km for MCR Primary Roads than Kazakhstan, Kyrgyzstan and Afghanistan whereas it has comparatively lower direct input costs for construction of roads; implying that there may be various indirect costs affecting the total construction costs of roads in Tajikistan including financial charges relevant to licensing, tender, consultancy, and other price related contingencies. Additionally, a profound research into the key driving factors showed that foreign exchange variation, interest rate on the debt component and agency/administrative costs ultimately affect the cumulative project cost. Moreover, there may be some hidden costs such as rent-seeking, commissions and others.

Similarly, final construction costs for MCR Primary Roads in Turkey are estimated to be the lowest, the data for direct input costs indicates that Turkey has the highest direct input costs for the materials used in the construction of roads. This leads to an anomaly that even though the input costs of Turkey are highest in our sample group of countries, it still manages to employ its resources efficiently, thus constructing the road with lowest absolute costs. Moreover, this research finding also denotes that the aforementioned unforeseen costs remain relatively lower in Turkey as compared to the other countries.

4.2.2.2. Analysis on the Road Work Types

The road class types defined in the questionnaires were a) New Construction; b) Reconstruction; c) Resurfacing by Strengthening; c) Pavement Replacement; d) Reconditioning; f) Expansion (Capacity Improvement); g) Resurfacing;

However, analysis could not be performed on resurfacing and pavement replacement due to non-availability of data.

A. New Construction

New construction includes Construction of all parts of a road: structures, subgrade, pavement where no road existed before.

When the data by new construction is compared, it is observed that;

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Azerbaijan	12,592,593	7,725,954	2,859,316	281
Uzbekistan	9,172,414	6,671,949	3,454,545	142
Turkmenistan	3,516,119	3,516,119	3,516,119	560
Pakistan	1,765,176	1,744,029	1,722,881	2,083
Turkey	1,314,653	690,233	294,040	85
Afghanistan	500,722	393,900	234,615	281
All Countries	12,592,593	3,457,031	234,615	3,431

Table 15 Data Comparison for Road New Construction

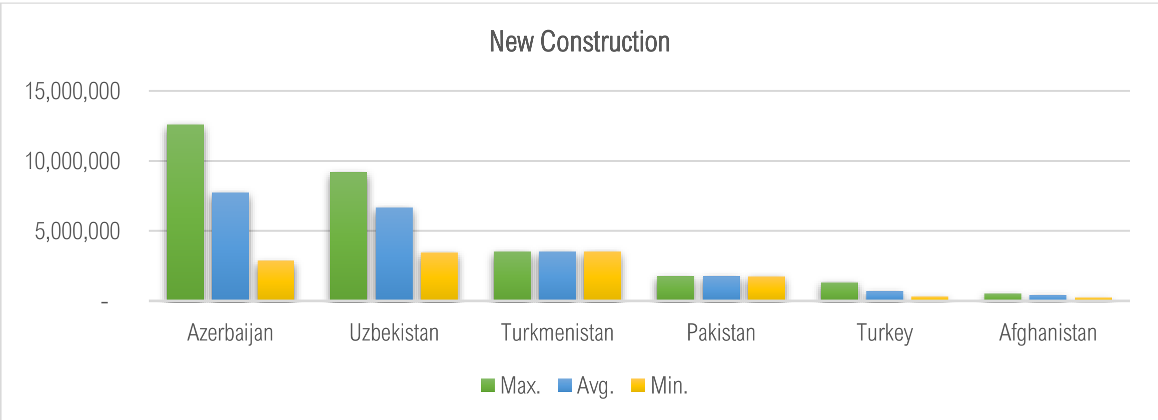


Figure 26 Data Comparison for Road New Construction

The data received for new construction was displayed as the maximum, average, and minimum final costs of construction per km of the sample countries and has been further organized in a descending order from the highest average construction cost per km to the lowest average construction cost per km. When data was compared with the factors that affect the construction costs of the projects, i.e. Table 13, a similar trend for Turkey was seen i.e. irrespective of having the maximum input costs for road construction, it exemplified the second lowest final costs for new construction of roads. This exploratory outcome implies that the administrative, transaction, and agency costs remain relatively lower in Turkey as compared to other countries. Likewise, certain other factors including construction permit charges, licensing and tender fees appear to be insignificant in impacting the overall construction costs. Moreover, it further signifies that the resource utilization in Turkey is exceedingly efficient as compared to the other sample countries. Additionally, it could be seen that Uzbekistan has comparatively higher direct input costs, as shown in Table 13, and likewise it has comparatively second highest output costs associated with construction of new roads.

B. Reconstruction

Reconstruction is defined as total rebuilding of both pavement and subgrade of an existing highway. It is the work which either changes the location of the existing subgrade shoulder points or removes all of the existing pavement and base course for at least 50 percent of the length of the project. In other words, reconstruction is the rebuilding of an existing roads' pavement and subgrade to correct road geometry, to increase road safety, to ease maintenance works and to increase preservation.

Data received for reconstruction from different countries show that:

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Azerbaijan	8,431,580	3,644,125	1,076,923	350.5
Turkmenistan	3,593,750	3,593,750	3,593,750	640
Kazakhstan	2,553,191	1,436,279	705,882	1240
Tajikistan	2,395,446	1,398,579	583,929	817.3
Kyrgyzstan	987,048	697,779	408,509	124.03
Turkey	616,823	449,303	259,204	2,711
All Countries	8,431,580	1,869,969	259,204	5,883

Table 16 Data Comparison for Road Reconstruction

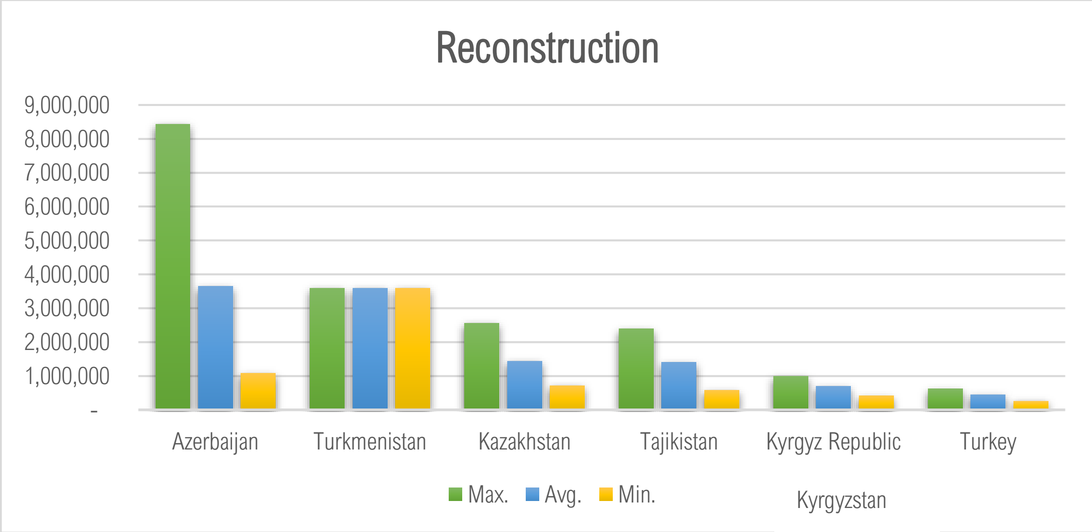


Figure 27 Data Comparison for Road Reconstruction

The maximum, average and minimum final costs of construction per km of reconstruction of roads across different countries has been further arranged in a descending order commencing from the highest average construction cost per km to the lowest average construction cost per km in a tabular and graphical form. When we compare this data with direct input costs, we observe that Kazakhstan and Turkmenistan have interchanged their positions. This means that despite having higher direct input costs, Kazakhstan manages to lower its final costs due to efficient management of resources. Whereas, Turkmenistan has comparatively lower direct input costs but still has higher output costs. This abnormality entails a significant impact of certain indirect factors that integrally inflate the overall reconstruction costs of roads in Turkmenistan. Some of the imperative factors affecting the aggregate reconstruction costs in the context of Turkmenistan include an augmented custom duty, insurance costs, and administrative costs. While the taxation structure of the country's economy and the administrative and regulatory frameworks are also considered as contributing factors towards topping reconstruction costs. In addition to this, a comparable trend for Turkey was seen, regardless of having highest input costs for construction of roads; it has second lowest final costs for reconstruction of existing roads. Therefore, this further denotes that the indirect factors impacting the overall costs do not affect the reconstruction costs in Turkey's perspective, while Turkey utilizes the scarce resources in an efficient manner as compared to the rest of the countries. Interestingly, Azerbaijan appears to have higher final costs while having comparatively higher direct input costs for construction of roads per km.

B. Reconditioning

Reconditioning includes improvement of grades, curves, intersections, or sight distances in order to improve traffic safety or changing the subgrade to widen shoulders or to correct structural problems in addition to resurfacing or pavement replacement.

Data for reconditioning was received from Azerbaijan and Turkey only—therefore the analysis is limited.

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Azerbaijan	2,484,213	1,621,339	589,935	443
Turkey	437,571	334,463	212,757	2,800
All Countries	2,484,213	977,901	212,757	3,243

Table 17 Data Comparison for Road Reconditioning

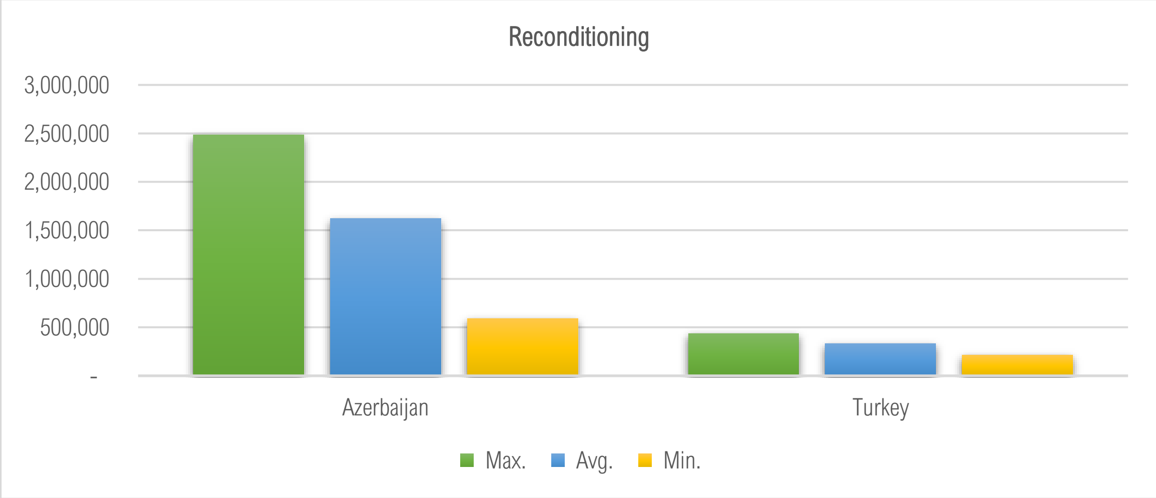


Figure 28 Comparison for Road Reconditioning

The tabulated and graphed data above displays the maximum, average, and minimum final costs per km of reconditioning of existing roads. The data for Azerbaijan and Turkey has been considered for the analysis and has been arranged in a descending order from the highest average construction cost per km to the lowest average construction cost per km. The comparative analysis exercise shows that when the data is compared to table 13, Turkey despite having the highest direct-indirect input costs, has the lowest reconditioning costs as compared to the rest of the countries. Moreover, due to data constraints, Azerbaijan could not be compared to other countries, thus leaving the data inconclusive.

C. Resurfacing by Strengthening

Resurfacing by strengthening includes renewing of road surface with reinstalling bituminous layer by removing determined depth of pavement by milling in order to increase bearing capacity of road and to eliminate road defects.

Data for Resurfacing was received from Uzbekistan and Turkey only—therefore the analysis is limited.

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Uzbekistan	3,533,333	2,433,333	1,333,333	375
Turkey	198,862	142,476	86,716	2,170
All Countries	3,533,333	1,287,905	86,716	2,545

Table 18 Data Comparison for Road Resurfacing by Strengthening

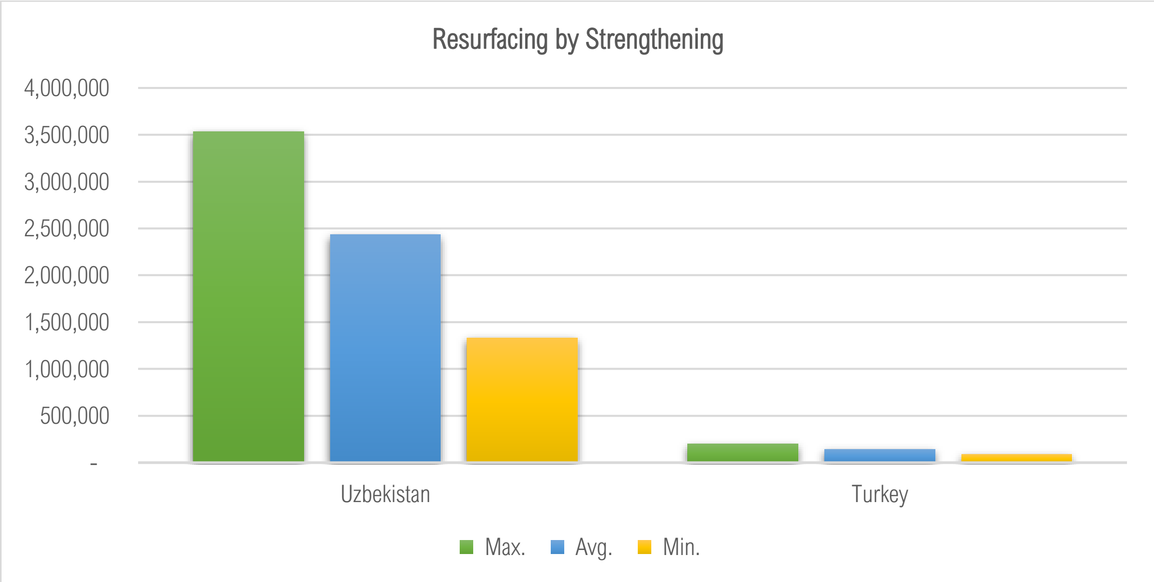


Figure 29 Data Comparison for Road Resurfacing by Strengthening

This data shows the maximum, average and minimum final costs of construction per km of resurfacing by strengthening of roads in different countries and has been arranged in a descending order from the highest average construction cost per km to the lowest average construction cost per km.

However, when this data is compared with table 13; a similar trend for Turkey can be seen as the input costs and overall resurfacing costs embodies a negative statistical relationship. This can be explained with certain indirect factors that affect the overall infrastructure building and up gradation costs as well as efficiency of resource utilization in the country. While the output costs for resurfacing in context of Uzbekistan are higher as compared to Turkey, the direct input costs of construction in Uzbekistan are relatively lower. Therefore, this shows that certain key factors affect the overall road infrastructure implementation costs.

4.2.2.3. Analysis on the Road Surface Types

The road surface types defined in the questionnaires were a) Asphalt and b) Concrete. However, analysis could not be performed on Concrete Road Surface Type due to non-availability of data.

Asphalt

When data is compared by the surface type, i.e. Asphalt, it can be seen that:

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Turkmenistan	3,593,750	3,593,750	3,593,750	640
Azerbaijan	12,592,593	2,953,405	589,935	1,074
Tajikistan	2,395,446	1,398,579	583,929	817
Kazakhstan	2,553,191	1,231,685	4,118	1,545
Afghanistan	5,019,310	845,598	151,474	915
Kyrgyzstan	987,048	697,779	408,509	124
Turkey	1,314,653	313,006	6,769	14,559
All Countries	12,592,593	1,576,257	4,118	19,674

Table 19 Data Comparison for Road Surface Type: Asphalt

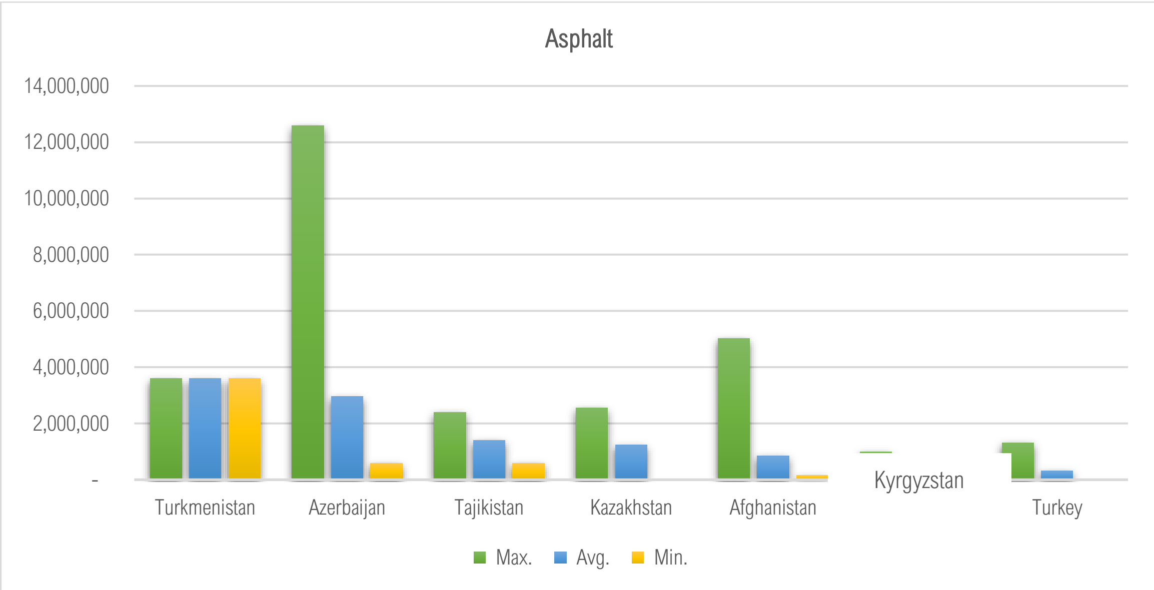


Figure 30 Data Comparison for Road Surface by Asphalt

The data above indicates the maximum, average, and minimum final costs of construction per km of asphalt roads in different countries. For a better analysis, the data is further organized in a descending order from the highest average construction cost per km to the lowest average construction cost per km. Comparing the data with table 13—it is observed that Turkmenistan records the highest final construction costs for asphalt roads whereas it has been ranked average in the input cost summary. This brings attention to the unaccounted indirect factors that contribute imperatively towards defining the construction costs. In the case of Turkmenistan, a profound research shows that several additional costs and institutional impediments inflate the overall construction costs for roads. These costs commonly refer to certain transaction and agency costs that affect the overall cost estimates of an infrastructure development. Likewise, some significant indirect taxes, duties, and fees relevant to inputs, contractual obligations, and licensing contribute towards piling up of project costs. Additionally, in this scenario, Tajikistan and Kazakhstan seem to have swapped their positions and portray a different picture when compared to Table 13. While one country manages to reduce its final output costs, the other has to face many indirect factors that heavily influence its output costs. Moreover, a similar trend is observed for Turkey, which irrespective of having the highest input costs for construction of roads has lowest output cost for asphalt roads.

4.3. Rail Infrastructure Cost Analysis

4.3.1. Country Statistics for Rail Infrastructure

The rail infrastructure statistics for each country were gathered via desk research and are summarized as below:

4.3.1.1. Afghanistan

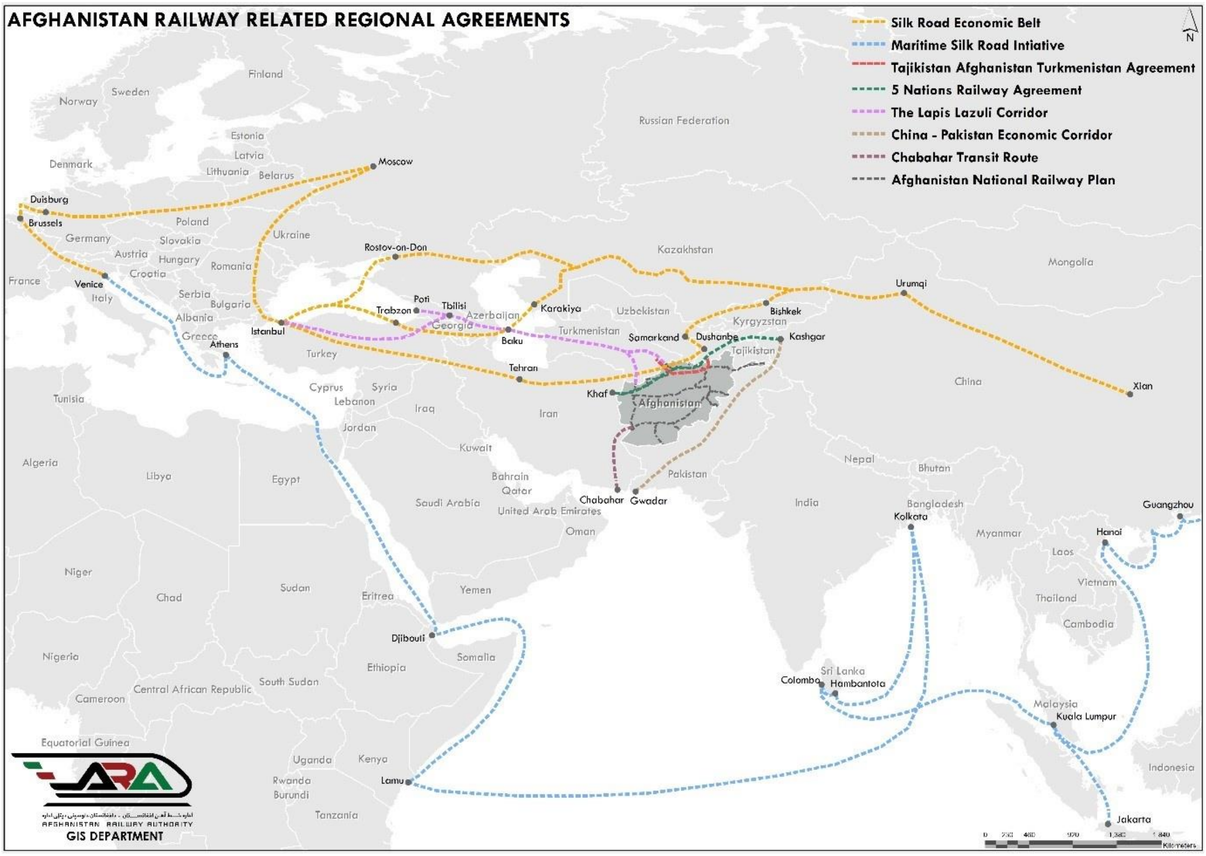


Figure 31 Rail Network of Afghanistan

Afghanistan has three major railroads which connect to two neighbouring Central Asian states, Uzbekistan through Balkh Province, Turkmenistan through the Herat province and Faryab Province. The rail line connecting Uzbekistan and Afghanistan crosses over the Amu Darya and is a 75 km line with a 1,520 mm (4 ft. 11 27⁄32 in) gauge and is located in the city of Mazar-i-Sharif. Turkmenistan and Afghanistan were connected by a railway system since the 1960s under the Soviet Union. A new 56 km extension was developed connecting to Andhkoy, with a rail corridor project in planning stages connecting Sherberghan to the border in Tajikistan.

Pakistan also shares a railway connection with a two broad gauge 1,676 mm (5 ft. 6 in) line at the border of Chaman and Torkham, operated by Pakistan Railways. In Feb 2020 the first freight train was inaugurated connecting the port city of Karachi to Kandahar and had a total travel time of 48 hours. A railway line connecting Iran, India and Afghanistan has been recently developed with two berths at Chabahar port which connects to the already 202 km existing route planned between Iran and will be implemented by the Trans-Iranian Railway.

There are no operating passenger or urban railway systems in Afghanistan, a national rail authority has been curated by the national government with the help of Asian Development Bank, but it is not yet operational.

4.3.1.2. Azerbaijan

Figure 32 Rail Network of Azerbaijan

Azerbaijan possesses an extensive railway system operating internationally and locally. The rail network is 2,944 km in length with a 2,944.3 km 1.520-m gauge, 1767 km of which is electrified. It has an open railway link with Russia, Georgia, Iran and Turkey. The railway system of Azerbaijan exhibits a rich history starting from the Russian Empire to the breakup of the Soviet Union.

Azerbaijan's rail system is also a part of the International North-South Corridor which will be accessed by five other countries to travel from India to Kazakhstan and includes 369 km of bridges. Azerbaijan Railways is the state-owned rail operator and a successor of Soviet Railways. It also launched a suburban 13.5 km railway line in Baku with a 1,520 mm (4 ft. 11 27⁄32 in) gauge and serves seven stations. It also operates a freight line to Turkey through the Kars-Tbilisi-Baku railway and a proposed passenger line is also on the way.

Baku also operates a metro system and plans to expand to an underground transit system. It has a total length of 36, 63 km and 25 stations running on three lines across the capital.

4.3.1.3. Kazakhstan

Map No. 3771 Rev. 6 UNITED NATIONS
January 2004

Department of Peacekeeping Operations
Cartographic Section

Figure 33 Rail Network of Kazakhstan

Kazakhstan has 16,614 km, 4200 km of which is electrified with a 1.520-m gauge and provides cargo and passenger traffic to 57 percent of the country. Some of these rail networks are outdated due to being constructed under the rule of the Soviet Union. Kazakhstan shares rail links with almost five countries including Russia, China, Kyrgyzstan, Uzbekistan and Turkmenistan. The Turkestan-Siberia railway plus the Northern Xinjiang Railway pass through Kazakhstan.

The Kazakhstan Temir Zholy (KTZ) is the national railway authority of the country and it is a part of the New Silk Road Initiative focusing on the Khorgos-Eastern Gate. The Trans-Asian railway system is also being developed to act as a transit between China and Europe with 3,900 kilometres of rail line planned, and a gauge matching the standards of the European rail system.

There are no operational high-rail train systems in Kazakhstan, but two have been planned between Almaty and Nur-Sultan and an international link between Moscow and Beijing is expected to be 1,011 km long. Kazakhstan does possess a rapid transit system with a tram system and a metro, the only country to have one in the Central Asian states. The Almaty Metro was constructed after 23 years of development with a route length of 11.3 km whilst serving nine stations. Two expansions have been planned 3.1 km to Dostyk and 5.52 to Kalkaman. A metro system for the capital of Kazakhstan, Nur Sultan is being developed with 1,011 km (628 mi) long route and the capacity to hold 146,000 people each day.

4.3.1.4. Kyrgyzstan

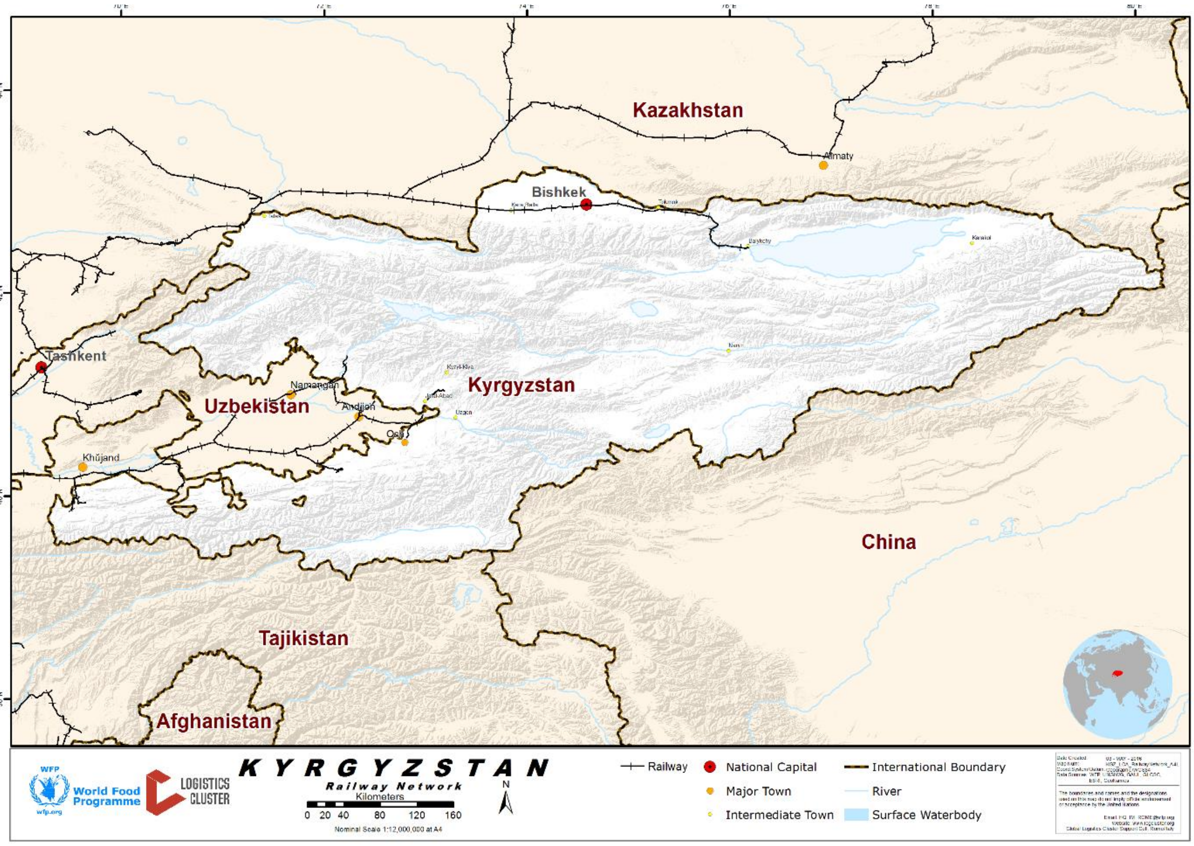


Figure 34 Rail Network of Kyrgyzstan

Kyrgyzstan has a railway system extending over two geographic regions in the North and South with a railway line of 424.6 km. The railway line in the North holds 323 km while the line in the south is approximately 101.2 km. These were endpoints used to travel into Central Asia in the former USSR.

It shares a rail link with Kazakhstan and Uzbekistan through the Bishkek and Osh branches while there is no direct connectivity with Tajikistan or China. The rail lines within Kyrgyzstan, are about 370 km of the 1,520 mm (4 ft. 11 27⁄32 in) broad gauge that Kyrgyzstan possesses. The main problems associated with border crossing points at these transit stations are poor maintenance of the buildings/offices and inadequate communication and data processing facilities The Kyrgyz Railway or the KJT is the national development of railways lines in the country. KJT acquired 2,500 freight cars, 450 passenger cars and 50 locomotives from the Soviet Union after the breakup. In average, the company carries out annually 15 percent of all freight turnover of the country, while the number of passengers is 750 000.

The Government of the Kyrgyzstan has also created a Railways Development Program, with the help of the Chinese government to construct a railway network connecting China and Uzbekistan with the country. Thus, in accordance with the National Strategy for Sustainable Development of Kyrgyzstan for the period of 2018-2040, the country's priorities have essentially been defined and national projects have been specified. These are: (i) the construction project China-Kyrgyzstan-Uzbekistan railway, and (ii) construction project Balykchi-Kochkor-Kara-Keche railway. The projects primarily focus on linking of the Northern part of the national railway with its Southern part. During this period of implementation of the above-noted two projects, the current plans are the following: the operationalization of new locomotives, steam locomotives; relevant infrastructures; railway links that will allow to increase the transit potential of Kyrgyzstan. Thus, within the framework of the renewal of the rolling stock of the Kyrgyz national railway system, six new mainline steam locomotives have been purchased and put into operation.

By the end of 2017, 150 units of freight semi-wagons had also been purchased based on funding from the joint Russia-Kyrgyzstan Development Fund. Starting from January till April 2018, the aforementioned wagons have gradually been commissioned to regulate operation at southern stations of the state enterprise “National Company “Kyrgyz Temir Zholu”. Currently, 30 manoeuvre and mainline steam locomotives are being actively utilized. Similarly, 300 passenger wagons and 800 freight wagons are in current use in the Southern part of the National Railway System.

4.3.1.5. Pakistan

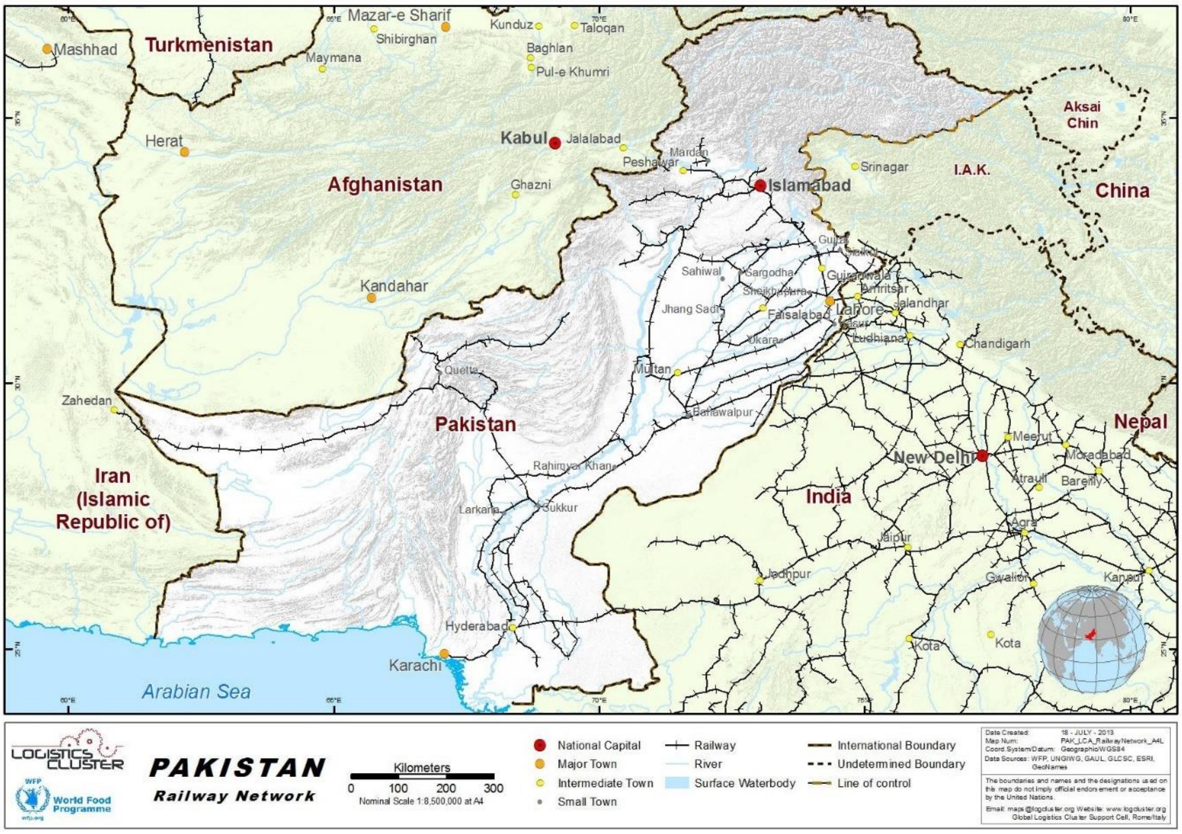


Figure 35 Rail Network of Pakistan

Pakistan has an expansive railway line connecting the four provinces of the country. There are international links with at least four neighbouring countries. Thar express runs from Karachi to Jodhpur and Samjhauta express from Lahore to Amritsar in India, which has now been suspended due to unfriendly relations between the two states. The Quetta-Taftan railway line is a major international route for Iran and Pakistan, covering 523 km with a 1,676 mm track gauge. A connection link between Istanbul and Islamabad via Tehran has been proposed covering 6,500 km and another link to China has been proposed over the Khunjerab pass, 4730 m above sea level.

Domestic train connections are a vital mode of transportation for many citizens of the country. There are three major railway lines in Pakistan, one is from Karachi to Peshawar with a length of 1,687 km. and 1,676 mm broad gauge. The other two lines are Kotri to Attock which is 1,519 km and Rohri-Chaman line with a 296 km length. Pakistan Railways is the governing authority in charge of maintenance and administration under the supervision of the Ministry of Railways. Under the CPEC project, a rail upgrade has been proposed which will increase the speed of the rail, the current infrastructure and will also include new locomotives. In 2019, 70 million passengers were served by Pakistan Railways.

There are a few rapid transit systems in major cities of Pakistan. The Lahore Metro has three lines which have been proposed, of which the Orange Line has been completed. The line spans 27.1 km (16.8 mi) with 25.4 km

(15.8 mi) elevated and 1.72 km (1.1 mi) underground. It is served by 26 stations and is expected to handle 250,000 passengers daily.

4.3.1.6. Tajikistan

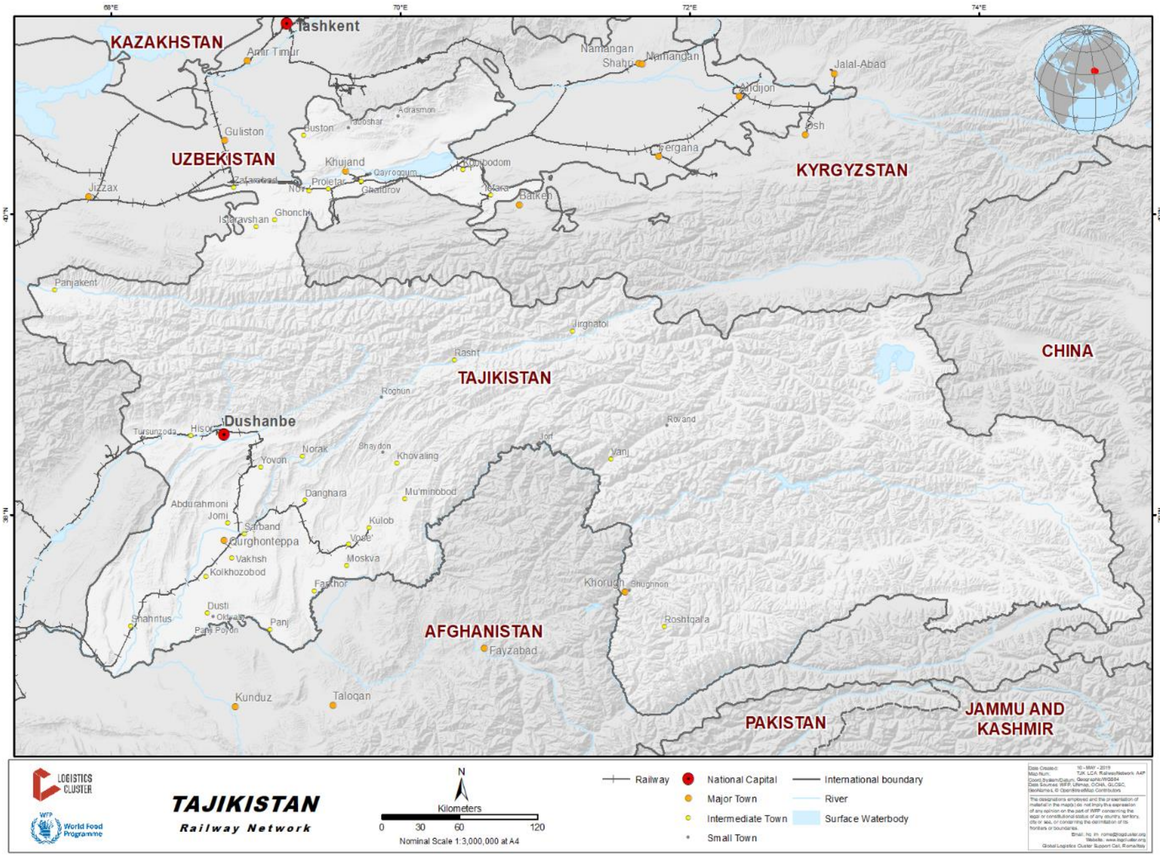


Figure 36 Rail Network of Tajikistan

The Railway system in Tajikistan is limited and a single track of 680 kilometres in length, none of which is electrified and 1,520 mm broad gauge. It only has an open international link with Uzbekistan.

There have been several international proposals set forth in order to modernize and expand the systems including the Ashgabat agreement which is proposed to connect Tajikistan-Turkmenistan to Afghanistan. The expansion of the Tajikistan rail network is also a part of the North-South Transport Corridor. There is a lack of local passenger transit due to weak governance and underfunding of the Tajik railways, the governing authority of the railway system. As the country has an irregular mountainous terrain it is not a popular system of commuting.

4.3.1.7. Turkey

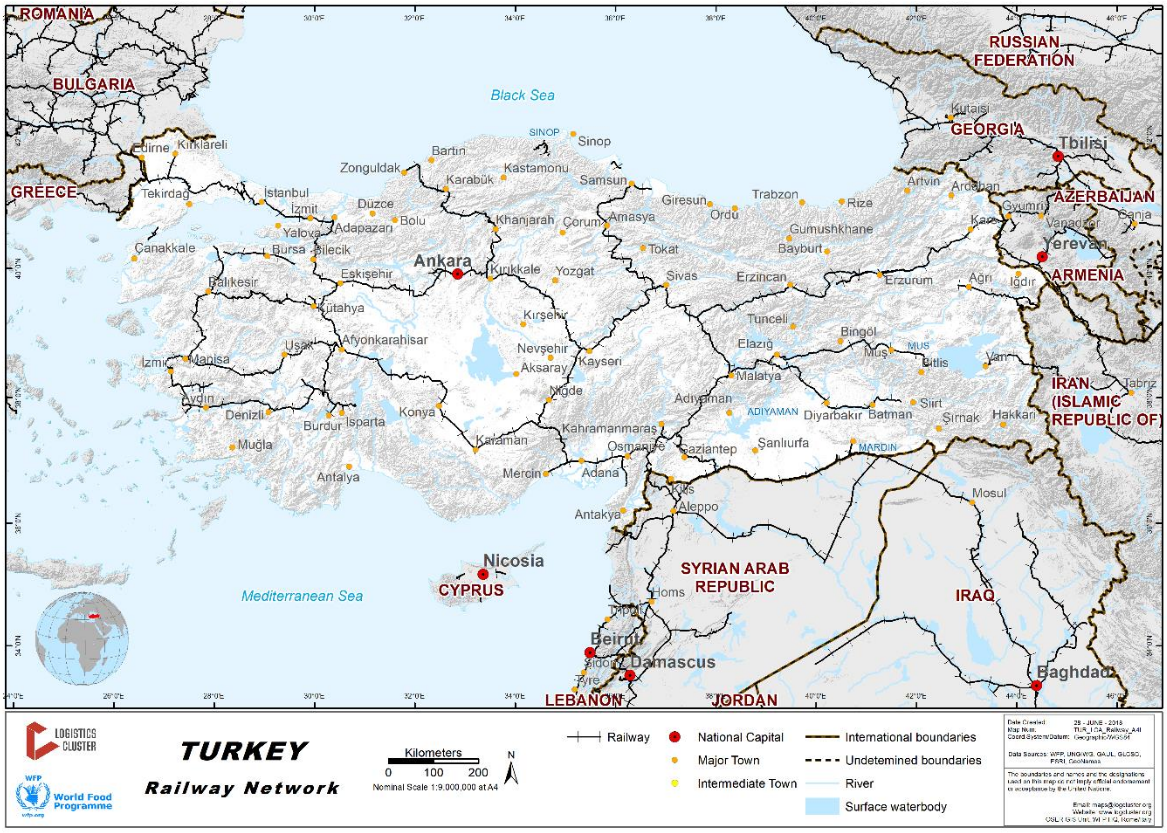


Figure 37 Rail Network of Turkey

Turkey has an extensive, well developed and connected rail network with open connections to five regional neighbours. Baku–Tbilisi–Akhalkalaki–Kars railway became operational in 2017 and connects Azerbaijan, Georgia and Turkey with an 826 km length and handled to operate 17 million tonnes of cargo. A total of 105 km has been built connecting the Turkish city of Kars to Akhalkalaki in Georgia.

A high rail speed network exists in the country connecting Ankara to Istanbul, Konya, Izmir and Bursa with a line to Kayseri in the planning stages and is 745 km double track with a gauge of 1435 mm. The Turkish rail network possesses 12,470 km of the rail network and an extension of 3,953 in development. 2288 km of the network is electrified (31 percent), and 3036 km of it is signalled. In the electrified network, there are 10 telecommand centres and 62 transformer centres which are handled remotely.

The Türkiye Cumhuriyeti Devlet Demiryolları or the Turkish State Railways are in charge of maintaining and the administration of the rail networks. There are also several affiliated companies that manufacture freight cars, locomotives and passenger wagons such as TÜVASAŞ which is also the largest railcar manufacturer in the Middle East and Northern Asian region.

Railway network in Turkey is actively used for passenger transportation with 45 million passengers having travelled according to 2018 estimates. Urban rail services have been developed in the three major cities of Istanbul, Ankara and Izmir with 1,435 mm (4 ft. 8 1⁄2 in) standard gauge. The tram system is also a major use of urban transport in many major cities across the country.

The Turkish State Railways is planning to divide its system into freight and passenger operations with a new company DETAS and will enable private companies to also access the railway system. Turkish Ministry of Transportation has a plan of constructing 2000 km conventional and 5000 km high speed lines till 2023

4.3.1.8. Turkmenistan

Figure 38 Rail Network of Turkmenistan

Turkmenistan possesses the 37th largest railway line in the world encompassing 4,980 kilometres in length. It has several international links such as a 10 km long line extending from Seherebat to Afghanistan. A planned extension to Andhkoy about 58 km is also in the works. The Berekat Railway station is of strategic importance to the Trans-Caspian railway system connecting Central Asian states to The Persian Gulf.

Türkmendemirýollary or the Turkmen railways is the governing authority of the railway system in Turkmenistan. It operates over 345 railway stations in the country and is a major mode of transport for many. It serves 6 million passengers daily.

The nation of Tajikistan holds the Trans-Karakurum railway network which is 540 km in length and serves 17 stations along the route, the construction of this network has reduced the trip from the capital of Ashgabat to the administrative centre of Dashoguz region by 700 kilometres. The north and south stretches are connected by 440 km and took five years to complete.

4.3.1.9. Uzbekistan

Figure 39 Rail Network of Uzbekistan

Uzbekistan has a modernized rail infrastructure, the total length of which is 4,669 km and carries 15 million passengers and 60 million tons of freight annually. Almost 2,446 km of the rail network is electrified. The track gauge is approximately 1,520 mm (4 ft 11 $^{27}\!/_{32}$ in).

There are many international rail links between Uzbekistan and neighbouring countries such as Russia via Kazakhstan and Tajikistan. There is also rail connectivity to Urumqi in China via Almaty. An electrified rail line link to Afghanistan via the Qarshi-Termez line has been developed. With access to Moscow, Uzbekistan has a direct link to Central European states.

The Tashkent-Samarkand high-speed rail line is a 344 km network between the two largest cities in Uzbekistan passing through four provinces. This network has successfully been able to cut travel time from 7 hours to Bukhara to around 3 hours, a distance of 600 km. An extension of the railroad to Urgench in Western Uzbekistan is to be completed by 2021. All railways in the country are run by O'zbekistan Temir Y'ollari or Uzbekistan railways

The Tashkent metro is one of the only rapid transit systems in Central Asia and was built in the former USSR. The Tashkent Metro consists of three lines, operating on 36.2 kilometres (22.5 mi) of route and serving 29 stations. The depth of the metro's tunnels varies between 8–25 meters (26–82 ft). The strong construction of these three lines can resist earthquakes of a magnitude of 9.0 on the Richter scale. The Tashkent Metro is famous for having one of the most decorative stations in the world.

4.3.2. Analysing the Data Received for Costing of Rail Infrastructure in Different Countries

In order to analyse the limited data of rail received from different countries, it was pertinent to study the factors that had a direct as well as indirect effect on the construction costs of the road. These costs were normalised to 2016 by using the GDP Deflator Index. A summary of input costs was tabulated as Table 21.

The table below shows the factors that have a direct effect on the construction costs of the rail. The data in this table reflects the sum of these individual factors and is arranged in a descending order starting from most costly to least costly input costs. According to this classification, direct input construction costs in Turkey are the highest while the direct input construction costs in Afghanistan are comparatively lower.

Country	Labour cost	Cement	Iron	Concrete	Power Cost	Wood	Fuel	Total Cost USD
	per month	Per Bag/50kg	Metric Ton	USD/Ton	USD/unit	USD/40kg	USD/Litre	
Turkey	468.75	2.97	638.88	3.09	0.11	14.51	1.05	1129.36
Uzbekistan	87.83	4.18	821.64	4.32	0.06	13.20	1.10	932.32
Azerbaijan	139.50	4.44	654.03	4.99	0.06	21.90	0.62	825.54
Kazakhstan	156.00	4.34	589.82	4.23	0.05	13.16	0.46	768.05
Pakistan	166.00	3.65	521.74	3.97	0.06	10.12	0.53	706.07
Turkmenistan	156.00	3.15	508.06	2.99	0.03	11.22	0.46	681.92
Tajikistan	13.26	3.93	596.81	4.12	0.03	17.47	0.47	636.10
Kyrgyzstan	78.64	2.63	494.05	2.73	0.02	9.40	0.49	587.96
Afghanistan	25.32	3.56	518.00	3.02	0.06	6.91	0.58	557.45

Table 20 Summary of Input Costs for Rail Infrastructure in USD

Note: This data is collected from different sources as the data could not be extracted from a single source. Also, it is important to understand here that the factors shown in the table above are just some of the factors that may directly or indirectly affect the construction costs of the projects.

The data extracted from the questionnaires was compared to the input costs derived, and for each rail characteristic i.e. New construction, Renewal and Upgrade—the results deduced were as follows.

4.3.2.1. New Construction

When data is compared by the construction type, i.e. New Construction, the following information is summarized;

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Turkey	7,743,376	3,929,273	1,777,778	117
Azerbaijan	5,035,555	3,383,429	1,731,302	48
Tajikistan	-	1,598,488	-	45
Turkmenistan	-	608,814	-	936
All Countries	7,743,376	2,380,001	608,814	1,146

Table 21 Data Comparison - Rail New Construction

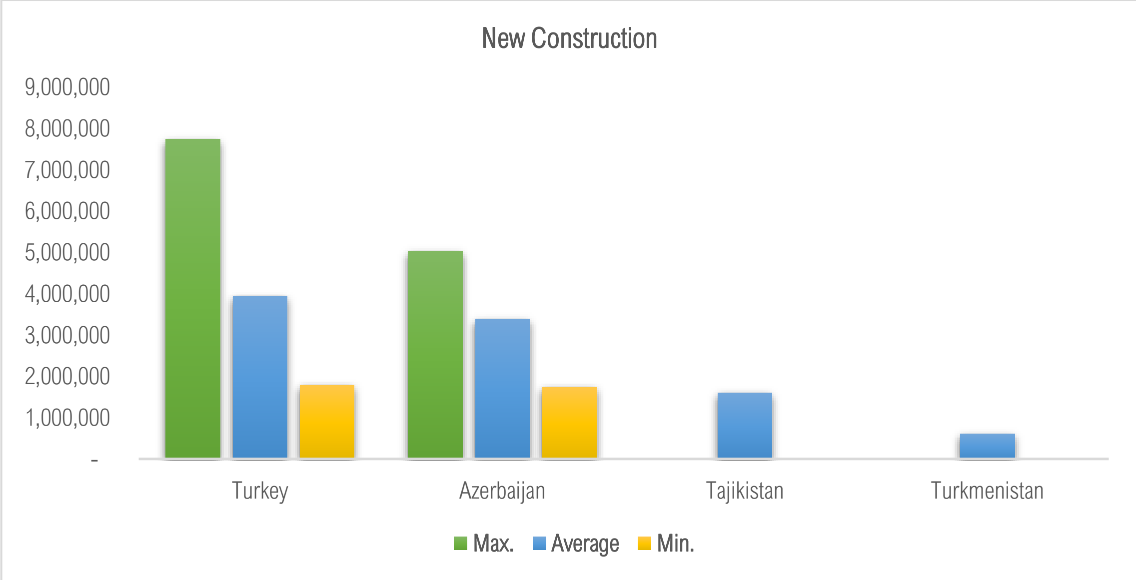


Figure 40 Data Comparison - Rail New Construction

The tabulated and graphed data above displays the maximum, average, and minimum final costs per km of construction of rails. The data for the countries being considered for the analysis has been arranged in a descending order from the highest average construction cost per km to the lowest average construction cost per km. The countries with no maximum and minimum values indicate that there's only one project in this specific category for that country. The comparison of this data with the factors that affect the construction costs of the projects, i.e. Table 21, reveals that Turkey is the most expensive country to build a new railway infrastructure. This is due to the fact that Turkey has comparatively higher labour costs, fuels costs and power costs. Azerbaijan follows the same trend and is estimated to be on the third spot having higher direct input costs for construction of railways. Additionally, no comparison could be made between Tajikistan and Turkmenistan due to non-availability of data.

4.3.2.2. Renewal

Data for Renewal of Railway Infrastructure is summarized as;

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Azerbaijan	8,262,144	4,360,751	1,775,246	503
Uzbekistan	-	2,294,496	-	236
Turkmenistan	362,035	181,355	674	1,423
All Countries	8,262,144	2,278,867	674	2,162

Table 22 Data Comparison - Rail Renewal

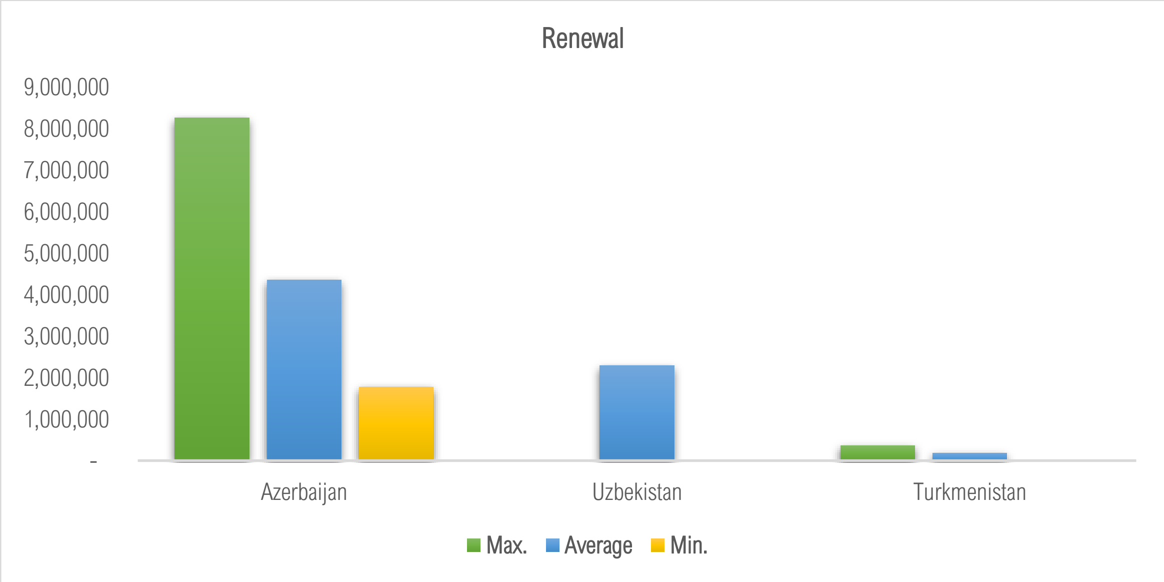


Figure 41 Data Comparison - Rail Renewal

The data above represents the maximum, average, and minimum final costs per km of renewal of rails. The data for the countries being considered for the analysis has been arranged in a descending order from the highest average construction cost per km to the lowest average construction cost per km. After the comparative analysis of this data with the factors that may directly or indirectly affect the construction costs of the projects, i.e. Table 21, it is apparent that Azerbaijan has a higher direct input cost for renewal of railways. On the other hand, Turkmenistan has comparatively lower output costs than Azerbaijan which reinforces the analysis of having comparatively lower direct input costs. Since Uzbekistan has only one project that falls under this category, no comparison with the rest of the sample countries could be made.

4.3.2.3. Upgrade

Data comparison for Rail Upgrade is summarized as under:

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Uzbekistan	-	2,500,000	-	40
Tajikistan	4,177,411	2,237,547	1,092,862	994
Kazakhstan	378,718	327,503	256,929	815
Turkmenistan	-	25,381	-	985
All Countries	4,177,411	1,272,608	25,381	2,834

Table 23 Data Comparison - Rail Upgrade

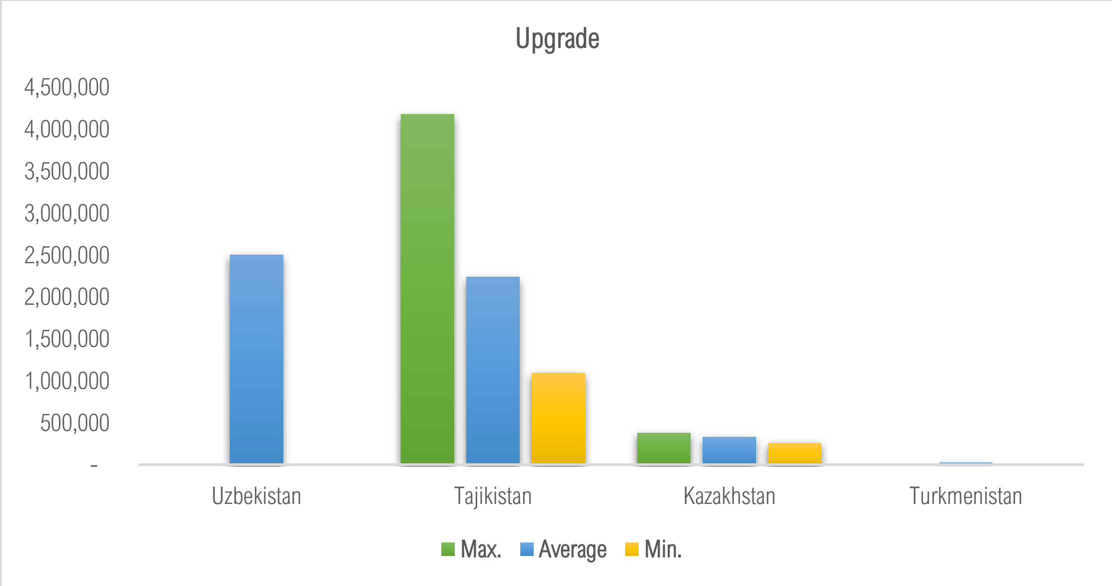


Figure 42 Data Comparison - Rail Upgrade

The data representation above shows the maximum, average, and minimum final costs per km of upgrading the rails. The data for the countries being considered for the analysis has been arranged in a descending order from the highest average construction cost per km to the lowest average construction cost per km. This makes Uzbekistan the country with the highest output costs while Turkmenistan being the one with the lowest output costs. The comparison with Table 21 shows that Kazakhstan despite being above Tajikistan in input costs, manages to employ its resources efficiently and subsequently reduce its output cost for the upgradation of the rails. Whereas, Tajikistan, despite having third lowest labour costs, seems to have involved other factors and indirect costs as well that increases its total actual construction costs.

4.3.2.4. Electrified Line

When the data for the type of line, i.e. Electrified was compared, the following information was assembled;

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Turkey	7,743,376	7,743,376	7,743,376	60
Tajikistan	-	1,598,488	-	40
Turkmenistan	362,035	129,363	674	2,408
All Countries	7,743,376	3,157,076	674	2,508

Table 24 Data Comparison for Rail Electrified Line

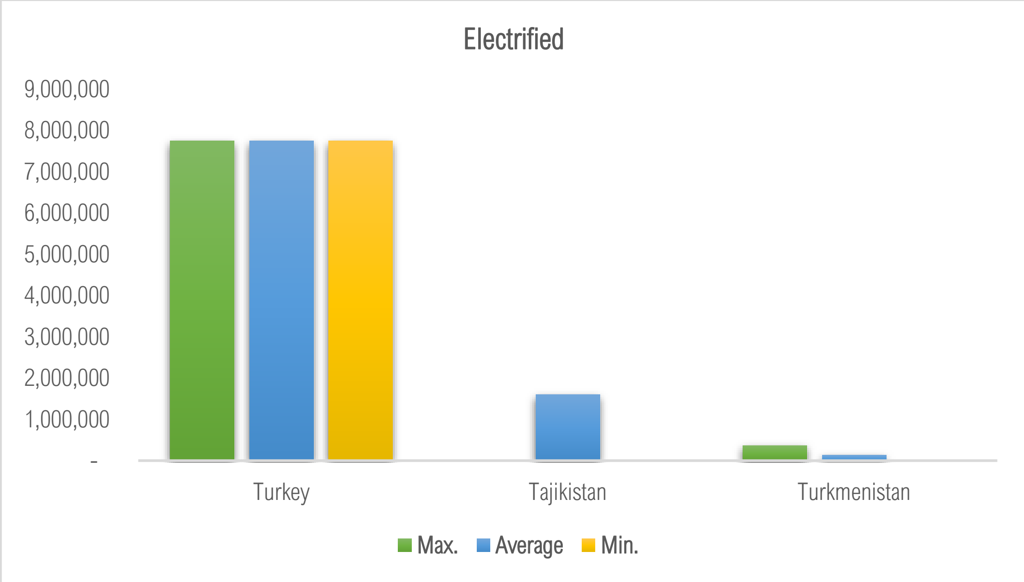


Figure 43 Data Comparison for Rail Electrified Line

The data above represents the maximum, average, and minimum final construction costs per km of electrified rails. The data for the countries being considered for the analysis has been arranged in a descending order from the highest average construction cost per km to the lowest average construction cost per km. The comparison with Table 21, i.e. the factors that may directly or indirectly affect the construction costs of the projects, disclose that Turkey has comparatively higher final construction costs than Turkmenistan and corroborate the fact that Turkey has higher direct input costs for the construction of the rails. Turkmenistan, on the other hand, has the lowest final construction costs when constructing the electrified rails. Moreover, the table above reflects only one project for Tajikistan and cannot be compared to other countries to reach a conclusive analysis.

4.3.2.5. Non-Electrified Line

For non-electrified line, the data is summarized as under;

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Azerbaijan	8,262,144	3,969,822	1,731,302	551
Tajikistan	4,177,411	2,237,547	1,092,862	994
Turkey	2,266,667	2,022,222	1,777,778	57
Turkmenistan	-	608,814	-	936
Uzbekistan	-	10,811	-	111
All Countries	8,262,144	1,769,843	10,811	2,649

Table 25 Data Comparison for Rail Non-Electrified Line

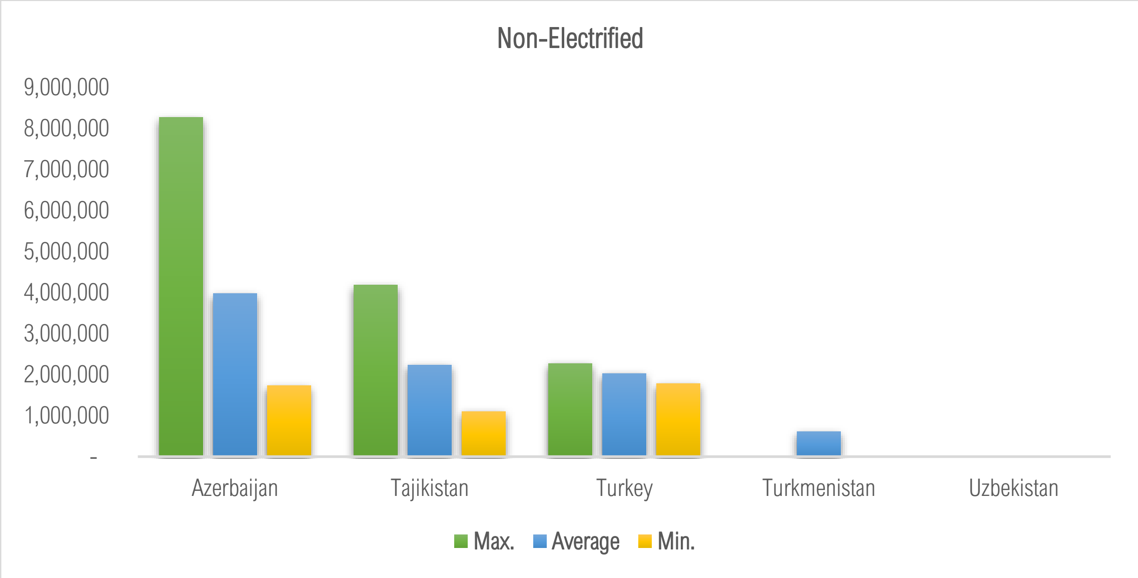


Figure 44 Data Comparison for Rail Non-Electrified Line

The data above represents the maximum, average, and minimum final construction costs per km of non-electrified rails. After arranging the data in a descending order from the highest average construction cost per km to the lowest average construction cost per km. The comparison with Table 21, i.e. the factors that may directly or indirectly affect the construction costs of the projects, disclose that Azerbaijan is the costliest country to build non-electrified rails when compared to the other sample of countries whereas the direct input costs for construction in Azerbaijan are comparatively lower than Turkey. It was observed that this situation changes for Turkey as it has lower final construction costs when compared to Azerbaijan but has comparatively higher direct input costs. This shows that Azerbaijan has some hidden costs involved when it comes to building non-electrified rails. These include legal costs, insurances, worker's compensation etc. Moreover, Turkmenistan and Uzbekistan have only one project that falls under this category therefore, no conclusive analysis could be made.

4.3.2.6. Line Speed Design - V<120

The summary of the data for line speed design, i.e. V<120 is as under;

Country	Max. Construction Cost/km	Avg. Construction Cost/km	Min. Construction Cost/km	Length of Regarded Projects (km)
Turkey	-	7,743,376	-	60
Azerbaijan	8,262,144	3,969,822	1,731,302	551
Tajikistan	4,177,411	2,077,782	1,092,862	1,039
Turkmenistan	-	608,814	-	936
Kazakhstan	-	378,718	-	402
Uzbekistan	-	10,811	-	111
All Countries	8,262,144	2,464,887	10,811	3,099

Table 26 Data Comparison - Rail line speed design V<120

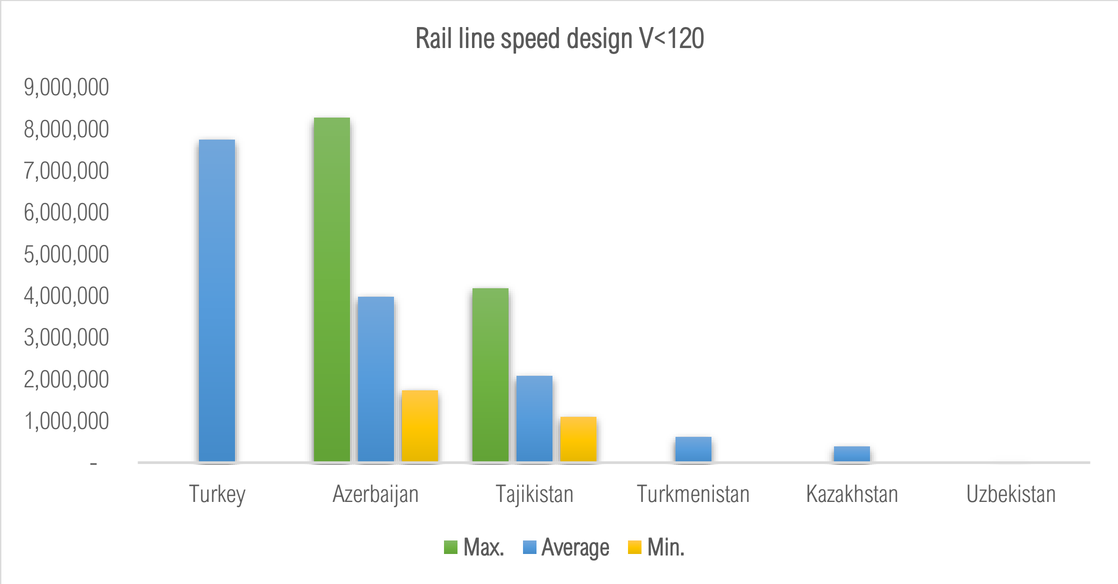


Figure 45 Data Comparison - Rail line speed design V<120

The data above represents the maximum, average, and minimum final construction costs per km for the rails having the velocity less than 120 Km/h. After arranging the data in a descending order from the highest average construction cost per km to the lowest average construction cost per km. Comparing Azerbaijan with Tajikistan reveals that both of the countries follow the same pattern as our research indicates i.e. Azerbaijan has higher direct input costs than Tajikistan. The same is reflected in the final construction costs as the factors that may directly or indirectly affect the construction costs of the projects are higher in Azerbaijan than in Tajikistan. No comparison could be made between Turkey, Kazakhstan, Uzbekistan and Turkmenistan due to non-availability of data.

4.3.2.7. Line Speed Design - 120<V≤160

The data by the line speed design, i.e. 120<V≤160 is as follows;

Country	Max.	Average	Min.	Length of Regarded Projects (Km)
Uzbekistan	2,500,000	2,397,248	2,294,496	276
Turkey	2,266,667	2,022,222	1,777,778	57
All Countries	2,500,000	2,209,735	1,777,778	333

Table 27 Data Comparison - Rail line speed design 120<V≤160

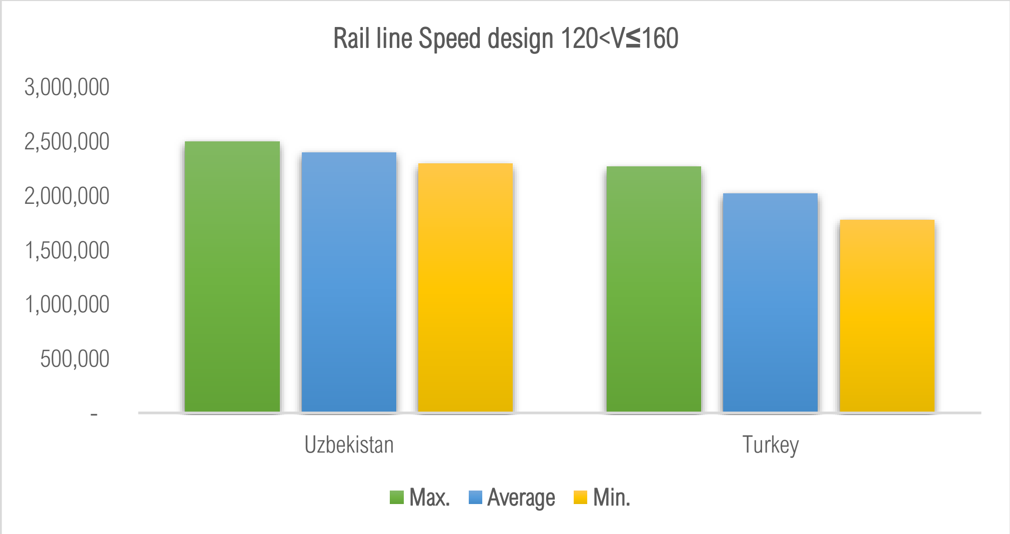


Figure 46 Data Comparison - Rail line speed design 120<V≤160

The tabulated and graphed data above displays the maximum, average, and minimum final costs per km of construction of the rails having the velocity more than 120 Km/h but less than 160 Km/h. The data for the countries being considered for the analysis has been arranged in a descending order from the highest average construction cost per km to the lowest average construction cost per km. The comparison of this data with the factors that may directly or indirectly affect the construction costs of the projects, i.e. Table 21, show that Turkey, despite having higher input costs like labour costs, power costs and the fuel costs, has lower final output costs than Uzbekistan. Whereas, Uzbekistan having comparatively lower direct input costs, emerges to be ahead of turkey when it comes to final construction costs for the rails with 120<V≤160-line speed design.

4.4. Ports, Water ways and Intermodal Terminals' Infrastructure

There was no substantial data to analyse for the Ports, Water ways and Intermodal Terminals' Infrastructure in the countries. However, information received from the NFPs of each country, along with the research conducted on open sources available; has been summarized below:

4.4.1. Afghanistan

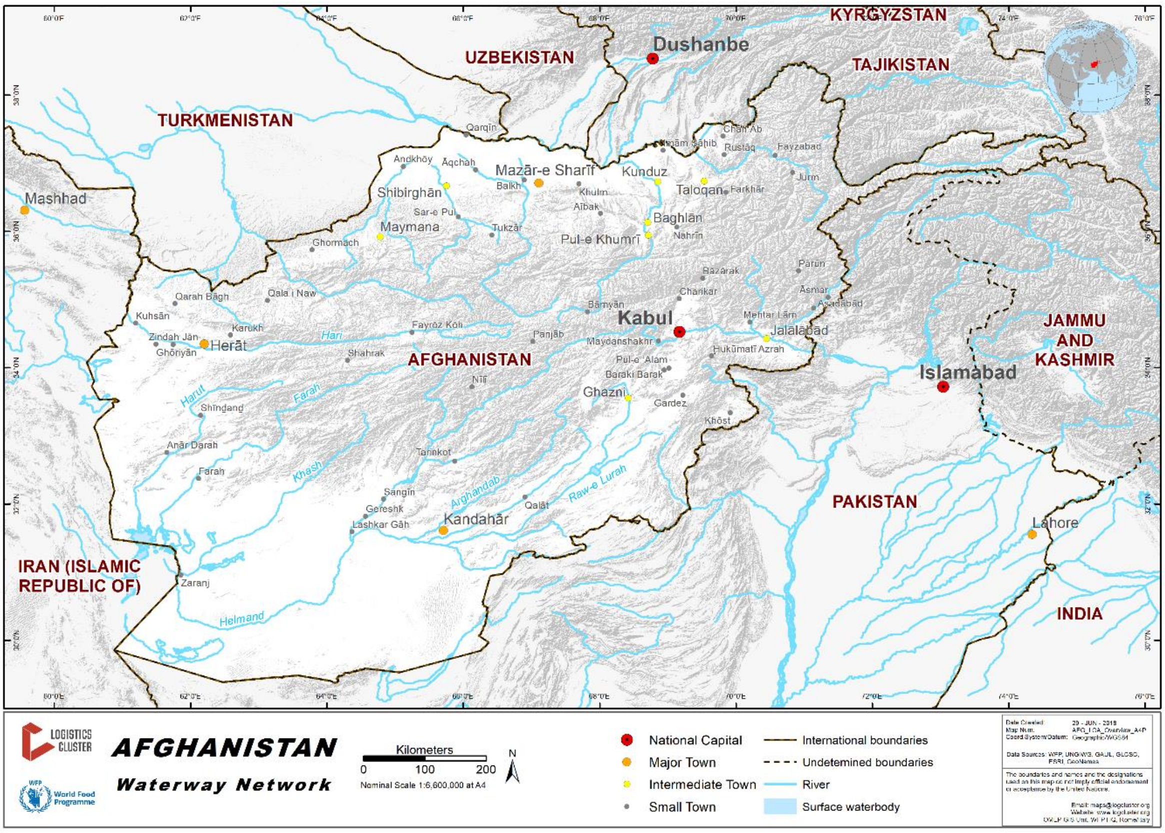


Figure 47 Water Network of Afghanistan

4.4.1.1. Ports

Afghanistan is landlocked, with no major sea bodies around, but has several rivers.

It has no major seaport. Though, it has two riverports Kheyrabad and Shir Khan Bandar. The Termez rail station between Uzbekistan and Afghanistan connects the two states through a bridge over the Amu Darya river.

4.4.1.2. Waterways

Afghanistan possesses four main rivers, Amu Darya, the Hilmand, the Harirud and the Kabul. River Kabul joins the Indus River in the neighbouring country of Pakistan and is the only one to do so. Most rivers in the country flow into arid portions or only flow seasonally. There are three major dams in Afghanistan, the Arghandab dam over Kandahar, the Kajakai on the Kilmand River and Naglu over Kabul. Unfortunately, due to lack of maintenance these dams are not in working conditions.

4.4.1.3. Intermodal Terminals

The main intermodal terminal is the Mazar-i-sharif station near the Amu Darya river—the only large body of water in a landlocked country. It is the transit hub between Afghanistan and Uzbekistan and shares at least 25000 tonnes per month of cargo including oil, wheat and other products and is then forwarded by trucks. The Torkan inland dry port is also situated at the Pakistani border of Torkham. Institutional and project management capacities are major challenges for the development of intermodal transport in Afghanistan[32]

4.4.2. Azerbaijan

Figure 48 Water Network of Azerbaijan

4.4.2.1. Ports

The capital of Azerbaijan, Baku also possesses the major seaport of the country which is located on the Bay of Baku. In 2007, a New Baku International Sea Trade Port Complex was agreed upon with the old port being completely destroyed. This new port is situated in the Alat settlement and will also serve as a transportation hub. Port of Baku at Alat will be able to hold 150 – 160 metre-long, 10,000 tonne capacity ferries and all other types of vessels. The port provides access to three international routes from Baku to Russia, through Georgia to Turkey and the Black Sea and the border area with Iran. The port was officially opened in May 2018. 80 percent of the cargo is transhipment while 20 percent is gateway.

One of the largest port operators Dubai Port World has signed an advisory agreement to establish a free trade zone in the Alat complex.

4.4.2.2. Waterways

Most of the water in Azerbaijan is part of the Caspian Sea Basin. The major source of water to the country are the Kur basin rivers and the Araz basin rivers, both flows directly into the Caspian Sea. The average density of the river system of Azerbaijan is 0.39 km/km². The density is even lower than 0.05 km/km² in the plains. There are also over 60 reservoirs in Azerbaijan which are used regulate the river flow in the country.

[32] https://www.unescap.org/sites/default/files/pub_2556percent 20Promotingpercent 20intermodalpercent 20transport.pdf
https://www.railway-technology.com/projects/hairatanuzbekistanra/

Azerbaijan has major sea routes with other countries sharing the Caspian Sea namely (Iran, Kazakhstan, Russia, and Turkmenistan). The Volga-Dan canal provides maritime access to the Russian High Seas. The main shipping partners are Caspian, Black, Mediterranean and Marmara seas.

The Ministry of Transportation of the Republic of Azerbaijan holds power over Maritime affairs in the country and has developed a regulatory authority which handles all maritime matters including implementing state programs as well as regulating transport of good and services.

4.4.3. Kazakhstan

Figure 49 Water Network of Kazakhstan

4.4.3.1. Ports

Kazakhstan holds two seaports as well as three riverports. The port of Aktau uses routed via Black Sea and Caspian Sea through the neighbouring country of Turkmenistan. Aktau seaport capacity is around 21 million tonnes per year. The Atyrau seaport is located on Ural River and is also used for oil exploration activities in the Northern Caspian Sea. The facility is to be used for loading out large modules weighing up to 1,500 tonnes to flat top barges for use in the oil fields of the Northern Caspian. The three river ports of Kazakhstan are Oskemen, Pavlodar and Semey.

4.4.3.2. Waterways

Aktau is a major waterway for as it is a transit to the Caspian Sea and then by rail through Azerbaijan and Georgia to Turkey. It also connects to other major cities such as Astana and Almaty through railway station near the city centre.

4.4.3.3. 4.4.3.3. Intermodal Terminals

There are several intermodal terminals in Kazakhstan connecting various modes of transport. The Khorgos East Gateway project is the main dry port being proposed in the special free economic zone which will connect with international links and has an area of 129 hectares, it will also hold a Container Yard(CY) with a capacity for 16,000 TEU (3,700 TEU ground-slots and a 4.3 tier average stack height). There will be two rail connected warehouses, each with an area of 5,000 square meters and each incorporating a 700 square meter temperature-controlled chamber. The transit corridor at Altynkol/Khorgos handled 2 million tonnes of international cargo. The rail-road intermodal system has been reported to have a flawed system with custom processing problems, high charges and delays of 2 days.

4.4.4. Kyrgyzstan

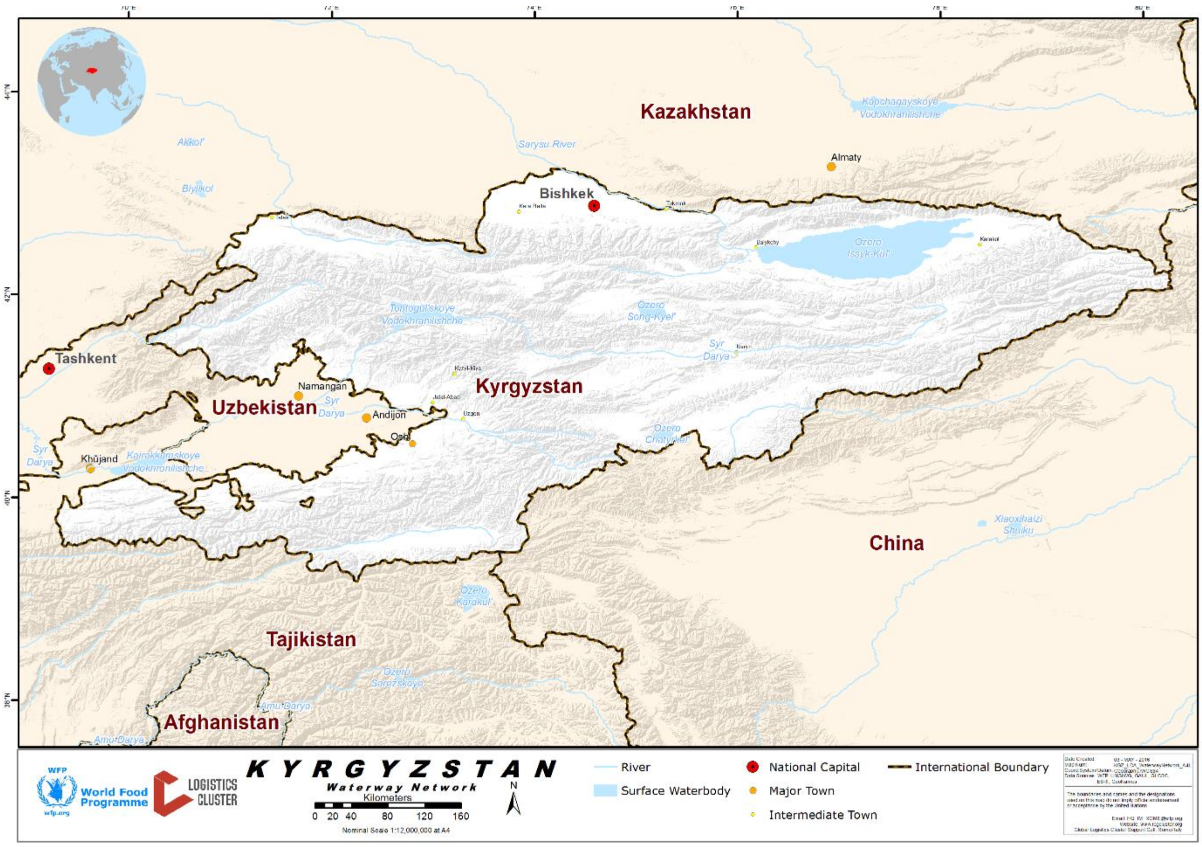


Figure 50 Water Network of Kyrgyzstan

4.4.4.1. Ports

The Kyrgyzstan is a landlocked nation. There is a smaller riverport on the Lake Issyk-Kul.

4.4.4.2. Waterways

Kyrgyzstan is a landlocked country. The Republic does not have waterways that are commonly shared with neighbouring countries.

By Decree of the Government of the Kyrgyzstan dated 31.01.2018 No.72, the State Enterprise “Issyk Kul Shipping” has been merged, as a sisterly branch, with State Enterprise “Kyrgyzkomur” under the State Committee of Industry, Energy and Natural Resources of the Kyrgyzstan. Also, by Decree No. 98 dated 2 March 2016 of the Government of the Kyrgyzstan the State Enterprise “Issyk-Kul Shipping” has been included in the national listing of strategic economic entities of the Kyrgyzstan. However, at present, due to limited financial resources the State Enterprise “Issyk-Kul Shipping” is in unsatisfactory condition.

4.4.4.3. Intermodal Terminals

Today, 17 logistical centres are functioning in territory of the Kyrgyzstan, including 7 in Chuy oblast, added to this are the 3 logistical centres that are temporarily halted, 1 in Issyk-Kul oblast, 2 in Batkent oblast, 3 in Osh oblast, 1 in Talas oblast and 5 in Jalal Abad oblast and 1 in Naryn oblast.

For the short-term period, the construction of the following trade and logistical centres have been planned at national level:

In Talas oblast:

1. Trade-and-Logistical Centre for storage of agricultural produce in Manas district in Kyzyl-Zhyldyz village (Uch-Korgon county). The capacity of the Centre has been designed at 10,000 thousand tonnes per annum;

2. Trade-and-Logistical Centre for storage of agricultural produce in Manas district, Kara-Burynsk district, Chymgent village in Cholponbayevks county. The capacity of the above-said Centre has been designed at 20,000 tonnes per annum; The cost of the project is USD 1.2 million. Feasibility study of the construction of the above-referred Trade-and-Logistical Centre has been fulfilled. Currently, the works are on for further process of the project till approval of construction works.

3. Trade-and-Logistical Centre for storage of agricultural produce in Talas city at designed storage capacity of 200 tonnes per annum. Currently, the additional funding of USD 300,000 is being processed. The land lot of 0.5 hectares has been allocated for the purposes of the project.

In Jalal Abad oblast:

1. Mini Trade -and -Logistical Centre in Aksyisk district in Zhergen village has been planned with designed storage capacity of 1,000 tonnes per annum. The cost of project is 8.2 million Kyrgyz Som. The project is being financed by the Regional Development Fund of Jalal Abad. The first tranche accounting to the 30 percent of the cost of the project has been transferred to winners of the tenders;

2. Mini Logistical Centre “Trade Centre” (Cooperative) in Nookensk district, Burgandy village at designed storage capacity of 120,000 tonnes per annum. The sources of financing of this project are: Private partners under GIZ auspices. The cost of the project is USD 7,500, 000. At present, the purchases of project equipment have been made and construction is ongoing.

3. Trade- and- Logistical Centre in Suzak district, Ulgu village of Barpinsk country. The cost of the project is USD 25 million. For construction of this Trade-and-Logistical Centre in the Barpinsk country 20 hectares of land have been allotted. At present, the project works are ongoing to address the issues relating to the transfer of land to project operators.

4. Trade and Logistical Centre in the city of Jalal Abad designed for storage of agricultural produce. The cost of the project is 100 million Kyrgyz Som. Currently, feasibility study is being processed.

5. Trade-and-Logistical Centre in Tash-Kumy city has been planned to use the base of Joint Stock Company “Argymak”. The cost of the project is USD 1.5 million. To date, the project has been provided with complete feasibility study.

<u>In Osh oblast</u>

1. Trade –and-Logistical Centre in Zhoosh Kara-Suyisk district, has been planned to be set up on the 33 hectares of land. The cost of the project is 20 million Kyrgyz Som.

2. Trade-and-Logistical Centre in the Mirmahmoudov country of Nookatsk oblast is being planned to be set up on the 10 hectares of land. The cost of the project is 167 million Kyrgyz Som.
3. Trade-and-Logistical Centre is being planned in Kara-Suisk district. At present, the feasibility study of the project is in process.

<u>In city of Osh:</u>

4. Trade-and-Logistical Centre for storage of agricultural produce using the base of Shareholder Society “Kelechek” is on. The estimated cost of the project is USD 800,000.

5. Trade-and-Logistical Centre for storage of agricultural produce basing the facilities of the “Daut Pirim” Ltd. The cost of the project is USD 1,600,000.

6. Trade-and-Logistical Centre for storage of agricultural produce using the base of Kyrgyz Organic Foods Ltd. The cost of project is USD 1,416,000.

<u>In Naryn oblast</u>

Trade-and-Logistical Centre for storage of agricultural produce Koshkor Logistics in Kochkor district at storage capacity of 10, 000 tonnes of potatoes and 2,000 tonnes of meat is being planned. 1.3 hectares of land has been allotted for the project. 10 storage houses will be constructed at capacity of 10,000 tonnes and 2 refrigerators for meat and 2,000 tonnes. The cost of project is USD 5,000,000.

<u>In Issyk-Kul oblast:</u>

1. Regional Multifunctional Retail Centre (RRC) for agro-produce in the western industrial zone in Balykchi city is being planned on 200 hectares of land. The unique economic and geographical location of city of Balykchi at juncture of the three oblasts (Issyk-Kul, Naryn and Chuisk oblasts) and at intersection of major highways running in the direction of «East-West» and in “North-South” and also the existence within the area of the municipal zone of the large railway terminal, which is connected to the comprehensive transport infrastructure attached the above-specified Centre creates favourable opportunities for inter-regional and trans-boundary exchange of goods and services through this Regional Multifunctional Retail Centre.

2. Trade -and-Logistical Centre for storage of potatoes and other vegetables in the city of Karakol connecting Aksuisk, Tupsk and Jetti-Oguz districts (logistical centre located on Kara-Bak land lot in the village of Barskon in Barskon county). The district produces 41-45 percent of gross agro-production in the entire Kyrgyzstan. Over 50 percent or nearly the volume within the range of 200,000-220,000 tonnes of gross agro-production of the oblast is targeted for exports.

<u>On Chuisk oblast</u>

1. Trade -and-Logistical Centre in Zhayil district with designed storage capacity of 8,000 tonnes per annum. The construction site has been identified as site No. 142 located on the land covering 27.9 hectares in the

territory of the Taldy-Bulak county of Zhayl district. The type of the activity under this project is calibrating, sorting, and packaging of beans designated for exports.

2. Trade -and-Logistical Centre for storage of agro-produce in Tokmok city. 3. Construction of the Trade-and-Logistical Centre is being planned in territory of Issyk-Atinsk district.

At present, the feasibility study is under development.

In Batkent oblast

1. Industrial -and-Logistical Centre (Aidan Group) in Kadamzhaisk district of Burgundunsk massland, on "Durker" lot of the Kadamzhar country and Ak-Turpak county covering land area of 1,000 hectares. The project cost is 7.9 million Euro. Production capacity of storage and processing capacity of agro-produce is within 5,600-12,000 tonnes. Currently, the feasibility study preparations are underway jointly with Republic of Poland.

2. Industrial -and-Logistical Complex in Batkent city. Project cost is 200 million Kyrgyz Som. Land area under construction is 172.9 hectares. The project has been approved by Special Decree No. 617 of 21 November 2019 of the Government of the Kyrgyzstan on transfer of land site covering 172.9 hectares.

4.4.5. Pakistan

Figure 51 Water Network of Pakistan

4.4.5.1. Ports

Pakistan has access to major seaports: Gwadar and Port of Karachi. It also has several smaller ports such as Port Pasni and Port Qasim in East Karachi.

Port of Karachi is one of the busiest and deepest seaports in South Asia, with an 11 kilometres long approach channel which provides safe navigation for vessels up to 75,000 tonnes deadweight. There are three terminals situated at the port, Pakistan International Bulk Terminal and Karachi International Container Terminal while a private terminal Al-Hamd International Container Terminal is also situated nearby. The PIBT has a capacity of 350,000 TEUs per annum and handles container ships up to 11.5-metre draught. Karachi Port Trust has been in charge of Administration since the 19th Century.

The Port of Gwadar has been acquired by China Overseas Port Holdings Limited and leased by the DRC till 2059. It is of strategic importance to China as it is a gateway to the Persian Gulf where China gets most of its oil from. The construction of the Port is also a part of the Belt and Road Initiative and New Maritime Silk Road projects. There are three Phases of the Plan which result in the Port being able to handle 400 million tonnes per year.

4.4.5.2. Waterways

There are several ferry services that run between Kimari and Minora Islands in Karachi. Pakistan has a 650-mile-long coastline along the Arabian Sea, itself part of the larger Indian Ocean. It also holds the Indus river which is one of the longest rivers in the world at about 1800 miles and is also a vast irrigation system. There are other major bodies of water the Sutlej, Jhelum, Chenab and River Ravi.

The Indus Inland Waterways System is a potential project that would connect all the major cities in Pakistan with Afghanistan and other Central Asian states. This will also help with water supply in the region as it will lower the water related tensions of India and Pakistan. The Inland Water Transport Development Company has been created by the Government of Pakistan to test a pilot project and connect Port Qasim with the city of Nowshera in KPK.

4.4.5.3. Intermodal Terminals

The following data was provided by NFP of Pakistan for Intermodal Terminals:

Construction Cost of Intermodal Transport	Unit Cost	Project
Land Adaptation	USD/m^2	Rohri-Sibi-Spezand-Taftan = 12.5 USD/m^2
Portable Water Supply	USD/m	Rohri-Sibi = 19 USD/m Sibi-Spezand = 26 USD/m Spezand-Taftan = 14 USD/m
Power Supply	USD/unit	Rohri-Sibi = 15 USD/m Sibi-Spezand = 43 USD/m Spezand-Taftan = 5 USD/m
Rain Drainage	USD/unit	Rohri-Sibi = 19 USD/m Sibi-Spezand = 26 USD/m Spezand-Taftan = 14 USD/m
Telecom Supply	USD/unit	Rohri-Sibi = 159 USD/m Sibi-Spezand = 155 USD/m Spezand-Taftan = 82 USD/m

Table 28 Summary of Intermodal Terminals in Pakistan

4.4.6. Tajikistan

Figure 52 Water Network of Tajikistan

4.4.6.1. Ports

Tajikistan is a landlocked country with no major sea bodies around. There are no ports in the country.

4.4.6.2. Waterways

There are about 947 rivers that are longer than 10 km and cover 28,500 km of the country and contain 60 percent of the hydro-resources in Central Asia. Tajikistan is also one of the wettest countries in the region with 691mm of average annual precipitation proving water for its many rivers and lakes. It also possesses almost 1300 natural lakes and glaciers covering 8,476 km. Tajikistan shares major rivers such as Amu Darya and Syr Darya with Kyrgyzstan and other neighbouring countries. Unfortunately, none of these waterways is navigable.

4.4.6.3. Intermodal Terminals

Tajikistan does not possess any intermodal terminals due to its lack of ports and topographical limitations. The Panj River, however, can be considered a transit hub for the Afghanistan and Tajikistan border with a rail link being proposed. There is a lack of intermodal traffic in the country due to its poorly equipped terminals and a small proportion of perishable cargoes.

4.4.7. Turkey

Figure 53 Water Network of Turkey

4.4.7.1. Ports

Turkey is a country surrounded by water, with having access to major sea routes. The country flows into the Black Sea, The Mediterranean and Aegean Sea. There are multiple seaports in Turkey such as Port of Haydarpasa in Istanbul as well as port cities of Izmir and Gulluk. There are two other major ports Mersin and Ambarli. These ports are under the Administration of TCDD, the Turkish State Railways except the Port of Ambarli which is owned by the ALTAS Ambarli Port Facilities Trade Company Inc.

The Port of Mersin acts as a major gateway to the Mediterranean Sea as it connects the country to major trade routes in Europe and the facilities at the port handle general cargo, containers, dry and liquid bulk and ro-ro, while the port of Haydarpasa being located in Istanbul gives it strategic importance, it also has a handling capacity of five container terminals with 1,700 vessels a year. The port of Izmir is a very busy seaport with historical significance to the Ottoman Empire and in 2018, the number of marine vessels which visited the port were 2,047.

4.4.7.2. Waterways

Turkey also provides two significant waterways internationally through the Turkish straits and the Sea of Marmara. Bosporus and Dardanelles are major rivers located in the country with historical and cultural significance. Turkey holds a number of Port Cities which have access to cruises and ferries alike. Izmir provides urban ferry system with 24 ferries shuttle between 9 quays and is controlled by the İzmir Metropolitan Municipality.

There are many ferry terminals in the country as it is a common use of transportation. The Eurasia tunnel is a dual-deck, 14.6 kilometres tunnel over the Bosporus which connects the European and Asian side together. İDO Istanbul Fast Ferries Co. Inc or IDO are sea transportation vessels with sea buses and fast ferries that serve at 29 terminals across the country.

4.4.8. Turkmenistan

Figure 54 Water Network of Turkmenistan

4.4.8.1. Ports

Port's official name: Turkmenbashi International Seaport.

Construction of Port has been started under port project on 06.01.2014. Port was commissioned to operation on 02.05.2018. The opening of port coincided with the 9th Meeting of Ministers of Transport of ECO Member States held on 1-3 May 2018 in Turkmenbashi (Turkmenistan). Port's land area is 375 acres, including ferries, passenger/cargo terminals, 1.7 kilometres of berths designed to serve 17 vessels at a time. Piers' length is 3,600 meters. Driveway roads with overpasses stretch for over 4,000 meters. Driveway railway tracks stretch for 30,000 meters. Port's total throughput capacity is 17-18 million tonnes of cargo per annum. Such throughput excludes oil products but includes 300,000 passengers, 75,000 road trucks, 400,000 twenty-foot equivalent unit containers, 3,000,000 tonnes of bulk and 4,000,000 tonnes of general cargo. Ship-to-shore berths operate with a capacity of 25 twenty-foot equivalent unit containers per hour. Port provides for functioning of the hotel designed for hosting capacity of 50 hotel rooms, a restaurant for 80 guest seats, a parking lot designed for 450 vehicles and other infrastructure. Port provides for free storage for the period from 30 to 45 days, based on License No. 3-26-39-126 dated August 27, 2018 to operate as a "bonded warehouse". Port has "Balkan" shipbuilding and ship-repair plant in its territory. Plant has the capacity to process 12,000 tonnes of steel per annum. Current plans of the plant are to construct 4–6 vessels per annum while providing maintenance facilities for 20–30 ships per annum.

4.4.8.2. Waterways

As with modest share of waterways in Turkmenistan, all area relating to water, notably, water management has been assigned to the Ministry of Agriculture and Water Management of Turkmenistan. In pursuit of reforms in national food industry and improving its quality, in 2018, State Food Industry Enterprise has been attached to the Ministry of Agriculture and Water Management of Turkmenistan (Decree of President of Turkmenistan "On Reorganization of State Food Industry Enterprise of Turkmenistan" No. 1433- 2018.04.12). Such measure indicates, among others, at the fact that water-related area in Turkmenistan, notably, water management is under agriculture and food industry.

4.4.8.3. Intermodal Terminals

Turkmenistan holds strategic importance in TRACECA route and is seen as a transit route for Europe to Central Asian regions. Turkmenbashi International Seaport is seen as an intermodal terminal with a marine passenger station as well as cargo and bulk terminals. The container terminal is designed as a 400 000 TEU/year with the capacity to hold 9080 volume of containers.

The Berekat railway station is also a major transit hub for passengers and freight moving into Central Asian states from Europe. Tajikistan is also a part of the North-South Transnational corridor that will help establish more multi-modal transportation and forwarding methods.

4.4.9. Uzbekistan

Figure 55 Water Network of Uzbekistan

4.4.9.1. Ports

Uzbekistan is a landlocked country. It has no seaports.

The main "river port" is Termez on Amu Darya but internationally it is being referred to as a Dry Port as it is an integral part of Uzbekistan's Dry Port network. Thus, Termez railway station provides railway connectivity between Uzbekistan and Afghanistan by extending its rail-based bridge over Amu Darya's narrowest part. Termez railway station has an international status of transit transport station.

4.4.9.2. Waterways

Even though Uzbekistan has, over the past, been reported to have 1,100 kilometres of inland waterways, since 1990s, commercial travel on Uzbekistan's portion of Amu Darya has been reduced because of shallow water levels not fit for navigation. Uzbekistan is not endowed with substantial waterways' systems. Bypass rivers, such as Amu Darya, Syr Darya and Zarafshon, all originate from other countries flowing across a small stretch in Uzbekistan.

Chapter 5: Conclusion and Recommendations

When carrying out external benchmarking i.e. comparing data from different countries, it is always expected that the data will not be directly comparable. Therefore, it was important to identify the differences and make a pragmatic adjustment where necessary. Hence, for this study, the approach adopted was two-pronged— 'first strike' benchmarking and open source desk review. In the 'first strike' stage, the most important thing to do was to identify anomalies which could help pave a way for a more in-depth analysis. This study encapsulates a comprehensive review on the benchmarking definitions, theories, concepts, methodologies, and best practice approaches used worldwide. Terminologies used for cost benchmarking of transport infrastructure were identified and even though the data received was sparse, a first strike benchmarking analysis on the data submitted by the NFPs was conducted.

For the Road Analysis, different input costs that have a direct/indirect effect on construction of roads were studied. Costs of labour (per month), cement bag (per 50kg bag), iron (USD/Ton), concrete (USD/Ton) and fuel (USD/litre) were tabulated and normalized to 2016 by using the GDP Deflator Index. The study of these costs showed that input costs for construction of roads in Turkey are found to be highest while the input costs for construction of roads for Kyrgyzstan are found to be comparatively lower.

For roads class type, the data was analysed for MCR Primary Roads and HCR Motorways.

For MCR Primary Roads, it was observed that Tajikistan has comparatively higher final output cost of construction per km than Kazakhstan, Kyrgyzstan and Afghanistan whereas it has comparatively lower direct input costs for construction of roads; implying that there may be various indirect costs affecting the total construction costs of roads in Tajikistan including financial charges relevant to licensing, tender, consultancy, and other price related contingencies. Similarly, final construction costs for MCR Primary Roads in Turkey are estimated to be lowest, while the data for direct input costs indicates that Turkey has the highest direct input costs for the materials used in the construction of roads. This leads to the conclusion that even though the input costs of Turkey are highest as compared to the other countries, it still manages to employ its resources efficiently, thus constructing the road with lowest absolute costs.

Data for HCR Motorways was received from Azerbaijan and Turkey only—therefore the analysis was limited. Turkey had comparatively lower cost of constructing HCR Motorways-Expressways despite having highest construction costs based on the key inputs and due to data limitations explained earlier, Azerbaijan could not be compared to the other countries.

The road class types analysed were a) New Construction; b) Reconstruction; c) Resurfacing by Strengthening; d) Reconditioning; e) Expansion (Capacity Improvement)

For new construction of roads, Turkey had the lowest construction costs; irrespective of having the maximum input costs—implying that the administrative, transaction, and agency costs remain relatively lower in Turkey as compared to other countries. Furthermore, it was seen that Uzbekistan has comparatively higher direct input costs and likewise has comparatively second highest output costs associated with construction of new roads.

For roads reconstruction, it was seen that despite having higher direct input costs, Kazakhstan manages to lower its final costs for reconstruction of roads due to efficient management of the resources. Whereas, Turkmenistan has comparatively lower direct input costs but still have higher output costs. This abnormality entails a significant impact of certain indirect factors that integrally inflate the overall reconstruction costs of roads in Turkmenistan. In addition to this, for Turkey it was seen that regardless of having highest input costs for construction of roads; it has second lowest final costs for reconstruction of existing roads while Azerbaijan not only have higher final costs but also comparatively higher direct input costs for construction of roads per km.

For road reconditioning, it was observed that Turkey, despite having the highest direct-indirect input costs, has the lowest reconditioning costs as compared to the rest of the countries. Moreover, due to data constraints, Azerbaijan could not be compared to other countries, thus leaving the data inconclusive.

For road resurfacing by strengthening, it was observed that while the output costs for resurfacing in context of Uzbekistan are higher as compared to Turkey, the direct input costs of construction in Uzbekistan are relatively lower which shows that certain key factors affect the overall road infrastructure implementation costs.

Analysing the data for road surface type, Asphalt, showed that Turkmenistan records the highest final construction costs for asphalt roads whereas it has been ranked average in the input cost summary. Tajikistan and Kazakhstan seem to have swapped their positions and portrays a different picture when compared to their input costs. While Tajikistan manages to reduce its final output costs, Kazakhstan has a number of indirect factors that heavily influence its output costs. Moreover, a similar trend is observed for Turkey, which irrespective of having the highest input costs for construction of roads, has lowest output cost for asphalt roads.

For the Rail Analysis, different input costs that have a direct/indirect effect on construction of railways were studied. Costs of labour (per month), cement bag (per 50kg bag), iron (USD/Ton), concrete (USD/Ton), power cost (USD/unit), wood (USD/40kg) and fuel (USD/litre) were tabulated and normalized to 2016 by using the GDP Deflator Index. According to this classification, direct input construction costs in Turkey are the highest while the direct input construction costs in Afghanistan are comparatively lowest.

The data analysis was carried out for each rail characteristic i.e. New construction, Renewal and Upgrade.

For new construction of rails, it was observed that Turkey is the most expensive country to build new railways infrastructure. This is due to the fact that Turkey has comparatively higher labour costs, fuels costs and the power costs. Azerbaijan follows the same trend and is estimated to be on third spot having higher direct input costs for construction of railways.

For renewal of rail infrastructure, Azerbaijan has higher direct input costs while on the other hand, Turkmenistan has comparatively lower output costs than Azerbaijan which reinforces the analysis of having comparatively lower direct input costs.

For railway infrastructure upgradation, Uzbekistan has the highest output costs while Turkmenistan has the lowest output costs. Kazakhstan, despite being above Tajikistan in input costs, manages to employ its resources efficiently and subsequently reduce its output cost for the upgradation of the rails. Whereas, Tajikistan, despite having third lowest labour costs, seems to have involved other factors and indirect costs which increases its' total actual construction costs.

Analysing the data for electrified lines showed that Turkey has comparatively higher final construction costs than Turkmenistan and corroborate the fact that Turkey has higher direct input costs for the construction of the rails. Turkmenistan, on the other hand, has the lowest final construction costs when constructing the electrified rails. Moreover, for non-electrified lines i.e. Azerbaijan is the costliest country to build non-electrified rails when compared to the other countries whereas the direct input costs for construction in Azerbaijan are comparatively lower than Turkey. It was observed that this situation changes for Turkey as it has lower final construction costs when compared to Azerbaijan but has comparatively higher direct input costs. This shows that Azerbaijan has some hidden costs involved when it comes to building non-electrified rails.

When comparing the data of the construction costs per km for the rails having the velocity less than 120 Km/h, it was observed that Azerbaijan has higher direct input costs than Tajikistan. The same is reflected in the final construction costs as the factors that may directly or indirectly affect the construction costs of the projects are higher in Azerbaijan than in Tajikistan. When comparing the data for construction costs per of the rails having the velocity more than 120 Km/h but less than 160 Km/h, it was seen that Turkey, despite having higher input costs like labour costs, power costs and the fuel costs, has lower final output costs than Uzbekistan. Whereas, Uzbekistan having comparatively lower direct input costs, is ahead of turkey when it comes to final construction costs for the rails with 120<V≤160-line speed design.

The scope of this study is just the tip of the iceberg and if explored in more depth, could pave a way for more avenues to branch out in transport infrastructure benchmarking.

Another round of primary data collection should be conducted for quality improvement. The data targeted for this study holds tremendous potential to become a ground-breaking study. Currently, the data received was sparse, owing to unavoidable extenuating circumstances. However, if this study is given the opportunity to re-conduct the survey to gather more data; promising results can be deduced.

In order to add meat around the bones of the study—Key Informant Interviews (KII) are an imperative tool. Key informant interviews are in-depth discussions with stakeholders who have first-hand knowledge about the subject matter. Under the circumstances that the report was compiled, the KIIs could not be carried out. However, if this study is given the opportunity for another round, conducting KIIs [virtually or in person, depending upon the situation at hand] will be the most important tool for the analysis as this allows the stakeholders from each country to reference the different projects—significant, recent, ongoing and proposed; which would result in a coherent and more in-depth benchmarking analysis.

Revamping the Questionnaire is pertinent to develop the bigger picture. Even though the questionnaires circulated for this survey were eloquent, adding more fields to the draft will add more weightage to the analysis. For example, fields like varying input costs, standard guidelines being used for each transport infrastructure, the geometrics of a standard transport infrastructure—to name a few.

It will be a promising prospect if the scope of Transport Infrastructure Benchmarking is explored beyond costing. It would be interesting to see the results if the transport infrastructure of the eleven countries are benchmarked in terms of their operations, functions and performance.

Meeting with the experts before the regional workshop would help identify key facets of the study that could be taken up for more further research and to devise a way forward for the data currently at hand.

GLOSSARY: Terms and Definitions

Glossary A General Terminology Relevant for Benchmarking of all Inland Transport Infrastructure Costs

Acquisition: The process of obtaining right of way by negotiation and/or eminent domain proceedings. Negotiation would involve getting the owner to convey, dedicate, or possibly option the property to the public agency. Compensation must be paid in all acquisitions or takings.[33]

Acquisition cost: All costs included in acquiring an asset by purchase/lease or construction procurement route, excluding costs during the occupation and use or end-of-life phases of the life cycle of the constructed asset. [1]

Administrative costs: The costs incurred in contract management and administration overhead expenses.[34]

Annual budget:

The total budget for the financial year as approved by the legislative body.

The annual budget is a group of appropriations which a department has the authority to disburse or encumber in a fiscal year.

Assets: Something that has a potential or actual value to an organization, can be physical or intellectual or financial.

Asset management: A systematic process of operating, maintaining, and upgrading transportation assets cost effectively by combining engineering practices and analysis with sound business practice and economic theory.

The management of the physical infrastructure such as pavements, bridges, and airports, as well as human resources (personnel and knowledge), equipment and materials, and other items of value such as financial capabilities, right-of-way, data, computer systems, methods, technologies, and partners.[35]

Budget: is a financial plan, actual or estimated, showing the items on which, the expenditure of contract funds is authorized.[36]

Capital Cost: The initial construction costs and costs of initial adaptation where these are treated as capital expenditure. Note 1 to entry: The capital cost may be identical to the acquisition cost if initial adaptation costs are not included. [1]

Construction contingency: The additional mark-up applied to cover the cost of undefined and yet unknown construction requirements that are expected to be zero at completion of construction. Construction contingency is a risk cost.[37]

Construction phase: The project development phase that includes advertising the project, awarding the contract, and performing the actual construction. [5]

Construction Product: The item manufactured or processed for incorporation in construction works. Note 1 to entry: Construction products are items supplied by a single responsible body. Note 2 to entry: Adapted from the definition in ISO 6707-1 according to the recommendation of ISO/TC59/AHG Terminology.[38]

Construction Service: The activity that supports the construction process or subsequent maintenance (Source: EN 15804:2012+A1:2013).[6]

---

[33] Draft international standard ISO/DIS 15686-5.2, (Buildings and constructed assets - Service-life planning Part 5: Life-cycle costing), 2016.

[34] NCHRP synthesis 499 (National Cooperative Highway Research Program), Alternate Design/Alternate Bid Process for Pavement-Type Selection, A Synthesis of Highway Practice, 2017.

[35] AASHTO Transportation Glossary, 4th edition, 2009.

[36] TxDOT Glossary, Texas Department of Transportation, 2013.

[37] NCHRP report 574 (National Cooperative Highway Research Program), Guidance for Cost Estimation and Management for Highway Projects during Planning, Programming, and Preconstruction, 2007.

[38] Sustainability of construction works - Sustainability assessment of buildings and civil engineering works - Part 5: Framework fort the assessment of sustainability performance of civil engineering works, European standard prEN 15643-5, 2016.

Construction Works: Everything that is constructed or results from construction operations. Note 1 to entry: This covers both building and civil engineering works, and both structural and non-structural elements. Note 2 to entry: Adapted from the definition in ISO 6707-1.[6]

Construction Administration Cost: The normal cost of administration, management, reporting, design services in construction, and community outreach required in the construction phase of a project.[5]

Construction Allowance: The amount of additional resources included in an estimate to cover the cost of known but undefined requirements for a construction activity or work item. A construction allowance is a normal cost.[5]

Contract:

The procurement document between two or more parties which creates an obligation to provide goods or services or perform tasks and which includes offer, acceptance, exchange of consideration, legal sufficiency, a defined contract period, a maximum amount payable, and terms and conditions as appropriate.

The legally binding document that provides determination of responsibilities and liabilities. [4]

Contractor: The private entity that provides design, construction, and/or maintenance services to a highway or railway agency. May refer to the design-builder or a concessionaire.[2]

Cost-based estimating: The method to estimate the bid cost of a work item by estimating the cost of resources (time, equipment, labour, and materials) for each component task necessary to complete the work item, and then adding a reasonable amount for contractor's overhead and profit.[2]

Cost: The monetary value or price of a project activity or component that includes the monetary value of the resources required to perform and complete the activity or component, or to produce the component. A specific cost can be composed of a combination of cost components, including direct labour hours, other direct costs, indirect labour hours, other indirect costs, and purchased price (However, in the earned value management methodology, in some instances, the term cost can represent only labour hours without conversion to monetary worth).[4]

Design life of infrastructure asset: The length of time for which an infrastructure asset is being designed.

Discounted cost: The Resulting cost when the real cost is discounted by the real discount rate or when the nominal cost is discounted by the nominal discount rate .[1]

Discount rate: The time value of money used as the means of comparing the alternative uses for funds by reducing the future expected costs or benefits to present-day terms. Discount rates are used to reduce various costs or benefits to their present value or to uniform annual costs so that the economics of the various alternatives can be compared (approximately equal to interest minus inflation).[6]

Disposal cost: Costs associated with disposal of the asset at the end of its life cycle, including taking account of any asset transfer obligations. Note 1 to entry: Asset transfer obligations could include bringing the assets up to a predefined condition. Note 2 to entry: Income from selling the asset is part of WLC[1], where the residual value of the road infrastructure components, materials and appliances can be included .[1]

Drainage structure: Any device or landform constructed to intercept and/or aid surface water drainage.[39]

Earthwork: The operations connected with excavating and placing embankments with soil, earth or rock.[4] Earthwork for rail: work conducted in order to prepare land for construction work; land grading, soil exchange etc.[40]

Embankment: The raised structure of soil, soil aggregate, rock or combination of the three. Materials used for fill section. [4]

[39] Mass Highway Glossary, 2006.

[40] Definitions compiled by experts of PKP Polish Railway Lines

Emulsion: The fluid system in which liquid droplets and/or liquid crystals are dispersed in a liquid. Note 1 to entry: Dispersion is thermodynamically metastable.

End-of-life cost: The net cost or fee for disposing of an asset at the end of its service life or interest period, including costs resulting from, deconstruction and demolition of the asset infrastructure; recycling, making environmentally safe recovery and disposal of components and materials and transport and regulatory costs.[1]

Environmental Impact Assessment – the ongoing identification of environmental factors to determine the past, current and potential impact (positive or negative) of an organisation's activities on the environment. This process includes the identification of the potential regulatory, legal and business exposure, as well as health and safety impacts and environmental risk assessment.[41]

Estimate The approximate quantity and cost of materials, construction items, and labour required for a specific construction project. [4]

Excavation: The act of cutting, digging, or scooping to remove material.

External costs: The costs associated with an asset that are not necessarily reflected in the transaction costs between provider and consumer and that, collectively, are referred to as externalities. Note 1 to entry: These costs may include business staffing, productivity and user costs; these can be taken into account in a LCC[2] analysis but should be explicitly identified. [1]

Feasibility study - a structured process that identifies the engineering options and their implications including environmental issues. It culminates in a feasibility report and a design development (and, sometimes, implementation) proposal. [9]

Foundation: That portion of a structure (usually below the surface of the ground) which distributes the pressure to the soil or to artificial supports. Footing has similar meaning. [4]

Implementation year: The year that a project is anticipated to be complete and open to traffic. [4]

Infrastructure: Basic facilities, services, and installations needed for the functioning of a community or society, including water and sewage systems, lighting, drainage, parks, public buildings, roads, railways, waterways and transportation facilities, and utilities. [7]

Life Cycle: The consecutive and interlinked stages in the life of the object under consideration. [6]

Life Cycle Cost - LCC: Cost of a civil engineering works or part of works throughout its life cycle, while fulfilling technical requirements and functional requirements. [6]

Life-cycle cost analysis: An economic assessment of an item, area, system, or facility and competing design alternatives considering all significant costs of ownership over the economic life, expressed in equivalent dollars. [2]

Net present value: The net value of all present and future costs and benefits converted to a single point in time using a discount rate factor. [2]

Nominal cost: The expected price that will be paid when a cost is due to be paid, including estimated changes in price due to, for example, forecast change in efficiency, inflation or deflation and technology. [1]

Normal Cost: The most probable cost for a unit or element of the project. The normal cost represents the cost that can most reasonably be expected if no significant problems occur. The normal cost typically has small uncertainty or variance. [5]

Operation Cost: The cost incurred in running and managing the facility or built environment, including administration support services. Note 1 to entry: Operation costs could include rent, rates, insurances, energy and other environmental/regulatory inspection costs, local taxes and charges. [1]

[41] University of Birmingham and Network Rail Railway Lexicon Mk 24, February 2011.

Project: The undertaking to develop, implement, or construct a particular transportation enhancement at a specific location or locations. [5]

Project classification: The official classification of the type of project provided for in construction. [4]

Real Cost: Cost expressed as a value at the base date, including estimated changes in price due to forecast changes in efficiency and technology, but excluding general price inflation or deflation. [1]

Risk: The potential impact of an uncertain condition or action on project objectives and outcomes. [2]

Risk allocation: The process of allocating contractual obligations and risks between parties. [2]

Terrain: The physical features of a tract of land. [7]

Topography: The details of a surface, including natural and man-made structures, on a map or chart. [4]

Whole-Life Cost: All significant and relevant initial and future costs and benefits of an asset, throughout its life cycle, while fulfilling the performance requirements. [1]

Whole-Life Costing: The methodology for systematic economic consideration of all whole-life costs and benefits over a period of analysis, as defined in the agreed scope. Note 1 to entry: The projected costs or benefits may include external costs (including, for example, finance, business costs, income from land sale, user costs). Note 2 to entry: Whole-life costing can address a period of analysis that covers the entire life cycle or (a) selected stage(s) or periods of interest thereof. Note 3 to entry: This definition should be contrasted with that for life-cycle costing. [1]

Glossary B Terminology on Benchmarking Road Transport Infrastructure Construction Costs

Abutment: The part of a bridge consisting of the cap, backwall, and wingwalls at the ends of a bridge which supports the superstructure, contains the earth in the approach fills, and directly receives the impact loads produced by traffic passing from the roadway onto the bridge. An abutment is a wall supporting the end of a bridge or span and sustaining the pressure of the abutting earth.[42]

Access: The driveway by which vehicles and/or pedestrians enter and/or leave property adjacent to a road.[43]

Access control: The condition whereby the road agency either partially or fully controls the right of abutting landowners to direct access to and from a public highway or road.[44]

Aggregate: The granular material of natural, manufactured or recycled origin used in construction.[45]

Alignments: The geometric design elements that define the horizontal and vertical configuration of the roadways.

Analysis period: The time period used for comparing pavement-type alternatives. An analysis period may include several maintenance and rehabilitation activities during the life cycle of the pavement being evaluated. The analysis period should not be confused with the pavement design or service life.[46]

Arterial: The highway designed to move relatively large volumes of traffic at high speeds over long distances. Typically, arterials offer little or no access to abutting properties.[12]

Asphalt: The homogenous mixture typically of course and fine aggregates, filler aggregate and bituminous binder which is used in the construction of a pavement. Note 1 to entry: Asphalt can include one or more additives to enhance the laying characteristics, performance, or appearance of the mixture.[47]

Asphalt binder: Asphalt cement or modified asphalt cement, which acts as a binding agent to glue aggregate particles into a cohesive mass. [10]

Asphalt cement: The asphalt specifically prepared or refined to standards of quality and consistency. It is prepared for direct use in the manufacture of asphalt pavements .[10]

Asphalt Concrete (AC): The asphalt in which the aggregate particles are continuously graded or gap-graded to form an interlocking structure. [15]

Asphaltic Concrete Pavement (ACP): The compacted mixture of mineral aggregate and asphaltic materials. An ACP overlay is a supplemental base-pavement or wearing surface placed on an existing base-pavement or wearing surface where major repairs to a pavement structure are required to restore a satisfactory riding surface or upgrade the strength of the pavement structure. [10]

Asphalt Concrete for very thin layers (AC-TL): The asphalt for surface courses with a thickness of 20 mm to 30 mm, in which the aggregate particles are generally gap-graded to form a stone to stone contact and to provide an open surface texture. [15]

Asphalt for Ultra-Thin Layers (AUTL): The hot mix asphalt road surface course laid on a bonding layer, at a nominal thickness between 10 mm and 20 mm with properties suitable for the intended use. The method of bonding is an essential part of the process and the final product is a combination of the bonding system and the bituminous mixture. [15]

---

[42] TxDOT Glossary, Texas Department of Transportation, 2013
[43] State Highway Geometric Design Manual, Glossary of Terms, Transit New Zealand, 2005
[44] Geometric Design Guidelines, South African National Roads Agency Limited
[45] Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas, EN 13043, 2016.
[46] NCHRP synthesis 499 (National Cooperative Highway Research Program), Alternate Design/Alternate Bid Process for Pavement-Type Selection, A Synthesis of Highway Practice, 2017
[47] Bituminous mixtures - Material specifications - Part 1-9, EN 13108 series (1-9), 2016.

At-grade: The combination of horizontal alignments and vertical grade lines which intersect. [10]

Backfill:

The material used to replace other material removed during construction.

The material placed adjacent to structures. [10]

Base: The layer used in a pavement system to reinforce and protect the subgrade or subbase.[48]

Balanced cantilever bridge: The type of bridge that constructed using balanced cantilever technique to attach the segments in an alternate manner at opposite ends of cantilevers supported by piers.[49]

Benefit /Cost Ratio (B/C): the method used to compare the benefit versus the cost of proposed alternatives. For highway projects, benefits may include reduced fuel consumption, travel time, and air pollution; costs may include construction, right of way, and maintenance. [10]

Binder: The material used to adhere to aggregate and ensure cohesion of the mixture. Note 1 to entry: Any solid support may be adhered with the binder. [15]

Binder Course: The structural part of the pavement between the surface course and the base. [15]

Bio-Fluxed Bitumen: The bitumen whose viscosity has been reduced by the addition of a flux oil derived from vegetal or animal oils. [15]

Bitumen: The virtually not volatile, adhesive and waterproofing material derived from crude petroleum, or present in natural asphalt, which is completely or nearly completely soluble in toluene, and very viscous or nearly solid at ambient temperatures. [15]

Bituminous Base: The main structural element of a pavement. Note 1 to entry: The base can be laid in one or more courses, described as “upper” base, “lower” base. [15]

Bituminous Binder: The adhesive material containing bitumen. Note 1 to entry: A bituminous binder may be in any of the following forms: unmodified, modified, oxidized, cut-back, fluxed, emulsified. Note 2 to entry: To avoid uncertainty, whenever possible the term describing the actual binder in question should be used. [15]

Bituminous Emulsion: The emulsion in which the dispersed phase is bituminous. Note 1 to entry: Unless otherwise stated, continuous phase is assumed to be aqueous solution. [15]

Borrow: The material used for embankments. Borrow is excavating, removing, and properly using materials obtained from approved sources of the right of way. Delivered borrow is borrow obtained by the contractor from sources other than the right of way .[10]

Box culvert: The culvert with a square or rectangular cross-sectional profile having four sides, including a bottom.[50]

Bridge: The structure, including supports, erected over a depression or an obstruction, such as water, a highway, or a railway; having a roadway or track for carrying traffic or other moving loads; and having an opening measured along the centre of the roadway of more than 20 feet between faces of abutments, spring lines of arches, or extreme ends of the openings for multiple box culverts or multiple pipes that are 60 inches or more in diameter and that have a clear distance between openings of less than half of the smallest pipe diameter.

The product that connects a local area network (LAN) to another local area network that uses the same protocol (for example, Ethernet or Token Ring network) .[10]

Bridge reconstruction: The process whereby an existing bridge is replaced by a new bridge construction.[17]

---

[48] AASHTO M 146, Standard Specification for Terms Relating to Subgrade, Soil Aggregate, and Fill Materials.
[49] General directorate of Turkish highways definition
[50] Mass Highway Glossary, 2006.

Bridge rehabilitation: The process whereby rehabilitation and repairing of an existing bridge with recovering. This definition is not valid for suspension bridges and similar ones bearing special construction techniques. [17]

Cable stayed bridge: A bridge in which the superstructure is directly supported by cables or stays, passing over or attached to towers located at the main piers.[51]

Capacity: The ability to accommodate a moving stream of people or vehicles in a given time period. [18]

Carriageway: The part of a road used by vehicular traffic:

Single carriageway: The road with only one line in each direction.

Dual (double) carriageway: The road on which travelling in opposite direction is separated (see divided highway) (7).

Centreline C/L, C.L., CL or C-Line: The line dividing the roadway in two parts, each of which is reserved for traffic moving in one of the opposite directions. It is a survey line with continuous stationing for the length of the project. Construction plans and right of way maps refer to this line. Horizontal alignment is the centre of the roadbed. [10]

Concrete: The composite material consisting of a binding medium within which are embedded particles or fragments of aggregate; in hydraulic cement concrete, the binder is formed from a mixture of hydraulic cement and water. [10]

Controlled access highway: The state highway in accordance with applicable state law on which owners or occupants of abutting lands and other persons are denied access to or from the highway except at such points only and in such manner as may be determined by the department. Maintenance Collection.

Controlled highways: Those highways officially designated as a part of the Interstate or Primary system of highways. [10]

Control of Access (COA):

Refers to conditions on certain sections of highways where the right to access the highway by abutting property owners or occupants is fully or partially controlled by a public authority. Control of access is a purchased property interest. [14]

Full control of access means that the authority to control access is exercised to give preference to through traffic by providing access connections with selected public roads only and by prohibiting crossings at-grade or direct private driveway connections.

Partial control of access means that the authority to control access is exercised to give preference to through traffic to a degree that, in addition to access connections with selected public roads, there may be some crossings at grade and some private driveway connections. [10]

Corrective Maintenance: The activity performed to correct deficiencies that negatively impact the safe, efficient operations of the facility, and future integrity of the pavement section. Corrective maintenance generally is reactive to unforeseen conditions to restore a pavement to an acceptable level of service. [14]

Corridor:

A strip of land between two termini within which traffic, topography, environment, and other characteristics are evaluated for transportation purposes. Also, for transmission of a utility.

A broad geographical band that identifies a general directional flow of traffic. It may encompass streets, highways, and transit alignments. [19]

Corridor study:

[51] AASHTO Transportation Glossary,4th edition, 2009

A planning project that defines the relationships between a roadway and its adjacent land. Corridor studies are used to:

a) Define acceptable levels of access and mobility,
b) Determine transportation system needs to support surrounding land uses
c) Consolidate and control access points,
d) Identify operational deficiencies and promote operational efficiency, and
e) Promote redevelopment of an underperforming corridor

Cost per lane Km: The average expenditure per lane km. [10]

Cost per Km: The average expenditure per km for single carriage highways.

Course: The element of a pavement constructed with a single asphalt mixture. Note 1 to entry: A course can be laid in one or more layers. [15]

Crack seal: The application of sealing material directly in the cracks of the pavement surface to prevent moisture damage [10].

Cross-section: The vertical section, generally at right-angles to the centreline showing the ground. On drawings it commonly shows the road to be constructed, or as constructed. [11]

Culvert: The structure, usually for conveying water under a roadway but can also be used as a pedestrian or stock crossing, with a clear span of less than six meters. [12]

Curb: The vertical or sloping element along the edge of a pavement or shoulder forming part of a gutter, strengthening or protecting the edge and clearly defining the edge to vehicle drivers. The surface of the curb facing the general direction of the pavement is called the "face". [10]

Curvature: The sharpness of a curve. [18]

Cut: The section of highway or road below natural ground level. Also referred to as a cutting or excavation. [12]

Design life of pavement (or Design period of pavement): The length of time for which a pavement structure is being designed based on structural distresses and traffic loadings. [14]

Divided highway: The highway with separate carriageways for traffic moving in opposite directions. [12]

Double layered Porous Asphalt (2L-PA): The asphalt where with a top layer of a grain size 4/8 mm of about 25 mm thick and the second/bottom layer of porous asphalt with a coarse aggregate (11/16 mm). The total thickness is about 70 mm. It gives a better noise reduction than a single layer porous asphalt due to the finer texture at the top (that gives less tyre vibrations).[15]

Drainage: The removal of water from the highway right-of-way area by use of culverts, ditches, outsell channels and other drainage structures. [11]

Edge line: The line used to differentiate the outer edge of the traffic lanes from the shoulder. [11]

Expansion (Capacity Improvement): The reconstruction which also involves the construction of additional through travel lanes beyond the work associated with reconstruction. [17]

Expressway: The divided arterial highway for through traffic. It has a full or partial control of access and generally has grade separations at major intersections. [10]

Fill: The embankment material placed above natural ground line. [10]

Flexible pavement: The pavement structure that maintains intimate contact with and distributes loads to the subgrade and depends on aggregate interlock, particle friction, and cohesion for stability. [10]

Freeway: The highest level of arterial characterized by full control of access and high design speeds. [12]

Geometric design: A geometric design refers to the dimensions and elements of a highway or road. [10]

Geometric improvement: The improvements which focus on increasing intersection capacity and enhancing safety; often involves widening to provide auxiliary turn lanes and the installation or modification of traffic signals. [18]

Girder: The horizontal main structural element of a bridge which supports vertical loads. [10]

Grade:

The slope of a roadway, channel, or natural ground.

Any surface prepared for the support of construction such as that for paving or laying a conduit. [10]

Grade controls: The automatic controls on an asphalt pavement which compensate for grade variations. A grade control sensor transmits an electronic signal to either thicken or thin out the depth of the asphalt mat. The signals are based upon the grade control sensor resting on the pavement surface or on a string line. [10]

Grade line: The slope in the longitudinal direction of the roadbed, usually expressed in percent, which is the number of units of change in elevation per 100 units' horizontal distance. [10]

Grade separation: The crossing of two roadways, a roadway and railroad, or a roadway and a pedestrian/bicycle facility at different levels. [18]

Grading for earthworks:

The preparation of a subgrade, in line and elevation, for application of pavement materials including base and surfacing materials.

Any striping, cutting, filling, stockpiling, or combination thereof which modifies the land surface. [10]

Guardrail: The traffic barrier used to shield potentially hazardous areas.

Highway: The entire width between the boundary lines of every way publicly maintained when any part thereof is open to the use of the public for purposes of vehicular travel. [10]

Highway class: The rural/urban description of the lane characteristics. [10]

Horizontal curve: The bend from a straight line along a roadway. [18]

Grading: The particle size distribution expressed as the percentages by mass passing a specified set of sieves. [15]

HCR-Motorways-Expressway: The high Capacity Roads such as Motorways and Expressways. These roads are full access or half access controlled (at least) double carriageway highways. Both physical and geometric capacity of this type of roads are high. The applied design speed on these roads are also higher than on other roads. They may be toll roads.

Hot Rolled Asphalt (HRA): The dense, gap graded bituminous mixture in which the mortar of fine aggregate, filler and high viscosity binder are major contributors to the performance of the laid material". Coated chippings (nominally single size aggregate particles with a high resistance to polishing, which are lightly coated with high viscosity binder) are always rolled into and form part of a Hot Rolled Asphalt surface course. This durable surface layer was often used as a surface layer in the United Kingdom of Great Britain and Northern Ireland. [14]

Interchange: The grade separation of two or more roads with one or more interconnecting carriageways.

Intersection: The place at which two or more roads cross at grade or with grade separation. [11]

Lane line: The broken line separating lanes for traffic moving in the same direction or a solid line for delineating traffic lanes and shoulder edge. [10]

Lane-Km.: The measure of the total length of travelled pavement surface. Lane-km. is the centreline length (in km.) multiplied by the number of lanes. [10]

Layer: The element of a pavement laid in a single operation. [14]

Limited access roadway: The roadway especially designed for through traffic and over, from, or to which owners or occupants of abutting land or other persons have no right or easement of access by reason of the fact that their property abuts such limited access facility or for any other reason. Interstate highways, parkways, and freeways are usually developed as limited-access facilities.

Line: The baseline of roadway. [10]

Local road: The road that primarily provides access to adjacent land and provides service to motorists over relatively short distances. [10]

Longitudinal slope: Either the fore slope, which occurs when the roadway is located on a fill and the clear zone slopes down from the roadway, or the backslope, which occurs when the roadway is located on a cut and the clear zone slopes up from the roadway.

Low-volume road: The roadway generally subjected to low levels of traffic. [10]

Medium Capacity Roads (MCR)-Primary Roads: The roads of which the geometric and physical capacity is medium. They are not access controlled. They are usually toll-free roads. They may be double or single carriageway highways. They are also main arterials and principal roads of national highways system of countries. The applied speed limits on these roads are lower than on HCR.

Medium Capacity Roads (MCR)-Secondary Roads: The roads whose geometric and physical capacity is medium but relatively lower than MCR-Primary Roads. They are not access controlled. They are toll-free roads. They may be double or single carriageway highways. They are important connectors of the national highways system to towns. The applied speed limits on these roads are lower than on HCR.

Maintenance of roadway infrastructure: The preservation through treatment activities of the entire roadway, including surface, shoulders, roadsides, structures, and such traffic control devices which are necessary for the roadway to perform its function.[14]

Maintenance activities: The combination of all technical and associated administrative actions during the service life to retain a civil engineering works or an assembled system (part of works) in a state in which it can perform its required functions. Note 1 to entry: Maintenance includes cleaning, servicing, repainting, repairing, replacing parts of the construction works where needed, or according to approved levels of service. (Construction Products Directive Guidance Paper F). Note 2 to entry: Adapted from the definition in ISO 15686-1, ISO 6707-1 and in Construction Products Directive Guidance Paper F. [6]

Maintenance cost for road: The total of labour, material and other related costs incurred to retain a road or its parts in a state in which it can perform its required functions. Note 1 to entry: Maintenance includes conducting corrective, responsive and preventative maintenance on constructed assets, or their parts, and includes all associated management, cleaning, servicing, repainting, repairing and replacing of parts where needed to allow the constructed asset to be used for its intended purposes. [1]

Major arterial: The roadway that services state-wide travel as well as major traffic movements within urbanized areas or between suburban centres (high mobility, limited access).[18]

Mastic Asphalt (MA): The void less asphalt mixtures with bitumen as a binder in which the volume of filler and binder exceeds the volume of the remaining voids in the mixed". This mixture is very durable and was often used as surface layer in certain countries. [14]

Median: The portion of a divided highway separating the opposing traffic flows. A median may be traversable or non-traversable.

Modified Bitumen: The bituminous binder whose rheological properties have been modified during manufacture by the use of one or more chemical agents. Note 1 to entry: in this context, “chemical agent” includes natural rubber, synthetic polymers, waxes, sulphur and certain organo-metallic compounds, but not oxygen or oxidation “catalysts” such as ferric chloride, phosphoric acid and phosphorus pentoxide. Fibres and inorganic powders (“fillers”) are not considered to be bitumen modifiers. Modified bitumen may be employed “directly” or in the form of cutbacks or emulsions or blended with (for example) natural asphalt.[52]

Motorway: The defined class of road for which certain activities or uses are restricted of prohibited by legislative provision. [11]

Multilane highway: The multilane highway is a highway with three or more lanes. [10]

Natural Asphalt: The naturally occurring mixture of bitumen and finely divided mineral matter which is found in well-defined surface deposits and which is processed to remove unwanted components such as water and vegetable matter. [14]

New Bridge Construction: The process involving construction of a bridge with approaching roads on an existing road alignment or on new road corridor. [17]

New road construction: The construction of all parts of a road: structures, subgrade, pavement where no road existed before. [17]

New Tunnel Construction: The process involving construction of a tunnel with approaching roads an existing road alignment or on new road corridor. [17]

Overlay: The layer or layers of paving materials placed on an existing surface where repairs to a pavement structure are required to restore a satisfactory riding surface and/or improve the strength of the pavement structure. [10]

Overpass for roads: The grade separation where a minor highway passes over the major highway. [12]

Pavement: That part of a roadway having a constructed surface for the facilitation of vehicular traffic. [10]

Pavement Condition: The quantitative representation of pavement distress at a given point in time. [14]

Pavement crack: The fissure or open seam in pavement which does not necessarily extend through the body of the pavement material. Pavement cracking includes alligator, longitudinal, and transverse cracking. [10]

Pavement design: Design for (1) mixture or materials and (2) structure or thickness. These two designs cannot be clearly separated at the design stage; there must be interaction between them. Specifications are the link between mixtures and thickness design.[10]

Pavement distress: The cracking, rutting, distortion or other types of surface deterioration which indicates a decline in the pavement’s surface condition or structural load- carrying capacity. [10]

Pavement management: The method of finding cost-effective strategies for providing, evaluating, and maintaining pavements in a serviceable condition. [10]

Pavement Management System (PMS): The set of tools or methods that can assist decision makers in finding cost-effective strategies for providing, evaluating and maintaining pavements in a serviceable condition. [10]

[52] Bitumen and bituminous binders - Terminology, EN 12597, May 2014.

Pavement preservation: The program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations.[53]

Pavement structure: The combination of sub-base, base, paving geotextiles, and surface courses placed on a subgrade to support and distribute the traffic load to the roadbed.[54]

Pavement reconstruction: The replacement of the entire existing pavement structure by the placement of the equivalent or increased pavement structure. Reconstruction usually requires the complete removal and replacement of the existing pavement structure.

Reconstruction may utilize either new or recycled materials incorporated into the materials used for the reconstruction of the complete pavement section. Reconstruction is required when a pavement has either failed or has become functionally obsolete. [21]

Pavement rehabilitation: The act of restoring a pavement to a former condition. It consists of structural enhancements that extend the service life of an existing pavement and/or improve its load carrying capacity. Rehabilitation techniques include restoration treatments and structural overlays:

Major rehabilitation consists of structural enhancements that both extend the service life of an existing pavement and/or improve its load-carrying capability.

Minor rehabilitation is non-structural enhancement made to the existing pavement sections to eliminate age-related, top-down surface cracking that develops in flexible pavements as a result of environmental exposure. [5,21]

Pavement replacement: The renewal of the pavement by providing a new paved surface without changing capacity or geometry of the road, i.e. without changing the subgrade or by removing the total thickness of all layers of pavement, existing asphalt layers from an existing pavement and providing a new paved surface without changing the subgrade. [17]

Paving Bitumen: The bitumen used to coat aggregate and/or reclaimed asphalt, mainly used in the construction and maintenance of paved surfaces and hydraulic works. Note 1 to entry: In Europe, the most-used grades of paving bitumen are defined by their needle penetration at 25°C, up to a maximum value of 900 x 0,1 mm. [20]

Pedestrian bridge: The bridge designed for, and intended to carry, primarily pedestrians, bicyclists, equestrian riders and light maintenance vehicles, but not designed and intended to carry typical highway traffic.[55]

Percent of grade: The grade of centreline or profile grade road between vertical points of intersection +0.10 percent = Increase in elevation by 0.10 feet for each 100 feet station. [10]

Percent slope (percent Slope): The change in elevation divided by the horizontal distance over which the change occurs for a vertical line. [10]

Periodic Maintenance: The periodic activities on a section of road at regular and relatively long intervals aiming to preserve the structural integrity of the road. These operations tend to be large scale, requiring specialized equipment and skilled personnel. They cost more than routine maintenance works and require specific identification and planning for implementation and often even design. Activities can be classified as preventive, resurfacing, overlay and pavement reconstruction.[56]

Portland cement: The finely powdered substance, usually grey or brownish grey, composed largely of artificial crystalline minerals, the most important of which are calcium and aluminium silicates. The calcium silicate

---

[53] Memo: Pavement Preservation Definitions - Pavement Preservation - Design & Analysis - Pavements - Federal Highway Administration.
[54] Standard specifications for construction of roads and bridges on federal highway projects FP - 14, United States Department of Transportation, Federal Highway Administration (Section 101), 2014.
[55] NCHRP 20-07, TASK 244 LRFD Guide Specifications for The Design of Pedestrian Bridges
[56] Word Bank, Transport Note No. TRN-4, June 2005, Washington, D.C

compounds, upon reaction with water, produce the new compounds capable of imparting the stone like quality to the mixture. [10]

Portland cement concrete pavement: the hardened mixture of Portland cement, aggregate, and water used to pave streets or highways. This mixture may or may not contain steel reinforcing. [10]

Pre-cast: The concrete that is formed, placed, and cured before being placed in its final position. An example is a pre-case concrete beam for a bridge. [10]

Prestressed concrete: The precast concrete subject to pretensioning, post-tensioning, or a combination of both. [10]

Preventive Maintenance: The planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing the structural capacity).[15]

Pre-stressed simple beam bridge: The type of bridge, simply supported prestressed concrete beams. [17]

Porous Asphalt (PA): The bituminous material with bitumen as a binder prepared so as to have a very high content of interconnected voids which allow passage of water and air in order to provide the compacted mixture with drain and noise reducing characteristics. [14]

Radius: The line segment extending from the centre of a circle to the curve. [10]

Reconditioning: The process including improvement of grades, curves, intersections or sight distances in order to improve traffic safety or changing the subgrade to widen shoulders or to correct structural problems in addition to resurfacing or pavement replacement. [17]

Recycled Aggregate: The aggregate resulting from the processing of inorganic or mineral material previously used in construction. Note 1 to Entry: Recycled aggregates can also be obtained from production residues or nonconforming products, e.g. crushed unused concrete.[57]

Regulating Course: The course of variable thickness applied to an existing course or surface to provide the necessary profile for a further course of consistent thickness. [15]

Remaining Service Life: The structural life remaining in the pavement at the end of analysis period. [14]

Reinforced concrete pavement: The Portland concrete pavement in which steel is used to control the width of shrinkage and thermal cracking of the concrete. The steel adds strength to the concrete in tension. [10]

Residual Value of pavement: Value of the in-place pavement materials less the cost to remove and process the materials for reuse. [14]

Restoration:

The act or process of accurately recovering the form and details of a property and its setting as it appeared at a particular period of time by means of the removal of later work or by the replacement of missing earlier work. [5]

The repair and/or replacement of specific lost functions within a natural system, such as habitat, water buffers, and soil function. [18]

Resurfacing: Placing a new surface on an existing road to increase skid resistance, to seal by aiming to preserve road from negative atmospheric conditions, to increase driver comfort, to extend pavement life, to reduce noise etc, etc. The aim is not to increase the bearing capacity of pavement. [17]

Resurfacing by strengthening: Renewing of road surface with reinstalling bituminous layer by removing determined depth of pavement by milling in order to increase bearing capacity of road and to eliminate road defects. [17]

[57] Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas, EN 13043, 2016.

Right of Way (ROW): The general term denoting land, property or interest therein, usually in a strip, acquired for or devoted to transportation purposes.

The general term denoting land, property or interest therein, usually in a strip, acquired for or devoted to a highway for the construction of the roadway. Right of way is the entire width of land between the public boundaries or property lines of a highway. This may include purchase for drainage. [11]

Rigid pavement: the pavement structure which distributes loads to the subgrade, having as one course a Portland cement concrete slab of relatively high-bending resistance. [10]

Road: A route trafficable by motor vehicles. In law, the public right-of-way between boundaries of adjoining property and is owned or administrated by a road authority. [11] Or Definition from 1968 Convention on Road Traffic: The entire surface of any way or street open to public traffic.

Roadbed: The graded portion of a highway prepared as a foundation for the pavement structure and shoulders. [22]

Roadside: The general term denoting the area beyond the shoulder breakpoints. [12]

Road infrastructure: The infrastructure which forms part of a roadway, pathway or shoulder, including:

structures forming part of the roadway, pathway or shoulder,

materials from which a roadway, pathway or shoulder is made. [17]

Road tunnel: The tunnel constructed for the purpose of building an underground road. [17]

Roadway: The portion of the highway within the limits of construction.

That portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the berm or shoulder. In the event a highway includes two or more separate roadways, the term "roadway" as used in the Equipment Manual shall refer to such roadway separately, but not to all such roadway collectively. [10]

Roadway alignment: The vertical and horizontal location of a road. [18]

Roadway improvement: The construction or reconstruction made to the roadway cross-section. [10]

Rolling terrain: The natural slopes consistently rise above and fall below the highway grade with, occasionally, steep slopes presenting some restrictions on highway alignment. In general, rolling terrain generates steeper gradients, causing truck speeds to be lower than those of passenger cars. [12]

Routine Maintenance for highway systems: The work that is planned and performed on a routine basis to maintain and preserve the condition of the highway system or to respond to specific conditions and events that restore the highway system to an adequate level of service. [21]

Rural: The areas with large expanses of undeveloped or agricultural land, dotted by small towns, villages, or any other small activity clusters. [18]

Rural road: The road, street, way, highway, thoroughfare, or bridge that is located in an unincorporated area and that is not privately owned or controlled, any part of which is open to the public for vehicular traffic, and over which the state or any of its political subdivisions have jurisdiction (11). It is characterized by low volume high-speed flows over extended distances. Usually without significant daily peaking but could display heavy seasonal peak flows. [12]

Salvage Value: The value (positive if a residual economic value is realized and negative if demolition costs are accrued) of competing alternatives at the end of the life cycle or analysis period. [It] typically consists of remaining service life and residual value. [14]

Seal coat: The asphaltic coating, with aggregate, applied to the surface of a pavement structure for the purpose of waterproofing and preserving the surface, reconditioning a previous asphaltic surface treatment, improving the surface texture of the wearing surface, changing the surface colour or providing resistance to traffic abrasion.[10]

Service life: The period of time from completion of construction until the structural integrity of the pavement is determined to be unacceptable and rehabilitation/replacement is required (Hallin et al. 2011).[14]

Shoulder: The portion of the roadway adjacent to the travelled way (on either side) for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface. [10]

Shoulder breakpoint: The hypothetical point at which the slope of the shoulder intersects the line of the fill slope. Sometimes referred to as the hinge point. [12]

Soft Asphalt (SA): The mixture of aggregate and soft bitumen grades". This flexible mixture is used in the Nordic countries for secondary roads. [15]

Shoulder drains: the drains usually used to drain runoff from bridge embankment areas. [10]

Shoulder hinge point: The point in the cross-section of a road, at which the side slope would intersect with the unsealed shoulder, or in the absence of an unsealed shoulder, the sealed shoulder. [11]

Sidewalk: The portion of the cross-section reserved for the use of pedestrians. [12]

Sight distance: The distance measured along the carriageway over which objects of defined height are visible to a driver. [11]

Single tube road tunnel: The tunnel through which the traffic normally flows in two directions (bi-directional flow).[17]

Skid resistance of a road surface: The capacity to convey friction in the contact area between tyre and road surface. Skid resistance is necessary to offset the horizontal forces that occur in the contact area between tyre and road surface during vehicle movements (accelerating, braking and steering). In order to be able to drive safely on a road it is important for a road surface to have adequate skid resistance in both wet and dry conditions.[58]

Stone Mastic Asphalt (SMA): The gap-graded asphalt mixture with bitumen as a binder, composed of a coarse crushed aggregate skeleton bound with a mastic mortar". This mixture is of often used as a surface layer in case high stability is needed. The surface structure also has good noise reducing properties. [15]

Subbase: The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base course (or in the case of rigid pavements, the Portland cement concrete slab). The layer used in the pavement system between the subgrade and the base course. [10]

Subgrade: The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed and extending to such depth as will affect the structural design. [22,59]

Substructure: That part of a bridge structure covered on bent details, or below the bridge seats including back walls and wing walls at abutments. [10]

Sunk costs: Costs of goods and services already incurred and/or irrevocably committed. Note 1 to entry: These are ignored in an appraisal. The opportunity costs of obtaining or continuing to tie up capital are, however, included in WLC analysis and the opportunity costs of using assets can be dealt with as costs in LCC analysis. [1]

Super elevation: The method of banking the roadway by attaining a vertical difference between the inner and outer edges of pavement. [10]

Super elevation rate: The rate of rise in cross section of the finished surface or a roadway on a curve, measured from the lowest edge to the highest edge. [10]

Superstructure: That part of a bridge structure covered on the span details, or above the bridge seats.[10]

---

[58] Skid Resistance on National Roads, Ministry of Infrastructure and the Environment, Rijkswaterstaat Major Projects and Maintenance, June 2017.

[59] AASHTO M 146, Standard Specification for Terms Relating to Subgrade, Soil Aggregate, and Fill Materials.

Surface Course: The top layer or layers of a pavement structure designed to accommodate the traffic load and resist skidding, traffic abrasion, and weathering. [22]

Surface treatment: The application of bituminous material followed by a layer of mineral aggregate. Multiple applications of bituminous material and mineral aggregate may be used.[60]

Suspension bridge: The type of bridge in which the deck (the load-bearing portion) is hung below suspension cables on vertical suspenders. [17]

Technical Performance: The performance related to the capability of construction works or an assembled system (part of works), which are required or are a consequence of the requirements made either by the client, users and/or by regulations. [6]

Technical Requirement: The type and level of technical characteristics of a construction works or an assembled system (part of works), which are required or are a consequence of the requirements made by the client, users and/or by regulations.[4]

Toll road: The highway open to traffic only upon payment of a direct fee. [10]

Traffic lane: The strip of roadway intended to accommodate the forward movement of a single line of vehicles. [10]

Travel lane: The portion of a roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes. [18]

Two-tube tunnel (twin tube tunnel): The tunnel through which traffic flows in one direction through each tube that is uni-directional flow. [17]

Underpass: The grade separation where the subject highway passes under an intersecting highway. [12]

Underwater tunnel: A tunnel which is partly or wholly constructed under a body of water. They are often used where building a bridge or operating a ferry link is impossible, or to provide competition or relief for existing bridges or ferry links. [17]

Urban: The central business districts, residential districts and open space parks typical of larger cities. [18]

Vertical curve: The parabolic curve drawn tangent to two intersecting grade lines to provide a smooth transition from one grade to another. [10]

Viaduct: The elevated roadway span over a valley, floodplain, wetland, or gorge which provides unrestricted wildlife movements or passage of other activity. [18]

[60] ASTM D8, Standard Terminology Relating to Materials for Roads and Pavements

Glossary C Terminology on Benchmarking Rail Transport Infrastructure Construction Costs

Active level crossing - automatic with user-side protection: The level crossing where user-side protection is activated by the approaching train. This shall include a level crossing with both user-side protection and warning.[61]

Active level crossing - automatic with user-side warning: The level crossing where user-side warning is activated by the approaching train. [29]

Active level crossing – manual: The level crossing where user-side protection or warning is manually activated by a railway employee. [29]

Active level crossing - rail-side protected: The level crossing where a signal or other train protection system permits a train to proceed once the level crossing is fully user-side protected and is free from incursion. [29]

Ballast: The selected material placed on the subgrade to support and hold the track with respect to its alignment within the bounds of specified top (vertical) and line (horizontal). Ballast preferably consists of accurately graded hard particles, normally stone, easily handled in tamping, which distribute the load, provide elasticity, drain well and resist plant growth. Generally, ballast must consist of broken stones. Granite is a very suitable material thanks to its toughness.[62]

Branch line: The line carrying trains from the mainline to destinations on lower priority routes than the mainline. [30]

Bridge: The structure that is built over a river, road, or other railway line to allow trains to cross from one side to the other.[63]

Broad-gauge: The track wider than the standard gauge of 1435 mm. [29]

Catenary system: The generalized term used to describe the whole overhead line equipment. [30]

Connected facility: The facility connected to the main railway network, such as a terminal or port. Such facilities are connected to rail transport but lie outside the main railway network.[64]

Construction of the railway infrastructure: The civil engineering, signalling, electrification, telecommunications, plant and electrical distribution and related computer systems. [30]

Contact wire: The overhead wire touched by an electric train's pantograph in order to draw power. [30]

Conventional lines: All railway lines that are not classified as 'dedicated high-speed lines' or 'upgraded high speed lines. [32]

Corridor (railway): The major railway line along a geographical route. [32]

Culvert: The small bridge or pipe carrying a stream under a railway. [31]

Dedicated high speed line: The line specially built to allow traffic at speeds generally equal to or greater than 250 km/h for the main segments. High speed line may include connecting lines, in particular connecting segments into town centre stations located on them, on which speeds may take account of local conditions. [32]

Dedicated line: The rail link used exclusively by one type of traffic (freight or passengers).[32]

Development of the railway infrastructure: The network planning, financial and investment planning as well as the constructing and upgrading of the infrastructure.[65]

---

[61] Directive (EU) 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety

[62] University of Birmingham and Network Rail Railway Lexicon Mk 24, February 2011

[63] Definitions compiled by experts of PKP Polish Railway Lines

[64] RailNetEurope (RNE)

[65] Directive (EU) 2016/2370 of the European Parliament and of the Council of 14

Diamond crossing turnout: The turnout where two tracks cross. [31]

Double-track line: The line in which one track is provided for each direction of travel. [32]

Ecopassage for railway: The structure which allows animals to cross the railway line safely. [31]

Electrified line: The line equipped with a power cable providing electric traction power to the trains.[66]

Elevator: The installation which transports people or goods vertically between specific levels of a railway station. [31]

Escalator: The installation in the form of moving stairs which transports people or goods vertically between specific levels of a railway station. [31]

European Railway Traffic Management System (ERTMS): The major industrial project being implemented by the European Union, which will serve to make rail transport safer and more competitive. It is made up of all the train-borne, trackside and lineside equipment necessary for supervising and controlling, in real-time, train operation. [32]

European Train Control System (ETCS): The component of ERTMS to guarantee a common standard that enables trains to cross national borders and enhances safety. It is a signalling and control system designed to replace the several incompatible safety systems currently used by European railways. As a subset of ERTMS, it provides a level of protection against over speed and overrun depending upon the capability of the line side infrastructure. [32]

Fastenings: The elements such as bolts and springs that fasten rails to a sleeper. [31]

Footbridge for railways: The engineering structure designed for pedestrians, constructed over the railway line. [31]

High speed line: The specially built high-speed line equipped for speeds generally equal to or greater than 250 km/h or specially upgraded high-speed lines equipped for speeds of at least 200 km/h.[67]

Infrastructure manager for railway (railway infrastructure manager): The body or firm responsible for the operation, maintenance and renewal of railway infrastructure on a network, as well as responsible for participating in its development within the framework of its general policy on development and financing of infrastructure. [33]

Interoperability: The ability of a rail system to allow the safe and uninterrupted movement of trains which accomplish the required levels of performance. [33]

Land grading: The work conducted in order to ensure a level base for further construction work [31]

Level crossing: Any level intersection between a road or passage and a railway, as recognised by the infrastructure manager and open to public or private users. Passages between platforms within stations are excluded, as well as passages over tracks for the sole use of employees. [29]

Lighting installation: The non-traction installation including lighting of passenger passages, platforms, level crossings, marshalling yards, signal boxes etc. [31]

Main line: The main inter-city and other main passenger or freight route available for rail services. Main railway lines comprise the high-speed railway lines and important major conventional railway lines. [32]

Maintenance of the railway infrastructure: The works intended to maintain the condition and capability of existing infrastructure. [33]

December 2016 amending Directive 2012/34/EU as regards the opening of the market for domestic passenger transport services by rail and the governance of the railway infrastructure

[66] Infrabel, www.infrabel.be/en

[67] Directive (EU) 2016/797 of the European Parliament and of the Council of 11 May 2016 on the interoperability of the rail system within the European Union

Marshalling yard: The railway facility equipped with tracks with special layout and technical facilities, where sorting, formation and splitting-up of trains takes place; wagons are sorted for a variety of destinations, using a number of rail tracks.[68]

Narrow gauge: The gauge tracks narrower than the standard gauge of 1435 mm.[30]

Network: The lines, stations, terminals, and all kinds of fixed equipment needed to ensure safe and continuous operation of the rail system. [34]

Non-electrified line: The line not equipped with a power cable providing electric traction power to the trains; usually trains on such line are driven by diesel engine. [31]

One-sided turnout: The turnout where from one main track (of a main line), one or two diverted tracks (of a branch line) diverge. [31]

Overhead power line: The electric power transmission line suspended to towers or poles. Overhead line equipment includes the wires and associated equipment, suspended over or adjacent to the railway line, for supplying electricity to trains. [32]

Passenger information system: The system presenting all key elements of a railway timetable for passengers at stations. [31]

Passive level crossing: The level crossing without any form of warning system or protection activated when it is unsafe for the user to traverse the crossing. [29]

Pedestrian passage: The structure that allows pedestrians to pass the railway without any threat of collision with a train; there are different types of pedestrian passages e.g. footbridges or tunnels. [30]

Platform: The structure constructed alongside the tracks at a passenger station that allows passengers wait, board and disembark from a train. [31]

Preparatory work: The work conducted in order to prepare land for earthwork; removal of trees and bushes, demolition, etc. [31]

Rail: The rolled steel shape designed to be laid end-to-end in two parallel lines on sleepers, to form a track for railway rolling stock. [31]

Railway infrastructure: The railway lines and engineering structures, buildings, and equipment, including grounds on which they are situated, dedicated to management passenger and freight services as well as maintenance of the property of the railway manager. [31]

Railway infrastructure in ports and terminals: The line infrastructure in the administrative area of ports and terminals. [31]

Railway line: One or more adjacent running tracks forming a route between two points. [32]

Railway station: A building or a building complex designed to provide services for passengers and accompanying persons, i.e. ticket offices, waiting rooms, shops, bars; facilities for train operations are excluded from this definition. [32]

Ramp: The structure constructed alongside the tracks at a freight station which allows goods to be loaded and unloaded from a train. [31]

Removal of wired infrastructure collision: The removal of any type of cables or wires which were originally installed at the place of construction, upgrade or renewal work, in order to avoid collision with new wired infrastructure to be installed at this place. [31]

[68] Eurostat/ITF/UNECE, RNE

Renewal of the railway infrastructure: The major substitution works on the existing infrastructure which do not change its overall performance. [33]

Retaining structure: The engineering structure used for soil stabilisation, especially at slopes. [31]

Secondary line (or branch line): The line of less importance than a main line (or trunk line).[32]

Section: The railway track between two locations (e.g. between two stations).[34]

Siding: The section which is directly or indirectly connected with a railway line, used to perform loading, maintenance, or parking operations of railway vehicles or movement and entering of railway vehicles into operation on a railway network. [31]

Signal box: The small building near a railway, which contains the switches used to control the signals.[69]

Signalling system: The system used to control railway traffic safely, essentially to prevent trains from colliding. The main purpose of signalling is to maintain a safe distance at all times between all trains on the running lines. [32]

Single-track line: The line where traffic in both directions shares the same track. [32]

Slab track: The form of railway track comprising a concrete base to which the base plates carrying the rails are secured. It eliminates the need for individual sleepers. [30]

Sleeper: The wood, concrete or steel object that holds the rails apart and supports the track on the ballast. [30]

Soil exchange: The excavation work conducted in order to remove the original soil and refilling this area with the soil meeting the requirements of the construction work. [31]

Standard-gauge: The track at the width of 1435 mm. [31]

Subgrade: The prepared surface of the natural ground or upper surface of fill material. [30]

Superstructure - The group of track elements that are found above the formation layer, i.e. rails, sleepers, fastenings, ballast. [31]

Switches and crossings: The specially designed rail components allowing trains to change tracks; any track elements which are not plain line. [30]

Tamping: The compacting ballast under the sleepers to maintain the correct geometry of the track. [30]

Technical specification for interoperability (TSI): The specification by which each subsystem or part of a subsystem is covered in order to meet the essential requirements and ensure the interoperability of the European Union rail system. [29]

Telecommunications and IT: The installation for wireless communications in railway traffic management. [31]

Terminal: The station where handling of goods takes place (goods are loaded on, or unloaded from, transport vehicles). May also include shunting of wagons between trains, without any loading or unloading. [32]

Track: The assembly of rail, fastenings and sleepers over which railway carriages, wagons, locomotives and trains are moved. [30]

Track bed: The foundation of the track, adjusted for laying the superstructure. [31]

Traction current: The electric current supplied for the purpose of electric traction, collected by pantograph from the overhead supply. [32]

Traction electric power engineering: The construction of overhead power lines, cable lines, substations, lightning protection, earthing systems etc. [31]

---

[69] Collins Dictionary.

Trunk line: The line that is the main route on a railway. [32]

Tunnel: The structure provided to allow a railway line to pass under higher ground, and which has excavated without disturbing the surface of that ground. [30]

Turnout: The trackwork element where a track divide into two. [30]

Turnout sleeper: The special kind of a sleeper laid under a turnout; it is longer than a regular sleeper. [31]

Upgrade of the railway infrastructure: The major modification works to the infrastructure which improve its overall performance. [33]

Upgraded high speed line: The conventional line specially upgraded to allow traffic at speeds of at least 200 km/h for the main segments. [32]

Viaduct: The multi-span bridge structure for non-collision traffic across the railway line. [31]

Glossary D Terminology on Benchmarking Inland Waterways Transport Infrastructure Construction Costs

1. Hydrological and hydrotechnical terms

Alluvial: something made of gravel/mud/silt/sand deposited and formed by rivers or floods.[70]

Alluvium: a fine-grained deposit, composed mainly of mud and silt, deposited by a river. [38]

Apron: layer of stone, concrete or other material to protect a structure's toe against scouring. [38]

Aquatic dredged material placement: dredged material placement options under which the dredged material is submerged and remains under water. [38]

Bar: an elevated region of sediment (sand or gravel) that has been deposited by the flow. [38]

Barrage: hydraulic structure designed to retain head water on secondary branches of a river in order to regulate the delivery rate in the main channel.[71]

Bathymetry: the study of underwater depth of water bodies, topography of a water body. [38]

Bed profile: a curve indicating the elevation and shape of a riverbed; may be a longitudinal curve or a transverse curve at a cross-section. [38]

Bottom water outlet: hydraulic structure for draining reservoir or channel. [39]

Canal: artificially created watercourse in an earthen cutting or embankment. [39]

Canalization of rivers means of increasing depth of waterways by creating pools using dams and connecting them with locks. [39]

Chevron: U-shaped river engineering structure with blunt nose and open end facing downstream; the current is diverted along both sides of the structure. [38]

Cross-section, profile: a plane, generally perpendicular to the centreline of the river or the fairway. [38]

Dam: water retaining structure partitioning off the waterway and its valley to raise the water level. [39]

Design level: water level at the stream flow measuring station established with multi- year probability. [39]

Differentiated parameters: planned dimensions of inland waterways depending on water levels. [39]

Discharge (Q): the volume rate of water flow, including any suspended solids (e.g. sediment), dissolved chemicals and/or biological material which is transported through a given cross-sectional area (Q=A x V, where A is cross sectional area (m^2) and V is the mean velocity of water (m/s).[39]

Drawdown: the difference between the working and the design water level. [39]

Dredged material: material excavated from the riverbed. [39]

Dike (or dike): hydraulic structure in the form of an embankment designed to protect against flooding, to restrict artificial water bodies and watercourses or to guide diverted water flows. [39]

Fairway: area on an inland waterway for the movement of craft and marked locally and (or) on a map. It also allows for safe passage on the water, indicated by aids to navigation. [39]

Fairway axis: centreline of the fairway. [38]

---

[70] via donau, Good Practice Manual on Inland Waterway Maintenance, www.viadonau.org/fileadmin/content/viadonau/01Newsroom/Bilder/2016/167_PL2_Manual_Waterway_Maintenance.pdf.

[71] National standards of member countries of the Working Party on Inland Water Transport (SC.3).

Fairway parameters: depth, width, vertical clearance and bend radius of the fairway. [39]

Flood control: regulation of flood waters to prevent or minimize inundation of valuable property or land. [39]

Floodplain (flood plain): an area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge events. [38]

Ford: a shallow sector of the river that stretches across the whole width of the river. [38]

Free flowing river: sections of natural rivers which are not impounded due to barrages such as hydropower plants or lock facilities and where water levels can be subject to considerable fluctuations. [38]

Gauge zero: elevation of the gauging station with respect to the mean sea level. [38]

Gauging station: equipment for measuring the water level of surface water bodies. [38]

Geodetic survey: a survey that takes the configuration and size of the earth's surface into account and is used to precisely define horizontal and vertical positions suitable for conducting other surveys. [38]

Granulometric riverbed improvement: the use of coarse gravel to cover lower zones of the riverbed in order to halt riverbed degradation. [38]

Granulometry (of the sediment): size of particles of sediment forming the riverbed. [38]

Gravel: unconsolidated rock fragments that have a general particle size range and include size classes from granule- to boulder-sized fragments. [38]

Guaranteed parameters: dimensions of inland waterways as set in the technical specifications for the design levels. [39]

Guide bund: a transverse river training structure aiming to narrow the riverbed and to divert flow into the fairway in order to maintain sufficient depth by increasing the natural sediment transport capacity. [38]

Head water: raised water level caused by the obstruction or hindrance of the watercourse or a change in the flow of groundwaters.

High navigable water level (HNWL): corresponds to a level existing for not less than 1percent of the navigation period, established on the basis of observations over a substantial number of years (30 to 40 years), excluding periods when there was ice.[72]

Hydraulic complex: a set of hydraulic structures all at the same location and used for the same purpose. [39]

Hydraulic structure: engineering structure designed to make use of water resources and to control the harmful effects of the water. [39]

Hydroelectric power plant: a set of hydraulic structures and equipment used to convert the energy potential of a watercourse into electrical power. [39]

Hydromorphology: physical characteristics of a river, including the riverbed, banks, connections with the landscape, including longitudinal continuity and habitat continuity. [39]

[72] Inventory of Main Standards and Parameters of the E Waterway Network ("Blue Book"), third revised edition (ECE/TRANS/SC.3/144/Rev.3), www.unece.org/trans/main/sc3/sc3res.html.

Inland waterway network: all inland waterways open for public navigation in a given area.[73]

Inland waterways: natural or artificially created water bodies and watercourses indicated by navigation signs or other means and used for navigation. [39]

Note: inland waterways include rivers, lakes, reservoirs, canals and other water bodies. The length of rivers and canals is measured in mid-channel. The length of lakes and lagoons is measured along the shortest navigable route between the most distant points to and from which transport operations are performed. A waterway forming a common frontier between two countries is reported by both.

Lock (navigation lock): hydraulic system to overcome differences in height along a waterway, in which vessels may be raised or lowered by filling up or emptying out one or more lock chambers. [38]

Lock chamber: an enclosure consisting of a section of canal that can be closed to control the water level. It is used to raise or lower vessels that pass through it. [39]

Longitudinal dike (training wall): a rock structure parallel to the river centre line to confine the flow in the fairway. [38]

Low navigable water level (LNWL) corresponds to a long-term mean water level reached or exceeded on all but 20 ice-free days per year (approximately between 5percent and 6percent of the ice-free period).[40]

Maintenance of navigable hydraulic structures: operation and repair of hydraulic structures designed to allow navigation.

Mean discharge: average quantity of water that flows through a certain cross-section of the river per unit of time over a certain period of time (m^3/s).[38]

Mean high water (MHW): mean of multi-year maximum water levels; the average water level is measured at a water gauge over a specific period of time. [38]

Mean low water (MLW): mean of multi-year minimum water levels. [38]

Mean water level (MWL): mean water level over a multi-year period. [38]

Morphological modelling: application of specialized software packages in order to determine and predict morphological changes of the riverbed.[38]

Morphology (of the riverbed): describes the shapes of river channels and how they change over time. [38]

Multibeam: specialized equipment for hydrographic surveys used for precise 3D imaging of the riverbed. [38]

Navigable canal: waterway built primarily for navigation. [41]

Navigable hydraulic structure: hydraulic structure on a waterway allowing navigation (including bank protection structures, breakwaters, dykes, moles, dams, approach channels, underwater structures created by dredging, pumping stations, navigable locks, boat lifts, hydroelectric power plant buildings, spillways, bottom water outlets and outlet works, tunnels and other facilities) designed to comply with set fairway parameters and allow the passage of vessels.

Navigable pass: navigable hydraulic structure allowing passage of vessels through a hydraulic complex. [39]

Navigable river: natural waterway open for navigation, irrespective of whether it has been improved for that purpose. [41]

[73] UNECE, Eurostat, ITF, Illustrated Glossary for Transport Statistics. ec.europa.eu/eurostat/documents/3859598/5911341/KS-RA-10-028-EN.PDF/6ddd731e-0936-455a-be6b-eac624a83db4.

Radius of curvature of the fairway: measured on a plan or a map, the radius of an arc on the axis of the fairway. [39]

Reservoir: an artificial water body formed of a water retaining structure on a watercourse for water storage and flow regulation. [39]

Riprap: rock armour, rubble or other material used to armour shorelines, streambeds, bridge abutments, etc. against scour and water or ice erosion. [38]

River basin: the land area that is drained by a river and its tributaries. [38]

Riverbed (riverbed): bed formed by the flow of the river, along which run-off is carried without flooding the flood plain. [39]

Shoal: shallow section of riverbed difficult for navigation. [39]

Spillway: hydraulic structure for passage of water discharged from upstream pool to avoid overfilling. [39]

Stream flow measuring station: hydrological station for monitoring water levels and flows. [39]

Towpath: bank that the fairway runs along. [39]

Water conduit: hydraulic structure for water supply and drainage in the appropriate direction. [39]

Water outlet: hydraulic structure for release from the upstream pool of the channel or waterway. [39]

Water retaining structure: hydraulic structure designed to retain head water. [39]

Waterways: stretches of water bodies and watercourses used for navigation and logging. [39]

Weir: device in hydraulic structure in which water is discharged through an opening from a free surface of the flow. [39]

2. Inland waterway infrastructure and inland water transport

Aids to navigation (AtoN): devices, systems or services, external to a vessel, designed and operated to enhance safe and efficient navigation of all vessels and/or vessel traffic.[74]

Beach area: part of the coastal protection belt on the water line, along the sea, around marine bays and estuaries subject to restrictions on economic activity. [39]

NB.: In some cases, the “carrying capacity of vessels” may be used to classify navigable inland waterways.

Coastal protection belt: part of a water protection zone of a given width along a river, the sea or around reservoirs which is subject to stricter controls on economic activity than the rest of the water protection zone. [39]

Combined transport: waterway suitability for combined transport is classified as follows:

Waterways suitable for combined transport: inland navigation vessels with a width of 11.40 or 11.45 m and a length of approximately 110.0 m are able to operate on such waterways carrying three or more layers of containers, 50percent of the containers being empty. Otherwise a permissible length of pushed convoys of 185.0 m should be possible, in which case they could operate with two layers of containers, 50percent of containers being empty.

Waterways suitable for combined transport with restrictions: this is mainly interpreted by Governments as inland waterways allowing the transport of at least two layers of containers, 50percent or less of them being empty, sometimes with the use of ballasting.

[74] International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), International Dictionary of Marine Aids to Navigation, 2016 revised edition, www.iala-aism.org/wiki/dictionary.

Waterways not suitable for combined transport: waterways where the transport of even two layers of containers is impossible. [40]

Connections to other modes of transport: availability and distance from ports to connections to other modes of transport in km:

a) Maritime shipping;
b) Passenger rail connection;
c) Freight rail connection;
d) Motorway access;
e) Airport.[41]

Deepening dredging: dredging to maintain specified parameters in approach channels (in a port).[39]

Draught: vertical distance from the lower part of the hull to the water level mark corresponding to the current load of the vessel.

In which:

Declared draught: maximum draught of vessels arriving in a port within one year or season;

Navigable draught: maximum draught with which a vessel can move through an approach channel (in a port) in actual hydrometeorological conditions at the time of the vessel's passage. [39]

Dredging: work to deepen, expand or align existing and create new navigation channels. [39]

Dry dock: structure for the inspection, repair and construction of vessels in a dry basin in which the vessel stands below the level of the water in the port. [39]

Engineering works: dredging, remedial work, sweeping, maintenance dredging, hydrographic surveys and maintenance of inland navigation equipment. [39]

Hydrographic conditions of navigation: a range of measures to ensure conditions for inland navigation, including equipping inland waterways with navigation and communications systems, aids to navigation, visible and audible alarms, and providing information to vessels on navigation and hydrometeorological conditions. [39]

Hydrographic survey: geodetic and hydrological work performed for the purposes of engineering works and maintenance of hydraulic structures with the necessary technical documentation. [39]

Inland waterway infrastructure: all facilities for inland navigation, including hydraulic structures on the waterway, beacons, roadstead, winter harbours, places of refuge, aids to navigation, power generation facilities, communications networks and facilities, alarm systems, information systems and vessel traffic management systems, and other facilities for the operation of inland waterways. [39]

Internavigational period: the period during which inland waterways are closed to navigation. [39]

Maintenance dredging: work to remove obstacles to navigation. [39]

Maintenance of navigation equipment: preparation, installation, rearrangement and cleaning of navigation signs, work to ensure their visibility, soundings, provision of informing to skippers about current and changing conditions. [39]

Navigational equipment: a system of special alarms for safe navigation. [39]

Navigational period: the period during which the inland waterways are open for navigation. [39]

Pilot chart: schematic map of inland waterways with navigation equipment indicated. [39]

Remedial work: installation in riverbed of structures to create and support differentiated guaranteed depths or to protect bank from scouring .[39]

Roadstead: part of inland waterways intended for berthing, formation and uncoupling of vessel convoys, integrated fleet service operations and for trans-shipment operations .[39]

Slipway: structure for the construction or repair and launch of a vessel .[39]

Sweeping: work to locate underwater obstructions to navigation .[39]

Turnaround time: total of operating time of vessel or survey team, time required for servicing and time towing vessel .[39]

Vertical clearance: height in the middle of the bridge with due regard of the fairway and the shape of the bridge; it takes into account the security clearance of about 30 cm between the uppermost point of the vessel's structure or its load and the bridge .[40]

Waterline: boundary of water on shore of water body (shoreline).[39]

Winter harbour/ shelter: part of a surface water body and (or) set of structures set up and equipped for the repair, winter mooring, berthing or technical inspection of vessels and floating objects .[39]

3. Ports and port infrastructure

Bollard: mooring post for the purpose of berthing of ships and other vessels to a port structure.[75]

Breakwater: hydraulic structure providing protection to port or coastal waters from waves, deposits and ice. Depending on the facilities protected, breakwaters can be subdivided into:

Port (external), separating port basin from the water body;

Internal (groynes), dividing a basin into smaller areas. [43]

Fender: shock absorption system for dissipating the force of impact of vessels, reducing load on the wharf structure and the side of the vessel, and protecting them from mechanical damage. [39]

Groyne: breakwater with neither end connected to the shore. [39]

Harbour aquatorium: defined section of the water body, except the fairway, designed for the safe approach, manoeuvring, berthing and departure of vessels. [39]

Infrastructure providing access to ports: fairways and facilities, devices and installations associated with their functioning, leading to each seaport and located within the area of a seaport. These include port entrance channels, fairways, anchorages, turning basins and vessel traffic services (VTS) and vessel traffic management systems (VMTS).[43]

Inner approach channel: hydraulic structure, a natural or artificial waterway located within a port, designed to allow vessels to approach or depart from quays and to maneuver within seaport waters. Some ports have loading/unloading and parking quays along channels Landing stage: a place solely for vessels to embark or disembark passengers, not part of an inland port. [39]

Mole: breakwater with one end adjacent to the shore. [39]

Outer harbour: area of water within the port adjacent to roadstead and the entrance to the port, separated from the port by breakwaters. Used for performing manoeuvres by entering and exiting vessels, it is also the area where waves act differently, and their height and influence becomes much less severe. [43]

[75] ECE/TRANS/WP.5/GE.4/2018/4, www.unece.org/trans/main/wp5/ wp5_ge_bench marking_transport_infrastructure_construction_costs_05.html.

Port basin: area of water adjacent to the shoreline surrounded by quays or other port structures, maintained at the required depth level, by which ships are berthed and their cargo is exchanged. [43]

Port infrastructure: harbour and freely accessible facilities, devices and structures within the land area or waters of the port, associated with the functioning of the port and intended for performing tasks assigned to the port by the port management body.

Port or quay operator: transport organization operating the port or quay, goods operations (including trans-shipment), servicing of vessels or other vehicles and (or) services for passengers and their luggage. [39]

Public port infrastructure: harbour aquatorium, rail and road access routes (up to the first intersection outside the port area), telecommunications, heating, gas, water and electricity installations, utilities systems, other objects for the use of two or more economic actors at the seaport. [39]

Quay wall: constructed vertical or almost vertical wall to hold waterside cranes. [38]

River port: all the facilities located on the land and in the waters of inland waterways, set up and equipped to provide services for passengers and vessels, loading, unloading, receiving, storage and dispatching of goods, in combination with other modes of transport. [39]

Ro-Ro berth: a location at which a Ro-Ro ship can berth and load and unload motor vehicles and other mobile Ro-Ro units via ramps from ship to shore and vice versa. [41]

Seaport hydraulic structures: engineering structures (harbour aquatorium, quays, jetties, other types of wharf facilities, moles, dams, groynes, other shore protection structures, artificial or natural underwater structures, including channels, operational aquatorium of a wharf, anchorages) located within the land area or waters of a seaport and designed to ensure the safety of vessels during navigation, manoeuvring and when moored. [39]

Seaport infrastructure: mobile and fixed objects that allow the seaport to function, including harbour aquatorium, hydraulic structures, docks, tugs, icebreakers and other ships of the port fleet, aids to navigation and other navigation and hydrographic equipment for maritime routes, vessel traffic management systems, information systems, trans-shipment equipment, rail and road access ways, telecommunications, heating, gas, water and electricity installations, other installations, equipment and utilities systems located within the land area or waters of a seaport and designed to ensure the safety of maritime navigation, the provision of services and State monitoring in the seaport. [39]

Statistical port: a statistical port consists of one or more ports, normally controlled by a single port authority, able to record ship and cargo movements. [41]

Turning basin: a basin located between docks and port channels or fairways, with special provisions for the safe performance of rotating manoeuvres of ships to allow them to enter port channels, change course, or align in port with the use of their own thrusters or with the help of tugboats. The diameter of a turning basin should correspond to 150percent of the length of the largest vessel to use its area. [43]

Wave absorber: a structure preventing from forming rebound waves in a dock; may be a separate unit or a part of a quay or a breakwater. [43]

Wharf (wharf structure): hydraulic structure with devices for the safe approach of vessels and used for the safe berthing, loading, unloading and servicing of vessels and the embarkation and disembarkation of passengers. [39]

Note: types of quay according to design feature:

a) massive reinforced concrete box caisson;
b) massive caisson foundation;
c) on a cellular cofferdam;
d) L-shaped wall;
e) with capping beams and anchor slab;
f) with capping beams and raking trestle;

g) with capping beams;
h) slab quays.[43]

Types of wharf:

Quay: wharf structure adjacent to the shore and located along the water's edge.[39]

Pier: wharf structure set on the slope of the shore such that there is practically no side pressure on the construction.[39]

Jetty: wharf structure standing proud from the shore in the port waters and allowing ships to berth on at least two sides.[39]

Dolphin: wharf structure consisting of a separate standing structure for positioning of the vessel during docking or for guiding vessels and other craft along the wharf.[43]

Floating jetty: berthed vessel fixed to the shore or in the roadway of an inland waterway, designed for mooring and berthing of vessels and manufacturing operations.[39]

Wharf length: total length of wharf structures in metres.[41]

Glossary E Terminology on Benchmarking Intermodal Terminals Infrastructure Construction Costs

Slope: The incline angle of a roof surface, given as a ratio of the rise to the run. Should be above 2 per cent.
Internal Road: Roads that are completely inside the Logistic / Intermodal Platform. Should support mega trucks operations (two lines in each direction, wide enough) and mega trucks weight (about 5 Tn/sq. m).
Plot: any measured piece or parcel of land, prepared for the installation of logistic activities. The entrance should be free of obstacles, to allow truck operations.
Installations: any construction needed to guarantee the supplying to the plot.
Telecommunication installation: a kind of telecom technology to guarantee the voice and wide band connection to any plot. Should be done by optical fibre. In addition, itshould include an installation to guarantee the supply to all the designed area by connecting to an external network.
Energy installation: electrical installation to guarantee the energy consumption ofthe plot. Should be designed at least with 50 W/sq. m. In addition, it should include an installation to guarantee the supply to all the designed area. It can be done by a new electrical substation or by connecting to an external network.
Water Installation: installation to guarantee the water consumption of the plot. In addition, it should include an installation to guarantee the supply to all the designed area. It can be done by a depot or by connecting to an external network.
Water treatment installation: installation to guarantee the evacuation of sewage water of the plot. In addition, it should include an installation to guarantee the treatment to all the designed area. It can be done by an own treatment plant or by connecting to an external network.
Green areas: free areas inside the logistic/intermodal platform dedicate to gardens. It is mandatory in most of designing regulations.
Traffic signalization system: all the installation needed to regulate and control the circulation of vehicles into the designed area.
Security system: all the installation needed to guarantee the security into the logistic/intermodal platform. It includes gate control, monitoring, and perimeter security. It should select the best technology in any case.
Railway connections: connections between railways and logistic platforms, airports, ports or inland waterways.
Renewable energy: any kind of energy generation that has zero carbon emissions: solar, wind, etc. At least a 30 per cent of the power consumption of a logistic / intermodal platform should be generated by own systems of renewable energy.
Acquisition costs: All costs needed to obtain the terrain needed to develop the logistic platform. Can be obtained by expropriation, buying or leasing.
Logistic Platform: Centre in a defined area within which all activities relating to the transport, logistics and distribution of goods, both for national and international transit, are carried out by various operators on a commercial basis.
Intermodal terminal: Area prepared for the interchange of goods between two different transport means, mainly trucks and train.
Administrative Costs: Costs incurred in contract management administration overhead expenses.
Project: Document that reflect the construction plan and costs of developing o modifying a logistic area.
Line: Each part of a road wide enough for one vehicle, often marked off by painted lines.
Earthmoving: The needed movement to obtain a terrain with less of 2 per cent of scope.
Conduits: A pipe, tube or similar prepared to be used in water circulation or by electrical or telecommunications installations.
Carrying capacity: The capacity of the land to support weight without deformation.
Pavements: The upper part of a road.
Electricity supply: The installation needed to guarantee the power to be used by any area of the logistic platform.

Dark water treatment plant: The installation needed to treat residual water to be adapted for the waste.
IT: Installation of telecommunications.
Potable water: Water prepared for human consumption.
Fire Prevention: Installation needed to combat or avoid the fire risk.
Access Control: All installation needed to check the access of people or vehicles to an area. Usually informed by control cams, barriers, plate readers, etc.
CCTV: System of control by images used to security. Usually is formed by fixed cams, domos, recorders and control room).
Tasks preceding project development: all tasks to be implemented before the start of the project for a logistic platform (costs by unit)

(a) Demand study (USD/Unit): Analysis of demand to determine if the logistic platform is needed.

(b) Modification of urban planning (USD/Unit): tasks related to modification of the local town planning to allow the development of the logistic platform.

(c) Environmental impact assessment (USD/Unit): Assessment needed to receive the administrative environmental approval.

(d) Archaeological requirements (USD/Unit): Tasks related to receiving the administrative approval related to archaeological requirements.

(e) Other administrative approvals (USD/Unit): Tasks related to receiving other administrative approvals.

Land acquisition: Expropriation, purchase or renting the land needed to develop the logistic platform:

(a) Land Purchase (USD/m2): Cost (by m2) of land acquisition by purchasing the land. It includes the needed document management.

(b) Expropriation (USD/m2): Cost (by m2) of land acquisition by expropriating the land. It includes the needed document management.

(c) Renting (USD/m2/year): Cost (by m2 and by year) of land acquisition by renting the land. Include the needed documents management.

Engineering tasks: Tasks related to preparation for construction:

(a) Project (USD/Unit): Elaboration of the engineering project.

(b) Construction Permit (USD/Unit): Cost of licences (all taxes paid to start the construction jobs).

(c) Works Management (USD/Unit): Cost of engineering works during the construction.

Land adaptation: Tasks needed to adapt the available land to the technical requirements of a logistic platform:

(a) Land clearing (USD/m2): Tasks required to take out the topsoil. Price by m2.

(b) Earth movement (USD/m3): Soil movements needed to adapt the land to the requirements. Price by m3 of soil moved.

(c) Gravel Column (USD/m3): Technique to increase the carrying capacity of the land. This technique consists of inserting gravel columns into the underground. Price of m3 of gravel inserted.

(d) Concrete Column (USD/m3): Technique to increase the carrying capacity of the land. This technique consists of inserting into the underground concrete columns. Price of m3 of concrete inserted.

(e) Drain wick (USD/m2): Technique to increase the carrying capacity of the land. This technique consists of inserting into the underground drain geotextile. Price of m2 of geotextile inserted.

(f) Preload (USD/m3): Technique to increase the carrying capacity of the land. This technique consists of inserting additional soil into the underground to produce the desired effect. Price of m3 of soil placed.

(g) Perimeter fence (USD/m): Perimeter fence used to guarantee that the logistic area is a closed area. Price of lineal meter of fence.

Internal roads: Internal roads in the logistic area:

(a) Asphalt Road (USD/m2): m2 of asphalt road, including all the sub-layers needed.

(b) Concrete Road (USD/m2): m2 of concrete road, including all the sub-layers needed.

Pavements: Internal pavements in the logistic area:

(a) Pedestrian pavement (USD/m2): m2 of pavement adapted to pedestrian. Such pavement cannot support truck circulation. Price by m2 of pavement.

(b) Plot access pavement (USD/m2): m2 of pavement constructed to access the plot. This pavement should support truck circulation. Price by m2 of pavement.

Conduits: A pipe, tube or similar prepared to be used in water circulation or for electrical or telecommunications installations:

(a) Rainwater drainage conduit (USD/m): Conduits to guarantee the drainage of rainwater. Price by lineal m of conduit.

(b) Dark water conduit (USD/m): Conduits for dark water. Price by lineal m of conduit.

(c) Potable water conduit (USD/m): Conduits for potable water. Price by lineal m of conduit.

(d) Low-tension line conduit (480 v) (USD/m): Conduits for low-tension electrical line. It does not include the cables. Price by lineal m of conduit.

(e) Medium-voltage line conduit (480 v - 20 kv) (USD/m): Conduits for medium- tension electrical line. It does not include the cables. Price by lineal m of conduit.

(f) High-tension line conduit (>20 kv) (USD/m): Conduits for high-tension electrical line. It does not include the cables. Price by lineal m of conduit.

(g) Telecommunication conduit (USD/m): Conduits for telecommunication lines. It does not include the cables. Price by lineal m of conduit.

(h) Telephony conduit (USD/m): Conduits for telephone lines. It does not include the cables. Price by lineal m of conduit.

(i) CCTV conduit (USD/m): Conduits for CCTV installation. It does not include the cables. Price by lineal m of conduit.

(j) Optical fibre conduit (USD/m): Conduits for Optical Fibre installation. It does not include the cables. Price by lineal m of conduit.

(k) Fire prevention conduit (USD/m): Conduits for Fire Prevention installation. It typically uses water from tanks. Price by lineal m of conduit.

Cables: Cables installed in the logistic area urbanization:

(a) Low-tension electrical cable (USD/m): Low-tension electrical cable installed in the logistic area. Usually a line requires more than 1 cable. Price by lineal m of cable.

(b) Medium-voltage electrical cable (USD/m): Medium-tension electrical cable installed in the logistic area. Usually a line requires more than 1 cable. Price by lineal m of cable.

(c) High-tension electrical cable (USD/m): High-tension electrical cable installed in the logistic area. Usually a line requires more than 1 cable. Price by lineal m of cable.

(d) Multimode optical fibre (USD/m): Multimode fibre optics cable installed in the logistic area. Usually each cable has more than 1 fibre (typically, 16 or 32). Price by lineal m of cable.

(e) Monomodal optical fibre (USD/m): Monomodal fibre optics cable installed in the logistic area. Usually each cable has more than 1 fibre (typically, 16 or 32). Price by lineal m of cable.

(f) Telephone cable of pairs (USD/m): Telephone cable of pairs installed in the logistic area. Usually each cable has more than 1 pair (typically, 32). Price by lineal m of cable.

Roads installation: Internal roads additional installation:

(a) Road Paint (USD/m2): All signalling painting on the roads. Price by m2 of paint.

(b) Pedestrian cross-roads (USD/m2): Pedestrian cross-roads. Usually are elevated from roads, in order to help the accessibility and the speed control of trucks. Price by m2 of pedestrian crossroad.

(c) Signposts (USD/unit): All the signposts needed in the logistic area to control the internal circulation. Price by signposts installed.

Streetlights (USD/unit): All the streetlights installed in the logistic area. Price by streetlights.

Potable water supply: Entire installation needed to guarantee the supply of potable water:

(a) Deposit (USD/m3): If needed, deposit of potable water to supply to the area. Prize of m3 of deposit.

(b) External conduit (USD/m): Connection from the logistic area to external point of connection (given by local water company supplier). Price by lineal m of conduit.

(c) Connection valve (USD/Unit): Connection valves installed in the logistic area. Price by valve installed.

(d) Check valve (USD/Unit): Check valves installed in the logistic platform. Price by valve installed.

(e) Pumping (USD/Unit): If needed, pump system of potable water. Price by system installed.

Power supply: Entire installation needed to guarantee the supply of electricity:

(a) Power station transformer (USD/Unit): Power station transformer installed in the logistic area. Price by unit installed.

(b) Low-tension electrical panel (USD/Unit): Electrical panel installed in the logistic area. Price by unit installed.

(c) Power sub-station (USD/MW needed): Construction (or payment) of sub-station needed to guarantee the power supply. Prize by MW needed in the logistic area and used in the sub-station.

Rain drainage: Entire installation needed to guarantee the rain drainage, excluding conduits:

(a) Pumping (USD/Unit): If needed, pumping system to guarantee the rain drainage. Price by unity installed.

(b) Oil separators (USD/Unit): Installation of fat separators to avoid that engine oils enter the rainwater drainage system. Price by unity.

(c) Storm tank (USD/Unit): Storm tank is a tank that can collect rainwater to avoid flooding. Price by unity installed.

(d) Canalization of existing courses (USD/m2): Canalising existing courses in the land selected for developing the logistic platforms. Price by m2 of canalization.

Dark water treatment: All the installation needed to guarantee the circulation and treatment of dark water:

(a) Treatment system (USD/sq. people): Installation of treatment system to adapt the dark water to the applicable regulations. Price by equivalent people served by the treatment system.

(b) Pumping (USD/Unit): If needed, a pumping system to guarantee the circulation of dark water should be installed. Price by unity installed.

Technical and social facilities complex:

(a) Hotels and Restaurants and other Social facilities (USD/Unit): including hotels, restaurants, resting area, training centre, hairdresser, sewer etc.

(b) Technical support and trade area (USD/m2): including facilities to provide technical support, incl. changing of the wheels/ tires, wires, mechanics, painting, maintenance, etc.

(c) Administration and commercial offices (USD/Unit): Customs, standards and permission issues; freight forwarding, transportation offices; insurance, banks and other commercial offices etc.

(d) Other facilities (USD/m2): support services for the companies at the logistic platform.

Garbage treatment plant:

Garbage Treatment Plant (USD/m3): solid and liquid waste management facility

Telecom supply: Entire installation needed to guarantee telecom services:

(a) Outdoor telephone panel (USD/Unit): Outdoor telephone panel installed (where any customer is connected to the telecom company). Price by unit installed.

(b) Monomodal optical fibre interconnection panel (USD/Unit): Interconnection panel for monomodal optical fibre. Price by unit installed.

(c) Optical fibre repeater (USD/Unit): Signal repeater of monomodal optical fibre. Price by unit installed.

(d) Multimodal optical fibre interconnection panel (USD/Unit): Interconnection panel for multimodal optical fibre. Price by unit installed.

(e) Multimodal optical fibre interconnection panel (USD/Unit): Signal repeater for multimodal optical fibre. Price by unit installed.

Fire prevention: The entire range of installations required by fire protection systems

(a) Fire tank (USD/m3): Water tank used to supply water to fire protection systems. Price by m3 of tank.

(b) Check valve (USD/Unit): Valves installed to prevent contamination and flooding from water sources used in fire protection systems. network. Price by valve installed.

(c) Fire prevention pumping (USD/Unit): Pump system to guarantee the pressure of water in the fire protection system. Price by pump system installed.

(d) Fire truck (USD/Unit): response time shall be less than 5 minutes.

Green areas: All tasks required for design and maintenance of the internal green areas:

(a) Transplantation (USD/Unit): Any transplantation that may be required from the original land into the logistic area. Price by transplant done.

(b) Topsoil movement (USD/m3): Topsoil moved to the green areas. Price by m3 of topsoil moved.

(c) Gardening (USD/m2): Gardening tasks required to finalize the green areas. Price by m2 of green area adapted.

(d) Irrigation network (USD/m): Network of pipes needed to guarantee the irrigation in the green areas. Price by lineal meter of pipe installed.

(e) Irrigation tank (USD/m3): Tanks designed to collect rainwater and other kinds of water for irrigation purposes. Price by m2 of tank installed.

(f) Irrigation pumping (USD/Unit): Pump system to guarantee the pressure needed in the irrigation water network.

CCTV: Close Control TV system:

(a) Fixed digital cams (USD/Unit): Fixed digital cameras installed in the logistic area. Price by unit.

(b) Domo cam (USD/Unit): Standalone camera which captures 360-degree panoramic videos and images installed in the logistic area. Price by unit.

(c) Digital recorders (USD/Unit): Digital recorders with more than 14 days of autonomy. Price by digital recorder installed.

(d) Control room (USD/Unit): Control room equipped with monitors, and other technical equipment, tables, chairs, etc. Price by control room installed.

Access control: Access Control system:

(a) Access control barrier (USD/Unit): Automated barrier for the access control system. Price by Access control barrier installed.

(b) Plate recognition (USD/Unit): Plate reader system in order to control the access of vehicles in the logistic area. Price by plate reader installed.

(c) Logical access control (USD/Unit): Tools and protocols used for identification, authentication, authorization, and accountability in computer information systems Price by system installed.

(d) Intermodal terminal: An intermodal terminal is a big area, usually constructed in reinforced concrete to allow the interchange between trucks and train. (construction requirements may include see items 34, a-g)

Truck park: A truck park is a big area, usually done in reinforce concrete to allow the trucks to park (construction requirements may include see items 34, a-g)

Container freight station (CFS): Area prepared for handling of incoming/outgoing the containers (consolidation and deconsolidation of cargo):

(a) General CFS area (USD/m3): Goods are prepared for another transport mode or destination.

(b) CFS area for Dangerous Goods (USD/m3): special segregation, separation and handling in accordance with a specific stowage plan.

Warehouse: a building for the storage of goods:

(a) General cargo Goods (USD/m2): Long, middle and short-term storage area.

(b) Heat Controlled Goods (USD/m2): Long, middle and short-term storage area for special products requiring temperature-controlled storage.

(c) Separated Goods (USD/m2): Long, middle and short-term storage area for products requiring specific treatment.

(d) Dangerous Goods (USD/m2): Long, middle and short-term storage area for dangerous goods in accordance with ADN or other relevant agreements.

(e) Goods in Pressurized Equipment (USD/m2): Long, middle and short-term products requiring pressurized storage.

(f) Explosive Goods (USD/m2): Long, middle and short-term for explosives.

(g) Cold Chain storage (USD/m2): Long, middle and short-term storage area for products requiring a temperature-controlled environment.

(h) Handling area (USD/m2): area designed for loading and unloading of cargo.

(i) Loading and Unloading area (USD/m2): the services of loading or unloading cargo between any place or point of rest on a wharf or terminal, and railcars, trucks, or any other means of land transportation and barges.

ANNEXURES

Annex A Sample of Road Questionnaire

This section of the questionnaire is attached as a sample. The complete questionnaire template is attached in a separate folder.

Construction costs for road infrastructure projects

Please provide data on road construction projects between 2007-2016, costs should exclude design costs, land acquisition costs and value-added cost

Project	Start date	End date	Construction costs of the project (USD million)	Currency	Prices of (year)	Road Class type	Road work type	Surface type	Number of lanes	Length of the project excluding tunnels and bridges in km	Number of tunnels	Length of tunnels in km	Cost of tunnels	Number of bridges and viaducts	Length of bridges and viaducts in km	Cost of bridges and viaducts	Total length of the project in km

Annex B Sample of Rail Questionnaire

This section of the questionnaire is attached as a sample. The complete questionnaire template is attached in a separate folder.

Construction costs for rail infrastructure projects

Please provide data on rail new construction, upgrade or renewal projects between 2007-2016, costs should exclude design costs, land acquisition costs and value-added cost

Project	Start date	End date	Construction costs of the project	Currency	Prices of (year)	Line speed design	Rail work type	Type of line	Number of tracks	Length of the project excluding tunnels and bridges/ viaducts in km	Number of tunnels	Length of tunnels in km	Costs of tunnels	Number of bridges/viaducts	Length of bridges/viaducts in km	Costs of bridges/ viaducts	Total length of the project in km	Number of active level crossings	Costs of level crossings	Number of stations	Costs of stations	Number of over/underpasses for pedestrians	Costs of over/underpasses

Annex C Sample of Ports Questionnaire

This section of the questionnaire is attached as a sample. The complete questionnaire template is attached in a separate folder.

	Breakdown Items	Unit Cost	Maximum	Average	Minimum	Length of regarded projects	Number of projects
HYDROTECHNICAL INFRASTRUCTURE	Breakwater	USD/m					
	(a) Port - (external)	USD/unit					
	(b) Groynes (internal)	USD/unit					
	Pier	USD/unit					
	Jetty	USD/unit					
	Dolphin	USD/unit					
	Wave absorber	USD/unit					
	Turning basin	USD/unit					
	Outer harbour	USD/unit					
	Entrance channel	USD/unit					
	Port basin	USD/unit					
	Port channel	USD/unit					
	Dredging works	USD/m2					
QUAY	Massive reinforced concrete box caisson;	USD/m					
	Massive caisson foundation;	USD/m					
	Cellular cofferdam;	USD/m					
	L-shaped wall;	USD/m					
	with capping beams and anchor slab;	USD/m					
	with capping beams and raking trestle;	USD/m					
	with capping beams;	USD/m					
	Slab quays.	USD/m					
	Bollard	USD/unit					

	Breakdown Items	Unit Cost	Maximum	Average	Minimum	Length of regarded projects	Number of projects
	Fender	USD/unit					
ROAD INFRASTRUCTURE	Roads	USD/km					
	Service Yard	USD/m2					
	Car parks	USD/m2					
RAIL INFRASTRUCTURE	Siding	USD/unit					
	Loading point	USD/unit					
	Wagon Scale	USD/unit					
	Railway loading platform	USD/unit					
	Traffic Post	USD/unit					
	Traffic Signal	USD/unit					
	Pumping station and water treatment works	USD/unit					
	Retention basins	USD/unit					
	Pump and pressure boosting systems and pressure tank units	USD/unit					
	Main and distribution water pipes with plumbing and support devices	USD/unit					
SEWAGE INFRASTRUCTURE	Gravity flow network tunnels and collectors	USD/unit					
	Powered network tunnels and collectors	USD/unit					
STORM WATER SEWAGE INFRASTRUCTURE	Networks, tunnels and collectors of storm water sewage system with the system of inspection manholes;	USD/unit					
	Retention basins;	USD/unit					
	Separators and settling tanks with equipment;	USD/unit					
	Storm water sewage pumping station with reservoirs, plumbing, hydraulic system as well as power and control devices;	USD/unit					
	Storm water sewage system exits	USD/unit					

	Breakdown Items	Unit Cost	Maximum	Average	Minimum	Length of regarded projects	Number of projects
HEATING INFRASTRUCTURE	Heat sources, including oil and electric boiler plants	USD/unit					
	Overhead heating pipes	USD/unit					
	Underground heating	USD/unit					
	Low parameter heating pipes	USD/unit					
	High-parameter heating pipes	USD/unit					
	Heat transfer stations	USD/unit					
	Heat distributors	USD/unit					
ELECTRICITY INFRASTRUCTURE	Transformer/switching station MV/MV, MV/LV;	USD/unit					
	Medium voltage (MV) and low voltage (LV) cable lines	USD/unit					
	medium (MV) and low voltage (LV) service cabinets;	USD/unit					
	Switching substations	USD/unit					
	Grounding and bonding system;	USD/unit					
	Terminal switchgear devices	USD/unit					
TERMINALS	Container terminal	USD/unit					
	Bulk terminal	USD/unit					
	LNG terminal	USD/unit					
	Liquid fuel terminal	USD/unit					
	Ro-ro terminal	USD/unit					
	General cargo terminal	USD/unit					
	Passenger terminal	USD/unit					
LOADING/UNLOADING INFRASTRUCTURE	Gantry crane	USD/unit					
	Semi-gantry crane	USD/unit					
	Bridge crane	USD/unit					
	Crane vessel	USD/unit					
	Overhead gantry	USD/unit					
	Conveyor belts	USD/unit					
	Ro-ro loading ramp	USD/unit					

	Breakdown Items	Unit Cost	Maximum	Average	Minimum	Length of regarded projects	Number of projects
SAFETY INFRASTRUCTURE	Fence	USD/unit					
	Entry gates	USD/unit					
	Security posts	USD/unit					
	Cargo monitoring system	USD/unit					
	CCTV monitoring system	USD/unit					
	Access control system	USD/unit					
WAREHOUSES		USD/unit					
COLD STORAGE		USD/unit					
STORAGE YARDS		USD/unit					
OFFICE BUILDINGS		USD/unit					
CONVEYOR (GRAIN SILO)		USD/unit					
LIQUID FUEL CONTAINERS		USD/unit					
FIRE SAFETY		USD/unit					

Annex D Sample of Waterways Questionnaire

This section of the questionnaire is attached as a sample. The complete questionnaire template is attached in a separate folder.

CONSTRUCTION COST OF WATERWAYS	Breakdown Costs	Unit Cost	Maximum	Average	Minimum	Length of regarded projects	Number of projects
1) LAND EXROPRIATION	Expropriation	USD/m2					
2) MOBILISATION	Construction of access roads	USD/m2					
	Establishment of Camp Areas	USD/lump sum					
	Renting /Purchasing the construction equipment & machinery	USD/lump sum					
2) ENGINEERING WORKS	Engineering Works for Detailed Design	USD/lump sum					
	Site surveys, investigations, model works	USD/lump sum					
3) CANAL EXCAVATION & DREDGING (INCLUDING TRANSPORTATION AND DISPOSAL)	Excavation on land	USD/m3					
	Dredging for sea	USD/m3					
	Construction of protection structure	USD/m					

CONSTRUCTION COST OF WATERWAYS	Breakdown Costs	Unit Cost	Maximum	Average	Minimum	Length of regarded projects	Number of projects
4) CONSTRUCTION OF OUTER PROTECTION BOUNDARY OF SEA FILLING AREAS	along the outer boundary of sea filling areas						
5) CANAL BANK & BOTTOM PROTECTION	Direct Protection	USD/m2					
	Indirect Protection	USD/m2					
6) IMPERVIOUSNESS OF CANAL	Imperviousness Lining	USD/m2					
7) AUXILARY STRUCTURES AT ENTRANCES OF THE CANAL	Construction of Quays	USD/m2					
	Construction of Breakwaters	USD/m					
	Construction Dolphins	USD/m2					
8) EMERGENCY AND WAITING MOORING BASINS	Construction of Quays	USD/m2					
	Construction of Breakwaters	USD/m					
	Construction Dolphins	USD/m2					
9)STREAMS CONNECTIONS	Headwater Stream	USD/Unit					

CONSTRUCTION COST OF WATERWAYS	**Breakdown Costs**	**Unit Cost**	**Maximum**	**Average**	**Minimum**	**Length of regarded projects**	**Number of projects**
	Year-Round Stream	USD/Unit					
	Seasonal Stream	USD/Unit					
	Rain-dependant Stream	USD/Unit					
8) ROAD ALONG BOTH SIDES OF CANAL	Road along both sides of canal	USD/m					
10) CANAL OPERATION AND MAINTENANCE STRUCTURES	Construction of pilots building	USD/m2					
	Construction of operation towers including radar, VHF etc	USD/Unit					
	Construction of tag-boat connection areas	USD/Unit					
	Establishment of lighting, marking, etc, along canal	USD/Lump sum					
11) CONSTRUCTION OF YATCH HARBOR(s)	Construction of Quays	USD/m2					

CONSTRUCTION COST OF WATERWAYS	Breakdown Costs	Unit Cost	Maximum	Average	Minimum	Length of regarded projects	Number of projects
	Construction of Breakwaters	USD/m					
	Construction of Floating Piers	USD/m2					
	Construction of Backyard	USD/m2					
12) CONSTRUCTION OF LOGISTIC HARBOR(s)	Construction of Quays	USD/m2					
	Construction of Breakwaters	USD/m					
	Construction Dolphins	USD/m2					
	Construction of Backyard	USD/m2					
14) RELOCATION OF INFRASTRUCTURE CROSSING BY CANAL	Relocation of water supply infrastructure	USD/crossing					
	Relocation of wastewater infrastructure	USD/crossing					
	Relocation of power infrastructure	USD/crossing					
	Relocation of telecommunication infrastructure	USD/crossing					

CONSTRUCTION COST OF WATERWAYS	Breakdown Costs	Unit Cost	Maximum	Average	Minimum	Length of regarded projects	Number of projects
	Relocation of oil and natural gas infrastructure	USD/crossing					
	Relocation of Railways (Canal Crossing only - bridges, tunnels	USD/crossing					
	Relocation of Highways (Canal Crossing only - bridges and tunnels)	USD/crossing					

Annex E Sample of Intermodal Terminals Questionnaire

This section of the questionnaire is attached as a sample. The complete questionnaire template is attached in a separate folder.

CONSTRUCTION COST OF INTERMODAL TRANSPORT	BREAKDOWN ITEMS	UNIT COST					
LAND ADAPTATION	Land Clearing	USD/m2					
	Earth Movement	USD/m3					
	Gravel Column	USD/m3					
	Concrete Column	USD/m3					
	Drain Wick	USD/m2					
	Preload	USD/m3					
	Perimeter Fence	USD/m					
INTERMODAL TERMINAL	Land Clearing	USD/m2					
	Earth Movement	USD/m3					
	Gravel Column	USD/m3					
	Concrete Column	USD/m3					
	Drain Wick	USD/m2					
	Preload	USD/m3					
	Reinforced Concrete Area	USD/m3					
TRUCK PARK	Land Clearing	USD/m2					
	Earth Movement	USD/m3					
	Gravel Column	USD/m3					
	Concrete Column	USD/m3					
	Drain Wick	USD/m2					
	Preload	USD/m3					
	Reinforced Concrete Area	USD/m3					
	Special Operations for Dangerous Goods	USD/m3					
CONTAINER FREIGHT STATION (CFS)	General CFS Area	USD/m3					
	CFS Area for Dangerous Goods	USD/m3					

CONSTRUCTION COST OF INTERMODAL TRANSPORT	BREAKDOWN ITEMS	UNIT COST					
INTERNAL ROADS	Asphalt Road	USD/m2					
	Concrete Road	USD/m2					
PAVEMENTS	Pedestrian Pavement	USD/m2					
	Plot Access Pavement	USD/m2					
CONDUITS	Rainwater Drainage Conduit	USD/m					
	Dark Water Conduit	USD/m					
	Potable Water Conduit	USD/m					
	Low-tension Line Conduit (480 v)	USD/m					
	Medium-voltage Line Conduit (480 v - 20 kv)	USD/m					
	High-tension Line Conduit (>20 kv)	USD/m					
	Telecommunication Conduit	USD/m					
	Telephony Conduit	USD/m					
	CCTV Conduit	USD/m					
	Optical Fibre Conduit	USD/m					
	Fire Prevention Conduit	USD/m					
ROADS INSTALLATION	Road Paint	USD/m2					
	Pedestrian Cross-Roads	USD/m2					
	Signposts	USD/unit					
	Streetlights	USD/unit					
CABLES	Low-tension Electric Cable	USD/m					
	Medium-voltage Electrical Cable	USD/m					
	High-tension Electrical Cable	USD/m					
	Multimode Optical Fibre	USD/m					
	Monomode Optical Fibre	USD/m					
	Telephone Cable of Pairs	USD/m					
PORTABLE WATER SUPPLY	Deposit	USD/m3					
	External Conduit	USD/m					

CONSTRUCTION COST OF INTERMODAL TRANSPORT	BREAKDOWN ITEMS	UNIT COST					
	Connection Valve	USD/unit					
	Check Valve	USD/unit					
	Pumping	USD/unit					
POWER SUPPLY	Power Station Transformer	USD/unit					
	Low-tension Electrical Panel	USD/unit					
	Power Sub-Station	USD/MW					
RAIN DRAINAGE	Pumping	USD/unit					
	Oil Separators	USD/unit					
	Storm Tank	USD/unit					
	Existing Courses Canalising	USD/m2					
FACILITIES COMPLEX	Social Facilities	USD/unit					
	Technical Support and Trade Area	USD/m2					
	Administration and Commercial facilities	USD/unit					
	Other Facilities	USD/unit					
DARK WATER TREATMENT	Treatment System	USD/sq. people					
	Pumping	USD/unit					
TELECOM SUPPLY	Outside Telephone Pairs Panel	USD/unit					
	Monomode Optical Fibre Interconnection Panel	USD/unit					
	Optical Fibre Repeater	USD/unit					
	Multimode Optical Fibre Interconnection Panel	USD/unit					
WAREHOUSE	General Cargo Goods	USD/m2					
	Heat Controlled Goods	USD/m2					
	Separated Goods	USD/m2					
	Dangerous Goods	USD/m2					
	Goods in Pressured Equipment	USD/m2					
	Explosive Goods	USD/m2					
	Cold Chain Goods	USD/m2					

CONSTRUCTION COST OF INTERMODAL TRANSPORT	BREAKDOWN ITEMS	UNIT COST					
	Handling Area	USD/m2					
	Loading and Unloading area	USD/m2					
FIRE PREVENTION	Fire Tank	USD/m3					
	Check Valve	USD/unit					
	Fire prevention Pumping	USD/unit					
	Firework Vehicle	USD/unit					
GREEN AREAS	Transplant	USD/unit					
	Topsoil Movement	USD/m3					
	Gardening	USD/m2					
	Irrigation Network	USD/m					
	Irrigation Tank	USD/m3					
	Irrigation Pumping	USD/unit					
CCTV	Fixed Digital Cam	USD/unit					
	Domo Cam	USD/unit					
	Digital Recorders	USD/unit					
	Control Room	USD/unit					
ACCESS CONTROL	Access Control Barrier	USD/unit					
	Plate Recognition	USD/unit					
	Logical of Access Control	USD/unit					
GARBAGE TREATMENT PLANT		USD/unit					

Annex F Sample of Relevance Checklist

RELEVANCE CHECKLIST

UNECE BENCHMARKING STUDY FOR TRANSPORT CONSTRUCTION COSTS

NAME OF COUNTRY: ___________________________________

TYPE OF INFRASTRUCTURE	☑ RELEVANCE TO YOUR COUNTRY	COMMENTS
RAILWAYS		
Rail gauges	☐	
Bridges and Tunnels	☐	
High Speed Trains	☐	
Upgraded Trains	☐	
Passenger Services	☐	
Freight Services	☐	
INTERMODAL TERMINALS		
Land Adaptation	☐	
Intermodal Terminal	☐	
Truck Park	☐	
Container Freight Station (CFS)	☐	
Internal Roads	☐	
PORTS		
Hydrotechnical Infrastructure	☐	
Quay	☐	
Terminals	☐	
Loading/Unloading Infrastructure	☐	
Conveyor (Grain Silo)	☐	
ROADS		
Single Carriageway Asphalt Roads	☐	
Double Carriageway Asphalt Roads	☐	
Single Carriageway Concrete Roads	☐	
Double Carriageway Concrete Roads	☐	
INLAND WATERWAYS		
Canal Excavation & Dredging (Including Transportation and Disposal)	☐	
Construction of Outer Protection Boundary of Sea Filling Areas	☐	
Canal Bank & Bottom Protection	☐	
Imperviousness of Canal	☐	
Auxiliary Structures at Entrances of the Canal	☐	
Emergency and Waiting Mooring Basins	☐	
Streams Connections	☐	
Canal Operation and Maintenance Structures	☐	
Construction of Yatch Harbour(s)	☐	
Construction of Logistic Harbour(s)	☐	
Relocation of Infrastructure Crossing by Canal	☐	