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Appendix 7: Assessment of the Transport Sector

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Abbreviations and Acronyms

AA	Appropriate Assessment
AR5	Assessment Report 5
BAS	Bulgarian Academy of Sciences
BFSA	Bulgarian Food Safety Agency
BGN	Bulgarian Lev (national currency)
BPI	Bulgarian Ports Infrastructure Company
BULATSA	Bulgarian Air Traffic Services Authority
BULRIS	Bulgarian River Information System
CAA	Directorate General Civil Aviation Administration
CBA	Cost-Benefit Analysis
CC	Climate Change
CCA	Climate Change Adaptation
CCC	Committee on Climate Change, UK
CEA	Cost-Effectiveness Analysis
CEF	Connecting Europe Facility
CoM	Council of Ministers
CPR	Common Provisions Regulation (Regulation (EU) No. 1303/2013)
CRBL	Central Roads and Bridges Laboratory
CWR	Continuously welded rails
DG CAA	Directorate General “Civil Aviation Administration”
DG	Directorate General
EEA	European Environment Agency
EIA	Environmental Impact Assessment
EMEPA	Enterprise for Management of Environment Protection Activities
ERTMS	European Rail Traffic Management System
EU ETS	European Union Emissions Trading System
ExAAA	Executive Agency Automobile Administration
ExAEMDR	Executive Agency for Exploration and Maintenance of the Danube River
ExAMA	Executive Agency Maritime Administration
ExARA	Executive Agency Railway Administration
ExEA	Executive Environment Agency
ExFA	Executive Forest Agency
FR7	7th Framework Programme of the European Commission, managed by DG Research and Innovation
GDP	Gross Domestic Product
GHG	Greenhouse Gas

GMDSS	Global Maritime Distress and Safety System
GRA	General Roads Administration (currently RIA)
ICT	Information and Communication Technology
IFI	International Financial Organization
ILS	Instrumental Landing System
IPURD	Integrated Plans for Urban Regeneration and Development
ITS	Intelligent Transport Systems
JRC	Joint Research Centre, European Commission
LOS	Level of Service
MAFF	Ministry of Agriculture, Food and Forestry
MC	Ministry of Culture
MCA	Multi-Criteria Analysis
MEc	Ministry of Economy
MEn	Ministry of Energy
MEx	Ministry of Exterior
MF	Ministry of Finance
MH	Ministry of Health
MI	Ministry of Interior
MoEW	Ministry of Environment and Water
MRDPW	Ministry of Regional Development and Public Works
MTITC	Ministry of Transport, Information Technology and Communications
NECCC	National Expert Council on Climate Change
NGO	Non-Governmental Organization
NIMH	National Institute for Meteorology and Hydrology
NRIC	National Railway Infrastructure Company
NRN	National Road Network
NSA	National Safety Authority
NSI	National Statistical Institute
NTEF	National Trust EcoFund
O&M	Operation and Maintenance
OHL	Overhead lines
OP	Operational Programme
OPRG	Operational Programme Regions in Growth
OPTTI	Operational Programme Transport and Transport Infrastructure 2014-2020
PA	Priority area
PBMS	Performance Based Maintenance System
PMB	Polymer Modified Bitumen

RCP	Representative Concentration Pathway
RIA	Road Infrastructure Agency
RVA	Risk and Vulnerability Assessment
S&T	Signaling and telecommunication
SUMC	Sofia Urban Mobility Centre
TEN-T	Trans-European Transport Network
WEATHER	The WEATHER project[1]
WGII	Working Group II

[1] http://www.weather-project.eu/weather/index.php

Glossary[2]

Climate change refers to a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions.
Adaptation is the process of adjustment to actual or expected adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.
Mitigation (of climate change) is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs).
Vulnerability to climate change is the degree to which any system is susceptible to, and unable to cope with, the negative impacts that climate change imposes upon it. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.
Resilience is the opposite of vulnerability and is defined as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.
Risk is the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.

[2] Definitions are based on WGII AR5 (IPCC 2014)

Executive Summary

1. Bulgaria is situated in one of the regions that are particularly vulnerable to climate change (mainly through temperature increase and extreme precipitation) and to the increased frequency of climate change related extreme events, such as droughts and floods. Meteorological statistics show that since the 1990's the average annual temperatures and rainfall volumes in Bulgaria have increased, together with the number of extreme weather events. In the 2010–2015 period only, the latter's annual number varied between some 1,500 and 4,600.

2. From an economic perspective climate change impacts on the transport sector due to:

- costs for infrastructure asset owners: for damage to infrastructure assets and for the operation and maintenance of the infrastructure;
- costs for the public: damage to vehicles, vehicle operation costs, safety issues, reliability of the services, potential losses of business, contracts and customers due to supply chain disruptions.

3. Although no comprehensive data exist for all transport sub-sectors, an estimate shows that annual average costs for damaged transport infrastructure, due to climate-related catastrophic events, are roughly in the range of ***BGN 115–135 million***. In addition, the risks inflicted may lead to loss of human life or cause considerable other losses, affecting economic growth and prosperity, both nationally and transboundary.

4. In the medium- to long-term perspective, the **most important risks** for the Bulgarian transport system expected as result of the anticipated climate change are the following:

- **Floods:** The frequency and impact of floods are expected to increase under all climate change scenarios. Floods cause heavy damage to road and railway infrastructure by deteriorating the subbase layers of the road or railway structures. Water may undermine the subbase leading to catastrophic failure of the engineering structures;
- **Landslides:** Precipitation is a major factor in the development of landslides and although the total annual volumes of precipitation are projected to decrease, landslides will continue to be a serious problem due to expected higher frequency of extreme precipitations. Landslides cause heavy damage to road and railway infrastructure and river banks. These may be the reason for long-lasting disruption of operation and restricted accessibility to specific population and/or economic areas.
- **Blizzards and snowfall**: In the long-term the annual volumes of snowfall are projected to decrease, but in the short and mid-term perspective blizzards and intense snowfall will continue to be a major source of disruptions to the services of all modes of transport. The Northern and Northeast regions are particularly prone to winter traffic disruptions due to high speed winds and snowfall.
- **Extreme heat:** Extreme heat affects roads' asphalt concrete pavements by softening their binding component – bitumen. This decreases the bearing capacity of the pavement and, combined with the traffic load, leads to its deformation and to formation of ruts. Furthermore, the combination of high heat and sunlight is the reason for surface cracks and reduces road pavement life. Regarding the railway infrastructure, extreme heat may cause rail buckling, which at its turn leads to the need of reduction of the maximum

admissible operational speed or even disruption of operation and reduces the life of the rails. Extreme heats combined with higher expected draughts will further harm the Danube River navigability, which even nowadays faces serious deficiencies.

5. Climate change related events are expected to negatively **impact** all transport sector stakeholders:

- **Infrastructure managers** due to deterioration, damage and even temporary closures of infrastructure sections and/or nodes;
- **Transport operators** due to higher operation costs and possible disruption of operations;
- **Transport users** due to delays, longer transit times and discomfort during the trip;
- **End consumers/society** due to higher costs for the transport infrastructure and operations.

6. The approach to adaptation of the Bulgarian transport sector to climate change has not been very systematic, so far. There are very few examples where on a case by case basis stakeholders identified specific climate change-related issues and have been addressing these by specific measures. Much remains to be done in raising the awareness among the transport sector stakeholders and pursuing a more systematic approach and understanding of the issues and their importance. Results of the interviews with stakeholders carried out during the preparation of this document prove that gaps exist in awareness and understanding of what climate change adaptation is, which is the reason why the transport sector's adaptive capacity is estimated as low.

7. Specific gaps are identified in respect to collection and analysis of data related to financial and economic costs associated with climate related events. This makes it impossible for stakeholders to plan and budget proper adaptation measures and emergency response actions, which in turn additionally increases the vulnerability of the transport sector and transport users.

8. Further issues are identified in respect to the codes for designing road and railway infrastructure. Climate change aspects are not integrated in the process of preparation of transport infrastructure projects, which may result in building new or modernizing existing infrastructure that is vulnerable to extreme climate events.

9. Plans for emergency response actions do not consider the level of criticality of transport network sections. The relatively low level of deployment of ITS does not provide for safe and efficient road traffic management in case of catastrophic events.

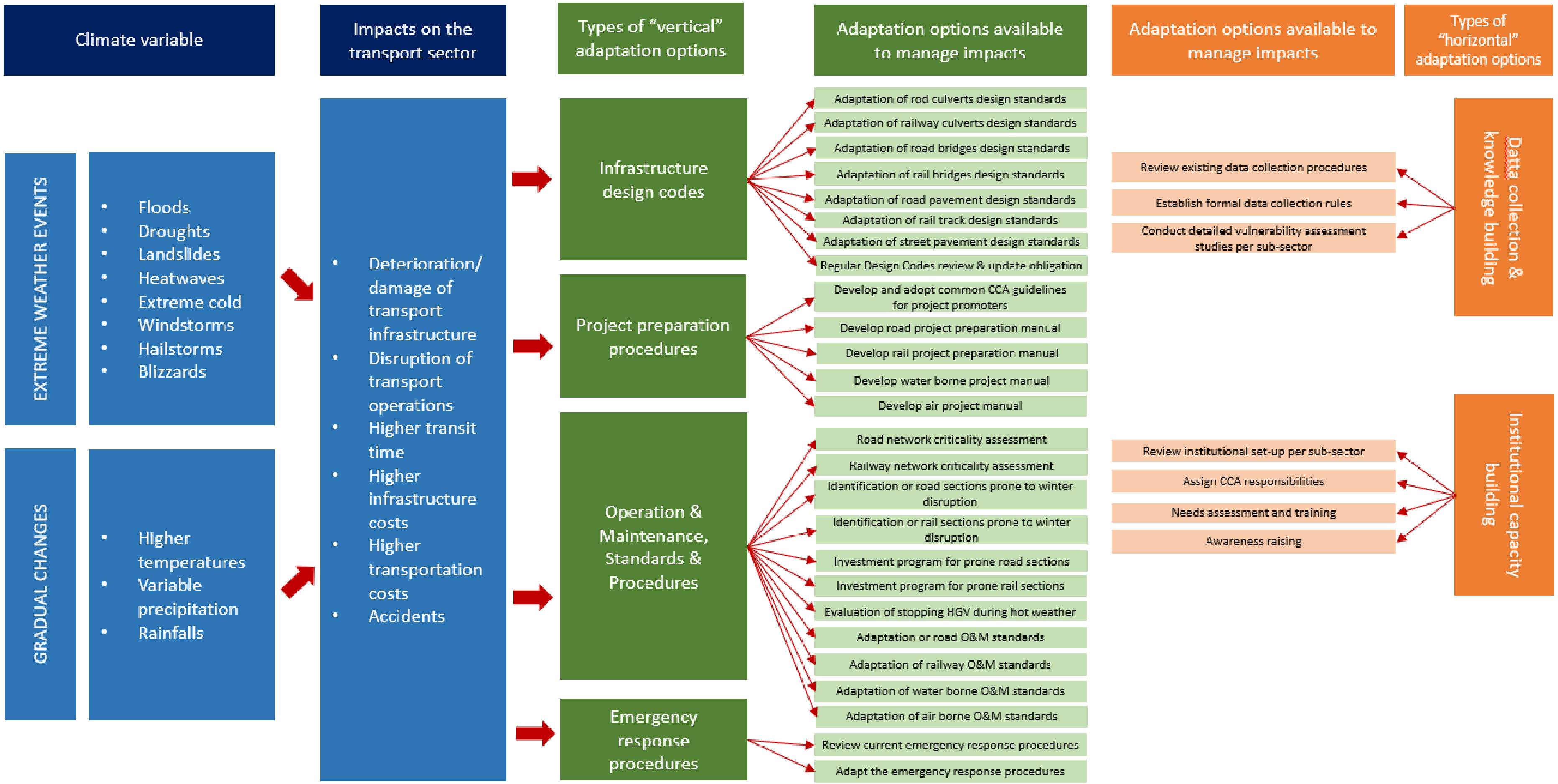
10. Besides the negative effects, the forecasted increase of the average temperatures in the long term is expected to decrease the costs for transport assets management and appropriate measures should be planned so not to miss possible benefits.

11. Based on a logic approach as visualized in ***Figure 1***, several climate change adaptation options were identified and clustered in two main categories, as follows:

1) Options for **building adaptive capacity**, such as:
   1.1 ***Data collection and knowledge building*** by establishing formal data collection rules and responsibilities and by carrying out comprehensive studies about the climate change adaptation needs per transport sub-sectors;
   1.2 ***Institutional capacity*** building by assigning climate change adaptation responsibilities in each of the relevant stakeholders' administrative set-ups, training needs assessment, training and awareness raising actions.
2) Options for **delivering adaptation actions**, such as:
   2.1 Review and adaptation of ***infrastructure design codes*** per transport modes
   2.2 Development and adoption of ***climate change adaptation guidelines for transport projects*** in general and for projects per transport mode;
   2.3 Review, adaptation and adoption of new ***operation and maintenance standards and procedures*** per transport mode;
   2.4 Review and adaptation of current ***emergency response procedures***.

12. Some of the proposed options are 'self-sufficient' and do not depend on other options; and some depend on the results of the implementation of one or more of the other options. Thus, implementation of the proposed options is a process that involves time and costs. Prioritization of the options is under way and only tentative results are available for the time being. Nevertheless, it is recommended that options aiming at building adaptive capacity should be given the highest priority because: (1) these will provide a suitable basis for development and implementation of adaptation options and (2) these could be brought in practice relatively fast, whereas their costs are minimal or nil.

Figure 1. Simplified illustration of impacts of climate change and examples of identified adaptation options



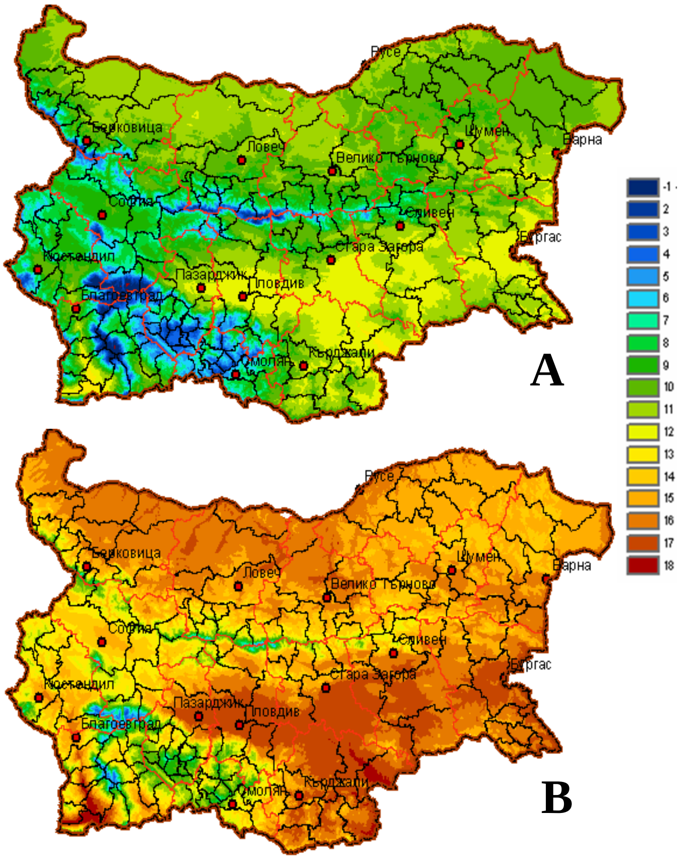
Source: World Bank design.

Introduction – Climate Change in Bulgaria

13. **Bulgaria is situated in one of the regions that are particularly vulnerable to climate change** (mainly through temperature increase and extreme precipitation) and to the increased frequency of climate change related extreme events, such as droughts and floods. The risks inflicted by climate change related events may lead to loss of human life or cause considerable damage, affecting economic growth and prosperity, both nationally and trans-boundary.

14. Consensus exists in the scientific community that **climate change is likely to increase the frequency and magnitude of extreme weather events**. Over the past decades, in Bulgaria this frequency has increased significantly. The most common hydro-meteorological and natural hazards are **extreme precipitation and temperatures, storms, floods, wildfires, landslides, and droughts.** The number of deaths and victims due to natural hazards is considerable, indicating weather and climate vulnerability. The vulnerability of Bulgaria's population and businesses to the impacts of climate change is accelerated by a relatively high degree of poverty in the most impacted areas, the continuing concentration of the country's population in several industrial and urban regions, and various consequences of the transition from a state-controlled economy to a free-market economy. A growing body of evidence suggests that **economic losses from climate- and weather-related disasters** have also been rising.

Figure 2. Average year temperature for 1961–1990 (A); Pessimistic climate scenario for average year temperature for 2080 (B)



Source: NIMH-BAS.

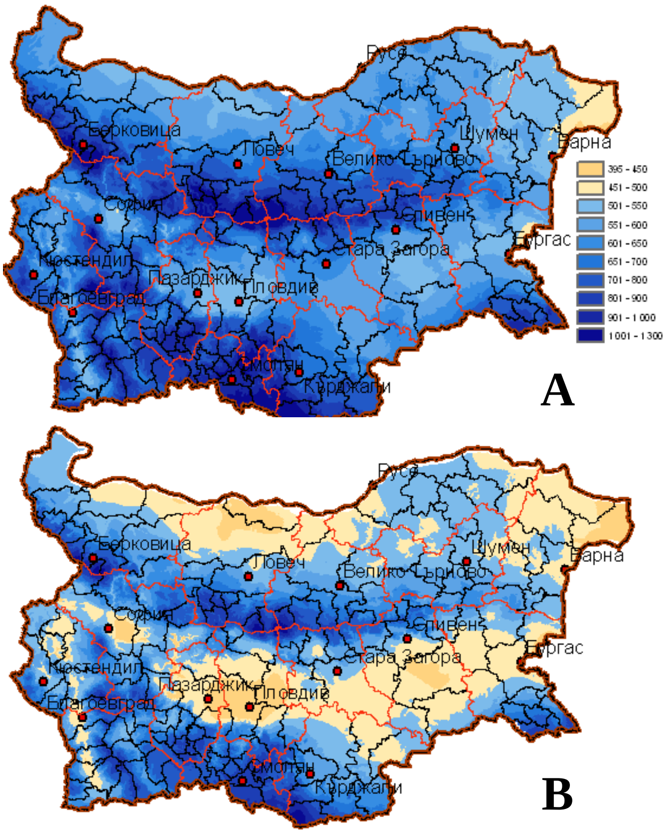
15. Scientific projections indicate that global temperature will rise between 1.8°C and 4°C by 2100, with a temperature increase in Europe expected to be even higher than the estimated global average.

16. Research conducted by the Department of Meteorology, National Institute of Meteorology and Hydrology (NIMH) to the Bulgarian Academy of Sciences (BAS), projects an **increase in annual air temperature in Bulgaria of between 0.7°C and 1.8°C by 2020**. Even warmer temperatures are expected by 2050 and 2080, with projected increases of between 1.6°C and 3.1°C and between 2.9°C and 4.1°C, respectively. Generally, the temperature increase is expected to be more significant during the summer season (from July to September).

17. In terms of the **expected changes in rainfall patterns**, a reduction in precipitation is likely, leading to a significant reduction of the total water reserves in the country. In this regard, projections suggest a decrease in precipitation by approximately 10 percent by 2020, 15 percent by 2050, and up to 30–40 percent by 2080. In most climate change scenarios, rainfall during the winter months is likely to increase by the end of the century, but significant decrease in rainfall during the summer months is expected to offset this increase.

18. According to the available climate change scenarios for Bulgaria, there is a **trend toward increased frequency of extreme events and disasters**, as demonstrated in more often occurrences of heavy rainfalls, heat and cold waves, floods and droughts, hurricane winds, forest fires, and landslides.

Figure 3. Precipitation per year for 1961–1990 (A); Precipitation per year for 2080, according to the pessimistic scenario (B)



Source: NIMH-BAS.

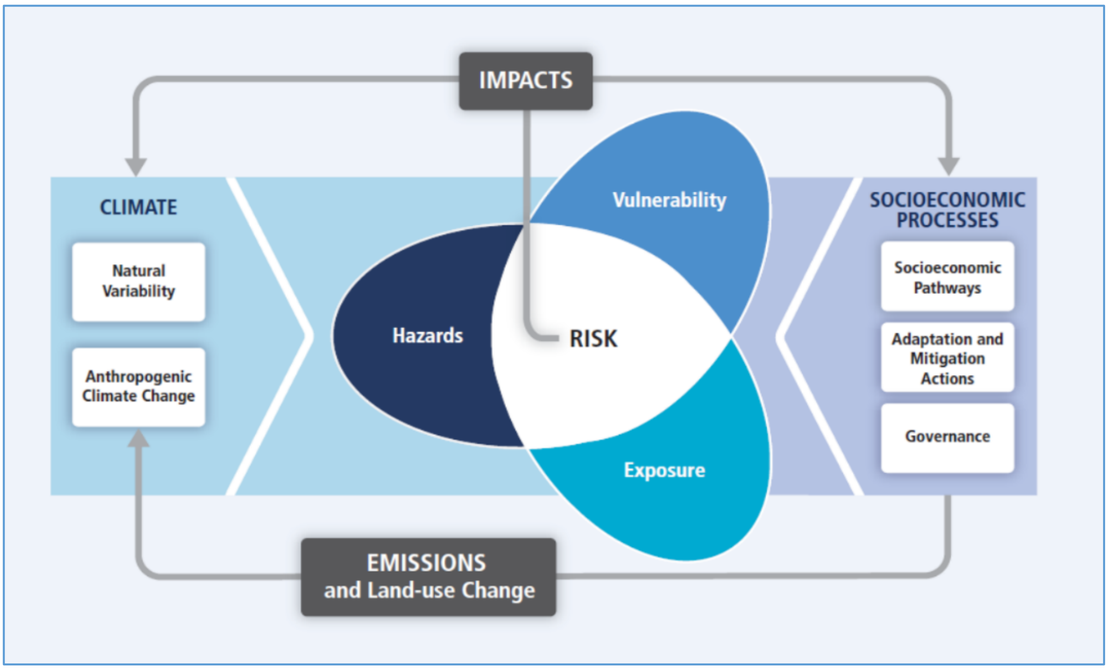
19. Infrastructure, transport, land and aquatic ecosystems, as well as water resources, agriculture, and forestry sectors are expected to be affected by anticipated changes. These changes would furthermore impact society and its citizens as well as the economy at large.

20. Climate change impacts do not affect all people and territories equally due to different levels of exposure, existing vulnerabilities, and adaptive capacities to cope. The **risk is greater for the segments of the society and businesses that are less prepared and more vulnerable**.

21. This report aims to inform on vulnerabilities to the Bulgarian transport sector and at identification of adequate climate change adaptation options. The report is part of a set of nine sectoral assessment reports considered under the climate adaptation support program for Bulgaria, which will form the baseline for the National Climate Change Adaptation Strategy and Action Plan. The report follows the general logic and structure as proposed for all sectors and is divided into three parts: (1) part one of the report (Chapter 1) focuses on the climate change risks and vulnerabilities' assessment; (2) part two comprises a gap analysis of the policy, legal and institutional context (Chapter 2); and (3) part three focuses on the identification and prioritization of adaptation options (Chapter 3). This sector assessment was carried out during March – November 2017, as a combination of quantitative and above all, qualitative analysis. Several workshops have been organized as part of an ongoing consultation process, bringing in the wealth of expertise of various stakeholders.

22. **The report uses the terms and definitions of risk, vulnerability and adaptation options as introduced by WGII AR5 (IPCC 2014).** Risk of climate-related impacts results from the interaction of climate-related hazards with the vulnerability and exposure. Changes in both the climate system (left side in ***Figure 4***) and socio-economic processes including adaptation and mitigation (right side if ***Figure 4***) are drivers of hazards, exposure, and vulnerability. This understanding reveals the importance of the adaptation options. When they are properly identified and timely implemented, vulnerability, hazard and/or exposure will be reduced, thus the risk will be mitigated.

Figure 4. General concept of WGII AR5



Source: IPCC 2014.

Chapter 1. Risk and Vulnerability Assessment and Analysis

23. The transport sector may be viewed in two main aspects – *infrastructure* and *services*. This understanding is reflected in most strategic documents related to the sector.[3] Such differentiation is also explicitly made in the national *Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change* (MoEW 2014). Clearly differentiating the issues related to infrastructure and services is the approach employed in this study as well.

24. Whilst data related to the impact of extreme weather on infrastructure generally exists, the impact on transport services in Bulgaria receives much less systematic attention. Disruptions to transport services are widely commented in the media, but sound statistical data is not always collected. The availability of data is explicitly commented upon hereunder when discussing extreme weather events and their impacts.

25. Apart from distinguishing the effects on infrastructure and services, further differentiation is made by subsector. The main subsectors to be discussed are: *road*, *railway*, followed by *water* and *air transport*. The issues related to each subsector (mode of transport) are separately discussed.

26. The analysis follows the causal chain between climate change factors, their effects and the consequent impact on the transport infrastructure and services.[4]

27. There is a large number or climatic factors that may potentially impact the transport infrastructure and services in the future. A summary of these factors and their possible impact is presented in ***Annex 1***.

1.1. Transport Sector Characteristics and Trends

1.1.1. Overview

28. Regarding the relative share of the different transport modes, land transport has the highest share in terms of *goods transported*. The share of land transport is 98.51 percent and the share of water transport is only 1.49 percent. Air transport accounts for less than 0.01 percent of the total freight transported. (For details see ***Table 1*** and ***Figure 5***).

Table 1. Shares of the transport mode groups by goods and passengers transported (2015)

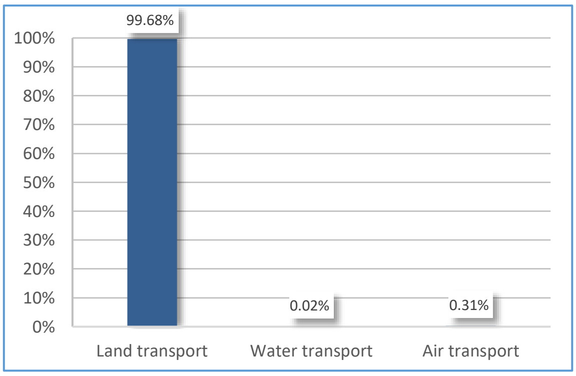
Mode group	Goods transported		Passengers transported	
	('000 tons)	(percentage)	('000)	(percentage)
Land transport	123,626	98.51	712,851	99.67
Water transport	1,867	1.49	115	0.02
Air transport	5	0	2,240	0.31
Total	**125,498**	**100**	**715,206**	**100**

Source: National Statistical Institute (Statistical Yearbook 2016; p. 337)

[3] See for example CCC (2016) and the German Strategy for Adaptation to Climate Change (2008).
[4] For an example of this approach also see EEA (2017).

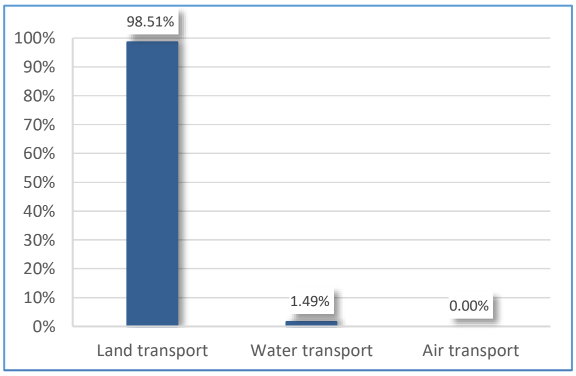
29. Land transport accounts also for the highest number of *passengers transported* and has a relative share of 99.67 percent (that includes road, rail and electric urban public transport). The share of water transport is 0.02 percent and airborne transport services 0.31 percent of the passengers. (For details see ***Table 1*** and ***Figure 6***).

Figure 5. Shares of the different transport mode groups by passengers carried (2015)



Source: NSI (Statistical Yearbook 2016; p. 219).

Figure 6. Shares of the transport mode groups by goods carried (2015)



Source: NSI (Statistical Yearbook 2016; p. 219).

30. Regarding the relative shares of land passenger transport modes, road transport is by far the most important with cars and buses having a total share of 96.37 percent in 2015, followed by railway transport, which has a share of only 3.63 percent (in terms of number of passenger trips by land mode in 2014; see ***Table 2***).

Table 2. Transport performance of the different land passenger transport modes (2008-2014)

	2008	2009	2010	2011	2012	2013	2014
Cars [percentage]	79.51	82.31	82.54	83.07	82.43	83.06	82.30
Buses [percentage]	16.54	13.83	13.54	13.21	13.93	13.46	14.07
Railways [percentage]	3.95	3.86	3.92	3.72	3.64	3.48	3.63

Source: MTITC Project "Development of an Integrated Transport Strategy for the Period until 2030" funded by OPTTI 2014 – 2020; MTITC 2017a (Report 2, Chapter 5, p. 8).

31. In terms of goods transported, road transport also has the highest relative share, followed by railway and sea transport. The share of air transport in freight shipping is very small.

32. Urban movement wise, walking is the main mode with a relative share of 40 to 60 percent of the total daily trips. There are two main factors for this: (1) relatively high generalized costs for traveling by public transport and car; and (2) relatively small urban area allowing walking access (Antov 2017; p. 69). In recent years, the share of cycling seems to be rising but remains low in the range of 0.5 to 2.5 percent of the total daily trips.

33. Another typical feature of the modal split in Bulgarian settlements is that the share of trips by car is much higher than the share of public transport. Among other reasons, this may indicate that the public transport systems do not function adequately.

34. A special case is the biggest city in the country, the capital city of Sofia, where public transport was the dominant mode of transport until the beginning of the 21st century.

Table 3. International freight transport per mode (2014)

Mode of Transport	Freight (x1,000 ton)
Road	22,890
Railway	1,590
Sea	21,340
Inland waterway	1,190
Total	**47,010**

Source: MTITC 2017a (Report 2, chapter 5, p. 127)

35. The public transport supply in Sofia is currently consisting of 14 tram lines with a total network length of 136.898 km, 9 trolleybus lines with a network measuring some 97,560 km in total, 45 urban and 49 sub-urban bus lines and 2 metro lines.[5] In 2014 the total number of passengers transported by the urban and suburban public transport in Sofia was 412.4 million, which is by some 10% lower compared to 2011 performance of 457.4 million passengers (Vitanov 2017; p.7- 9).

36. The public transport share has been decreasing at the expense of an increasing share of trips by car (Antov 2017; p. 7). In 1999, the share of public transport used to be as high as 65 percent and in 2009 it had fallen to 49 percent (as number of morning peak trips). At the same time, the share of trips by car has almost doubled from 17.4 percent in 1999 to 30.5 percent in 2009. The share of walking trips has remained constant at about 10–11 percent between 1999 and 2009 but had almost doubled to 19.63 percent in 2015. The relative shares of trips by public transport and by car have not changed significantly since 2009 and in 2015 these were 48.19 percent and 32.18 percent respectively.

37. A notable change in Sofia was brought by the introduction of the metro. The first section of 6.5 km was made operational in 1998 and new sections have been gradually introduced afterwards. As of 2016, the length of the metro network is 40 km with 35 stations. The number of trips by metro has been steadily increasing and in 2016 the metro system serviced about 350,000 passengers daily. The number of passengers transported is expected to increase to about 550,000 per day with the completion of the so-called 'third metro diameter', substantial part of which is being implemented[6] under the Operational Programme Transport and Transport Infrastructure 2014–2020. Main benefits of metro transport are reduction of exhaust gasses estimated at some 90,500 t per year and travel time savings of about 90 thousand hours per day.

38. There are several factors influencing the growth dynamics of the transport sector. Regarding *passenger transport*, the most important factor is the *dynamics of the population* of the country. The projected decrease of the population could in principle be expected to lead to a decrease of the number of trips made by all modes. There are, however, social and economic factors which act in the opposite direction.

39. Although the population is projected to decrease, the *number of persons employed* is expected to remain stable. This is the most active group having the highest mobility rate. *Car ownership* has been growing steadily in recent years and this trend is expected to persist. Combined, these factors lead to a projected moderate growth in the number of trips and distance travelled with car. In opposite, the number of trips and distance travelled by public transport

[5] Sofia Urban Mobility Centre (2018)
[6] As of 2017.

(buses and railway transport) is expected to decrease.

40. In summary, the forecasts for *intercity transport* are for moderate increase in the number of passenger trips to 2020, followed by a gradual decrease and reaching the 2014 levels in 2027 (MTITC 2017a; Report 5, p. 170). No such aggregate forecasts for the *urban passenger transport* exist, but the factors effecting the number of trips and distance travelled are the same, which means that a similar development may be expected.

41. Regarding *freight transport*, a steady increase in road transport performance in ton-km (projection to 2034) is expected, while the same for railway transport is expected to remain constant (MTITC 2017a; Report 5, p. 193).

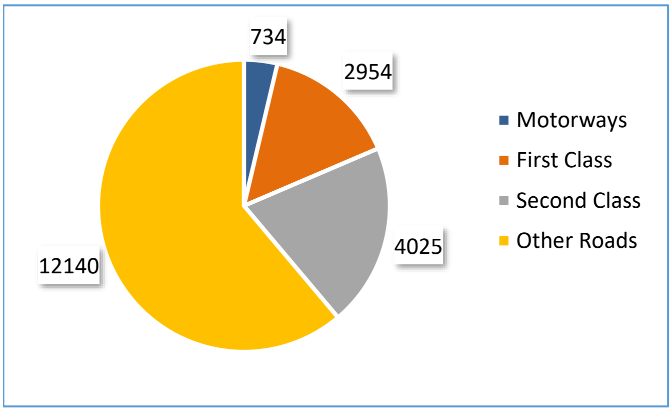
The parameters of the different modes are presented in more detail in the following sections.

1.1.2. Road transport

42. As of 2015 (National Statistical Institute [NSI] 2016b), the Bulgarian National Road Network (NRN), has a total length of 19,853 km. This includes 734 km of motorways (3.7 percent), 2,954 km of first class roads (14.9 percent), 4,025 km of second class roads (20.3 percent) and 12,140 km of other roads (61.2 percent). For 2014, the transport performance on the NRN is estimated at 46.812 billion passenger-km (MTITC 2017a; Report 2, chapter 5).

43. The length of the municipal road network, incl. private roads, as of the end of 2015 is 21,485 km, split into three categories: 8,116 km first category (37.8 percent), 6,216 km second category (28.9 percent), and 7,156 km (33.3 percent). No information is available for the transport performance on the municipal road network.

Figure 7. National road network length (in km) by road class (2015)



44. Total length of the street network in settlements is 61,024 km, out of which 3,961 are urban sections of the National road network. The length of the street network in the cities is 17,998 km (29.5 percent) and the remaining 43,026 km (70.5 percent) are in the villages. No reliable data for passenger trips by car in settlements are available, which makes it much more difficult to estimate the respective transport performance. It is, however, considered that the total volume of urban road transport services is substantially higher than the volume on the NRN.

45. Regarding road *infrastructure*, the main problem appears to be the maintenance. It is widely considered that maintenance of the NRN has been severely underfunded for decades.[7] This is a risk factor for the sector, as poor maintenance is likely to amplify the damage due to extreme weather.

[7] An electronic tolling system with wide coverage for HGVs and e-vignette is planned for implementation. Once operational, the system is expected to lead to a substantially increase in the funding of road operation and maintenance.

46. Similar problems may be observed in the maintenance of the municipal road network and the street networks of towns and cities. Especially challenging with respect to the planning of operation and maintenance are street networks.

47. Regarding the road transport *services*, a major problem is the high average age of the vehicle fleet, and this applies to both private cars and public transport vehicles. Only about 20 percent of the vehicles registered are less than 10 years old. This makes the fleet inherently more vulnerable to some types of extreme weather events, for example extreme cold.

1.1.3. Railway transport

48. As of 2015 the total length of the Bulgarian railway network is 5,486 km, of which 71.1 percent is electrified (see ***Table 4***). In recent years, the total length of the network has been slightly decreasing due to the optimization of its scope. Railways have a much lower share in both the number of passengers and volumes of freight[8] transported than road transport.

Table 4. Length of railway lines (2012–2015)

	2012	2013	2014	2015
Railway lines length (km)	5,658	5,540	5,493	5,486
Share of electrified lines (percentage)	70.3	71.2	71.1	71.1
Tram lines (km)	150	146	146	146
Metro lines (km)	29	29	29	37

Source: NSI (Statistical Yearbook 2016; p. 217).

49. *Tram transport* is available only in the capital city of Sofia. Tram network combines two operational gauges: on standard European gauge (1,435 mm), while the older part of the network still uses narrow gauge (1,009 mm). Tram transport had a dominant importance during the 20th century, but its current share is gradually decreasing: in 2011 the annual number of passengers transported was 107.6 million, while in 2014 it decreased to 90.6 million (Vitanov 2017; p. 7). This is mainly due to the shift of passengers to the metro transport and to private cars. It should be mentioned however, that Sofia City adopted and is implementing a program for renewal of trams, according to which in total 38 new trams and 60 second-hand trams have been and are to be put in operation in the 2013–2020 period. *Metro transport* is also available in the capital city of Sofia only. As already stated above, its importance is steadily increasing due to the higher speed and reliability compared to other transport urban modes: in four years only, the number of passengers transported by metro increased by over 50 percent from 58.2 million in 2011 to 87.9 million in 2014 (Vitanov 2017; p. 7).

50. As with roads, sound maintenance is the major problem for the railway infrastructure and the reasons appear to be similar – mainly underfunding. Inadequate maintenance of the railway infrastructure puts at major risk to its users – especially if combined with the effects of some

[8] Some consider that railway transport is not competitive to road transport for servicing freight largely because the use of the National Road Network is priced inadequately low, which gives it an advantage against the use of railway transport. (See for example the following statement made by the Minister of Transport I. Moskovski – Pariteni.bg, 2015. *Moskovski: the road taxes are not being efficiently used*. http://www.pariteni.bg/index.phtml?tid=40&oid=188562&nopassportcheck.) Once the use of roads is more reasonably priced, certain shift of freight to railway transport could be expected.

extreme weather events. Another problem is the obsolete signaling, telecommunication and power supply systems.

51. A recent study (MTITC 2017a; Report 2, chapter 4, pp. 110-115) about the quality of the railway transport shows that 62.94 percent of the railway users consider the quality of the rail services as poor. Among the stated reasons for this are the low speed, comfort and reliability of railway services in Bulgaria. The same factors contribute to the low share of railway transport in transporting goods.

52. In the country, there is only one licensed railway passenger operator. More than 10 freight operators are licensed for freight transportation on the Bulgarian railway market. The one with the highest, but steadily decreasing, share is the state-owned incumbent operator. An important part of the other operators belongs to owners of industries and thus, exclusively transport goods from and to these industries.

1.1.4. Water transport

53. Inland waterway transportation is possible along the Danube River, which is the country's only navigable waterway. The length of the Bulgarian section of the Danube River is 470 km. Danube is an important international waterway and it is part of the core TEN-T network. The most important Bulgarian riverports are Lom/Vidin and Ruse. There are two major seaports – Varna and Burgas.

54. With regard to *passenger services*, ferries are available across the Danube and the Black Sea. Predominant part, 95 percent of the total passengers, passes through the riverports and only 5 percent through the seaports (MTITC 2017a; Report 2, chapter 6, p. 13), but overall, the total number of passengers transported by water transport is negligible (about half of million passengers a year). As shown on ***Table 3***, most of the goods transported by water transport are handled in the seaports: 78 percent (27,912,548 tons) versus only 22 percent (6,144,000 tons) - in the riverports (MTITC 2017a; Report 2, chapter 6, p. 1).

55. Main problem for inland waterway transport is the navigability status of the river and notably the low depths of water (MTITC 2017a; Report 2, chapter 6, p. 220). According to the recommendations of the Danube Commission, the minimum depths of at least 2.5 m in the navigable channel at Low Shipping Regulation Level and at a higher level should be secured during 94 percent of the days per year. In recent years, the minimum draught level was secured along the Bulgarian section of the River in 70 percent of the days on average. It appears that due to underfunding, Danube River dredging is not done with sufficient frequency and scope, which affects the navigation conditions. Another problem, common to riverports and seaports, is the aging port equipment and facilities.

1.1.5. Air transport

56. There are five international airports in Bulgaria, namely Sofia, Plovdiv, Burgas, Varna and Gorna Oryahovitsa. As presented in ***Table 5***, the biggest of these are in Sofia, Burgas and Varna, which in 2014–2017 registered a very high growth in number of passengers of over 48 percent.

Table 5. Volumes of passengers and freight serviced by Bulgarian airports (2017)

Airport	Passengers (-)		Freight (t)	
	2014	2017	2014	2017
Sofia	3,814,868	6,486,883	15,910	33,914
Plovdiv	103,292	90,136	554	628
Burgas	2,504,074	2,952,442	5,354	14,230
Varna	1,373,144	1,949,394	74	230
Gorna Oryahovitsa	286	25	98	0
Total	**7,795,664**	**11,478,884**	**21,989**	**33,914**

Source: MTITC 2017a (Report 5, p. 114; 2018 DG Civil Aviation Administration)

57. No major air accidents have been registered in recent years in the country and the services are generally reliable. Problems occasionally occur during the winter in the event of heavy snowfall and show storms, as well as at the event of dense fog (for Sofia airport due to the local climate).

1.2. Past and Present Weather Events and Their Consequences and Response Actions in the Transport Sector in Bulgaria

1.2.1. Event types and impact

58. A multitude of extreme weather events may cause impact on the transport sector. In most cases the impact is clearly negative (to the transport infrastructure and/or services) and for a very limited number of events could be marginally positive.

59. The weather-related events in Bulgaria with relevance to the transport sector have been reviewed by Karagyozov (2012) as part of the FR7[9] WEATHER project. The study analyses the statistical information available for frequency and impact of various weather events such as floods, landslides, fires, earthquakes. The focus of the study is floods, as they appear to be the most important type of weather-related catastrophic events for Bulgaria.

60. The finding that floods have the highest impact in Bulgaria is consistent with other studies. For example, McGuinn *et al*. (2012, p. 61) gives an assessment of the relative scale of impacts on the transport sector from climate change-related events for Central and Eastern Europe to 2020 (***Table 6***).

Table 6. Assessment of the relative scale of impacts on the transport sector in Central and Eastern Europe to 2020

Event	Impact
Coastal Flooding	Low
River Flooding	High
Water Scarcity	Medium
Soil Erosion	Medium
Storms	Low
Ice/Snow	Medium
Temperature Extremes (including fires)	Medium
Temperature change over time	Low

[9] EU 7th Framework Programme.

61. The scale of impact (in terms of damage to the infrastructure and property[10]) of various catastrophic events is shown on ***Table 7***. Most of these events are in fact consequences of extreme weather, except for landslides, which may be due to a variety of other reasons.

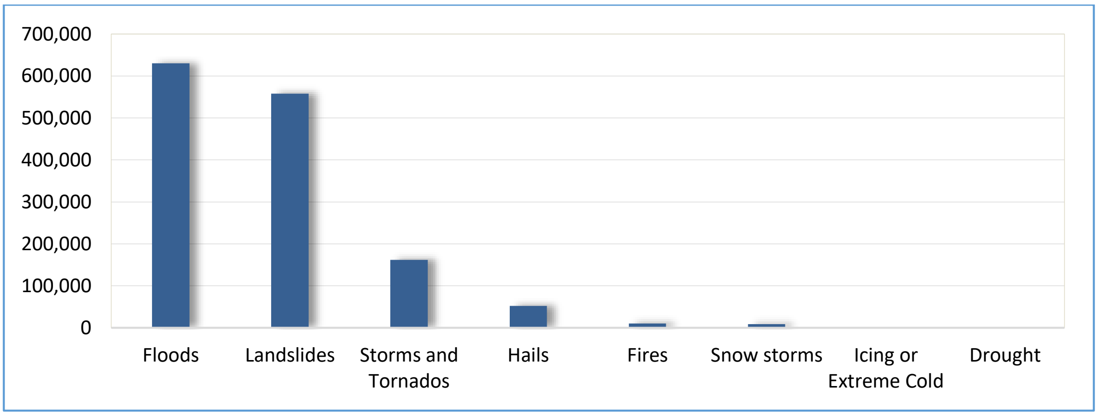
Table 7. Damage in Bulgaria due of catastrophic events by type (2010-2015)

Event	Damage (BGN '000)						
	2010	2011	2012	2013	2014	2015	Total
Floods	38,882	206,659	20,898	15,285	177,604	171,032	**630,360**
Landslides	2,182	224,790	17,384	294,459	9,291	10,011	**558,117**
Storms and Tornados	54,722	1,614	3,488	99,387	746	1,640	**161,597**
Hails	505	50,150	187	-	853	583	**52,278**
Fires	2,239	2,186	1,437	2,013	729	1,795	**10,399**
Snow storms	441	1,205	945	200	410	5,436	**8,637**
Icing or Extreme Cold	-	128	135	-	-	200	**463**
Drought	1	117	149	-	1	-	**268**

Source: National Statistical Institute 2016.

62. Floods and landslides have by far the most significant impact – the damage due to floods or landslides are 3.5 to 4.0 times higher than the third most damaging class of events, that is, storms and tornados.

Figure 8. Damage in Bulgaria due to some types of catastrophic events (2010–2015)



1.2.2. Event frequencies

63. A general review of the climate dynamics is made by Alexandrov *et al.* (2010) who summarize the main changes to climate in recent years in Bulgaria. Some of the factors, which potentially affect the transport sector are as follows:

- since the 1990's the average annual temperatures have increased;
- since the middle of the 1990's the annual volumes of rainfall have increased in most regions of the country;

[10] The source of the data is the National Statistical Institute, which compiles it from reports from regional municipal committees for protection of the population. These reports record only damage to infrastructure and property but not economic costs like for example lost time. The damage to *transport infrastructure* have the highest share.

- the frequency of extreme weather events has increased;
- the notable increase of the average number of days with rainfall of more than 100 mm;
- the number of registered cases of extreme rainfall has increased;
- the frequency of storms and hails between April and September has increased.

64. The annual number of occurrences of some classes of weather-related catastrophic events is shown on ***Table 8***. The most frequent class of event are fires followed by floods, storms and tornados, landslides and snow storms.

Table 8. Annual occurrences of catastrophic events in Bulgaria by type (2010–2015)

Event	Number of events (-)						
	2010	2011	2012	2013	2014	2015	Total
Fires	1,630	2,185	3,010	764	2,245	2,474	**12,308**
Floods	651	382	692	547	360	266	**2,898**
Storms and Tornados	47	48	528	89	14	12	**738**
Landslides	59	76	72	51	75	125	**458**
Snow storms	103	94	93	50	26	56	**422**
Icing or Extreme Cold	18	134	186	20	3	7	**368**
Hails	16	13	14	13	8	21	**85**
Drought	6	30	23	3	1	-	**63**

Source: National Statistical Institute 2016.

1.2.3. Causes of catastrophic events

65. The causes of *floods* can be classified in the following groups (Karagyozov 2012):

- Floods caused by heavy rain or intense melting of snow (also flooding caused by drifting ice)
- Coastal floods caused by strong winds
- Floods caused by earthquakes near lakes
- Floods caused by failure of hydro plant and equipment or protection structures

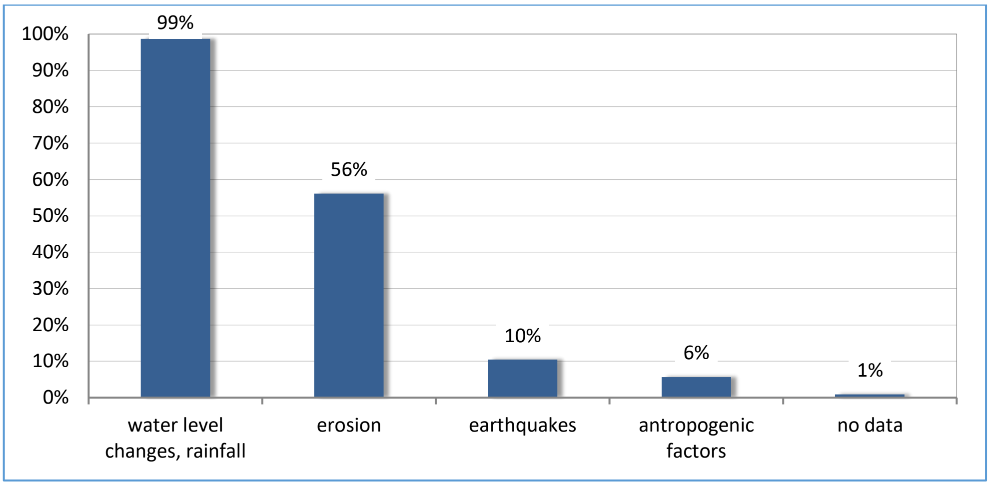
66. Out of these groups, typical for Bulgaria are floods caused by heavy rain or intense melting of snow, as well as (in recent years) floods caused by failure of water protection structures. This means that the areas prone to flooding are typically near the big rivers.

67. The causes of *landslides* are often much more difficult to establish than the causes of floods. Some may be attributed to extreme weather (for example heavy rainfall) but most often there are various causes working together that trigger landslides. The main causes of landslides are (Bruchev et al. 2007):

- weathered, sheared, jointed or fissured material;
- adversely orientated discontinuities in the material;
- material contrasts;
- rainfall and snowfall;
- earthquakes.

68. It would appear, however, that in many cases the activation of landslides can be directly linked to changes of the water level (near bigger water basins) or rainfall. A recent study (Dobrev et al. 2014, Bruchev et al. 2007) of the landslides in the Bulgarian section of the Danube River shows that the most frequent cause for landslide activation is water and erosion (caused by the river) is the second most frequent cause.

Figure 9. Causes of landslides along the Bulgarian section of Danube River



Source: Dobrev et al. 2014.

69. Another class of extreme weather events that influence the transport sector are *snow storms*. Whilst floods and landslides affect both transport infrastructure and services, snow storms affect mostly services.

1.3. Risks and Vulnerabilities

1.3.1. Factors and impacts

70. A comprehensive classification of weather factors and respective impacts by mode of transport is presented by the European Environment Agency (EEA 2017; p. 257). As this classification represents a general review, it shall be adapted to the Bulgarian conditions and the relative importance of the different factors and impact types. The discussion and classification provided under the PESETA II project (Nemry and Demirel 2012; p. 15) is also taken into consideration. Preliminary guidance as to that importance can be sought in risk and vulnerability assessments (RVAs) of other Member States, for example U.K., Germany, and so on

71. An initial review on the relevant factors and impacts is presented on ***Table 9***. It is largely based on EEA (2017) with some impacts considered as clearly not relevant for Bulgaria, removed.

Table 9. Summary of transport vulnerabilities to extreme weather factors

Factor	Impacts			
	Road	**Railway**	**Water-borne**	**Aviation**
Extreme heat	• Gradual pavement damage	• Rail buckling • Overheating of S&T equipment • *Operations' disruption*	• Low river flows • *Vessels' wedging* • *Operations' disruption*	
Extreme cold	• Gradual pavement deterioration • *Failure of vehicles and traffic management equipment*	• *Icing of trains* • OHL icing and breaking • *Operations' disruption*	• Icing, damaged navigation signs and infrastructure • *Operations' disruptions*	• Gradual pavement deterioration • *Failure of aircrafts and traffic management equipment* • *Icing of aircrafts*
Heavy precipitation	• Infrastructure damage due to floods and/or landslides • *Reduced visibility and traction* • *Reduced road safety*	• Infrastructure damage due to floods and/or landslides • *Operations' disruption*	• *Operations' disruptions*	• *Reduction in airport throughput*
Snowfall	• *Reduced visibility and traction* • *Obstacles on the road* • *Safety risk*	• Damage to signals and OHL • *Operations' disruption*		• *Reduction in airport throughput* • *Icing of aircraft* • *Reduced visibility and traction*
Storms and hails	• *Reduced visibility and traction* • *Obstacles on the road* • *Failure of traffic management systems* • *Damage to vehicles* • *Safety risk*	• Damage to signals and OHL • Obstacles on the line • *Operations' disruption*	• *Operations' disruption*	• Increased turbulence • *Safety risks for ground operations* • Damage to aircraft and equipment • *Operations' disruption*
Blizzards	• *Reduced visibility and traction* • *Obstacles on the road* • *Failure of traffic management systems* • *Safety risk*	• Damage to signals and OHL • Obstacles of the line • *Operations' disruption*	• *Operations' disruptions*	• Increased turbulence • *Safety risks for ground operations* • Damage to aircraft and equipment • *Disruptions to operations*
Fogs	• *Reduced visibility* • *Safety risk*		• *Operations' disruptions* • *Safety risk*	• *Reduction in airport throughput* • *Safety risk*

*Note: impacts on **infrastructure** shown in regular font; impacts on **services** shown in italics.*

A very detailed analysis of the existing and future vulnerabilities of the road and rail transport has been made in support of the Macedonian government for the development of green transport (World Bank 2012). Macedonia and Bulgaria have similar climate conditions and the comprehensive review of the anticipated climate change vulnerabilities can be directly applied to Bulgaria as well. A summary of the anticipated impact of future climate conditions on road and rail infrastructure and services from this study is included as ***Annex 4***.

1.3.2. Projected climate change

72. Section 1.2 summarizes the observed trends of occurrence and impact of some weather-related catastrophic events. To properly prioritize risks, it is important to also discuss the future climate dynamics. A thorough review for Bulgaria of the expected trends of 24 parameters under RCP8.5, RCP6.0, RCP4.5 and RCP2.6 for different future periods (2016–2035, 2046–2065, 2081–2100) is made as part of the national *Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change*. The main observations related to the transport sector are summarized below.

73. By the end of the century, the *average temperatures* are expected to increase under all scenarios. The expected increase for RCP8.5 is highest at about 6°C and lowest for RCP2.6 at 2°C. The *minimum and maximum temperatures* during all seasons are also expected to increase.

74. As shown on ***Table 9***, in principle extreme heat could be expected to lead to damage to transport infrastructure. Evidence of such damage, however, is sparse and they do not appear to be of high significance. This is clearly demonstrated by the WEATHER project (Enei et al. 2011; p. 93) – the study finds that the economic costs due to extreme temperature weather events are nil for all modes, except for the road transport, for which they have a minor share.

75. Increased average temperatures could also be expected to have a positive effect on the costs of winter infrastructure maintenance, which are significant in Bulgaria.

76. The projected change in the *annual average precipitation* vary by scenario and period. For example, for 2016–2035, scenario RCP2.6 projects an increase of about 10 percent of the precipitation in Northwest Bulgaria, and a decrease by the same percentage in the rest of the country. Under RCP8.5 for the same period, an increase in the average annual precipitation is expected for almost the whole country by about 10 percent.

77. Regarding determining the risk of floods of significance are the various precipitation-related indices of extreme weather such as:

- very wet days (R95p), extremely wet days (R99p) – the number of days with precipitation above or equal the 95th (R95p) and 99th (R99p) percentile;
- heavy precipitation days (R10) and very heavy precipitation days (R20) – the number of days with precipitation > 10 mm (R10) and > 20 mm (R20);
- the number of consecutive wet days (CWD).

78. The values of most indices are expected to increase, be it with different rates under the different RCPs (MoEW 2014; p. 96). This suggests that floods will remain among the most significant weather-related factors affecting the transport sector.

1.3.3. Costs and cost estimation methods

79. From economic perspective, the costs of climate change impacts on transport infrastructure and services can be separated into the following groups (Enei et al. 2011; pp. 24-25):

- costs to the infrastructure asset owners for damage to infrastructure assets;
- costs to the infrastructure asset owners for the operation and maintenance of the infrastructure;
- costs to the public – damage to vehicle assets, vehicle operation costs, safety issues, reliability of the services, potential losses of business, contracts and customers due to supply chain disruptions.

80. For the development of detailed climate change adaptation (CCA) action plans, it is important to associate specific costs to the different impacts and adaptation measures. Costs due to damage can serve as a natural measure of sensitivity of the systems to various events. They are also a major input in the formal feasibility analysis of proposed actions by means of cost-benefit (CBA) or cost-effectiveness (CEA) analyses. The costs (in terms of damage to property and infrastructure) resulting from weather-related catastrophic events are shown in ***Table 7***.

81. It is also of interest what is the relative share out of the total damage caused by catastrophic events by the type of infrastructure. Most vulnerable appear to be the national road network and the municipal transport infrastructure (streets, roads and public transport infrastructure, such as stops, overhead lines, metro tunnels, and so on), which is the longest one road network with in average 51 percent and 46 percent of the total damage respectively for the 2004–2008 period (see ***Table 10***). The damages to transport infrastructure make up for over 82 percent of the total damage caused by catastrophic events in the period of 2004–2008. No detailed data for damage to the transport infrastructure after 2008 have been published by the NSI because of amendments in the methodology of the statistical survey. Nevertheless, with a reasonable level of accuracy it can be assumed that the damage per type of network has remained relatively constant over time. However, the national statistics do not register social costs related to accidents, delays, and so on, which in many cases exceed direct financial costs.

Table 10. Damage to infrastructure (BGN '000) caused by catastrophic events (2004–2008)

	2004	2005	2006	2007	2008	Average (percentage)
Municipal Transport Infrastructure	40,079	125,449	32,205	26,575	20,141	*45.6*
National Road Network	6,363	85,829	22,951	13,216	91,963	*50.9*
Railway Network	n.d.	n.d.	3,440	1,793	414	*3.5*
Total Damage	46,442	211,278	58,596	41,584	112,518	*100*

Source: National Statistical Institute 2009.

82. As part of this study an attempt was made to collect more detailed data regarding the damage due to catastrophic events. The entities responsible for the operation and maintenance of transport infrastructure were requested to present information regarding the damage to infrastructure from floods, landslides, extreme heat, snow and blizzards over the last five years. The cost data received for railway and inland waterway infrastructures are presented in ***Annex***

8. A very rough estimation based on data collected for the 2004–2008 period per type of infrastructure and available recent data for railway infrastructure only shows the yearly average costs for transport infrastructure due to climate catastrophic events are in the range of BGN 115-135 million. It is important to note the so estimated costs refer to damaged infrastructure and do not include costs for rescue and emergency work, neither the social costs for accidents, time and potential losses of business, contracts and customers due to supply chain disruptions.

83. Some components of the *operation and maintenance* (O&M) costs could be directly estimated from data collected by the managers of the infrastructure. An example of such component is the cost for winter maintenance which can be estimated from actual expenditure incurred by the entities managing the infrastructure. In case sufficiently long series of cost data is available, attempts can be made to correlate it with measures of extreme weather events (for example quantities of snowfall and costs for winter maintenance). It must be noted, however, that establishing such correlations is not always possible due to the large variance of some indicators.

84. Other components of O&M costs are much more difficult to estimate. For example, the expected increase of the costs for routine maintenance of asphalt pavement due to extreme heat can be estimated only through systematic research and for a substantial period of time. For such cost components, the use of international studies to fill in data gaps is in principle possible but must be approached with extreme caution and care, as infrastructure construction, management and OM practices in different countries vary substantially.

85. The *costs to the public* and users of infrastructure are perhaps the most difficult to estimate. For example, establishing the costs of time lost due to extreme weather events would require very detailed statistics for interruptions of the services and consequent delays. Such statistics are not always available and are often not very reliable. For the road sector this would also require the use of transport models at the national level to evaluate the time lost in the event of blockage of road sections.[11]

86. The availability of detailed national studies of the cost components for the different modes of transport is an important condition for the development of feasible CCA plans and strategies.[12] The collection of coherent cost data, as well as general statistical data, is an area which certainly needs more attention from both the managers of transport infrastructure and the scientific community in Bulgaria.

1.3.4. Conclusions of the RVA

87. The national *Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change* (MoEW 2014) is a fundamental document for this study. For this reason, a short summary of the conclusions of the RVA for the transport sector is presented below.

88. The analysis of the vulnerability of the transport sector in the study is largely based on the conclusions of the PESETA II (Nemry and Demirel 2012) project and relies on the aggregated

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[11] This should be done in a way similar to the approach described by Enei *et al.* (2011; pp. 40-46) for assessment of the criticality of road sections.

[12] Nemry and Demirel (2012; p. 72) point out the uneven spatial distribution of many weather factors, which is a limitation of the usefulness of aggregate date for CCA.

climate and cost data and projections included therein. That is used to evaluate the impact of the different types of extreme weather events. The results of the WEATHER (Enei et al. 2011) project are also considered in the RVA.

89. Both sensitivity and adaptive capacity are evaluated using a simple scoring methodology. As a result, the transport sector is evaluated as extremely resilient for the period to 2035. It is noted, however, that the adaptive capacity of the sector is insufficient.

90. The RVA states that the high resilience of the transport sector is due firstly, to the expected moderate climate change to 2035 and secondly, to the transport system being designed and constructed with consideration of the local climate conditions.[13]

91. The study concludes that (MoEW 2014; pp. 147-148):

- No drastic climate change impact is expected in the short-term on the transport system and on the level of its economic efficiency;
- In the mid- and long-term, climate change is expected to impact most strongly the development and costs of road and railway transport;
- The impact would mainly consist of rise of maintenance and infrastructure construction costs as a result of the expected increase of thermal stress on the road and railway infrastructure;
- Serious adaptations costs are required to handle the issues due to thermal stress – annual increase of adaptation costs by 0.4 to 0.6 percent per year for road cover until 2070, and by 83 percent in total for the railway transport;
- Because of milder winter conditions in winter months, winter road maintenance costs are expected to decrease by 2.4 percent annually for the period 2040–2070;
- Extreme weather events are of local significance and it is expected that they would have a significant impact on operational costs and a lesser impact on the functioning of the transport system as a whole.

92. The RVA thus provides guidance as to the general effects and trends due to climate change that may be expected to affect the transport system of the country.

1.3.5. Main risks and vulnerabilities

93. This section discusses in more detail the vulnerabilities listed in ***Table 9***, considering the observed and projected frequencies of extreme weather events, as well as the scale of damage resulting from them. The discussion must be viewed in the light of the general conclusions of the RVA from 2014.

94. *Extreme heat* affects asphalt concrete pavements by softening their binding component – bitumen. This decreases the bearing capacity of the pavement and, combined with the load from the vehicles, may lead to its deformation and the formation of ruts. During rainfall ruts get filled with water and pose a hazard to vehicles travelling at higher speeds.

[13] The RVA does not actually look into how the design codes and standards consider climate and climate change. Such a review is included in this study as part of Chapter 2.

95. Furthermore, the combination of high heat and sunlight results in increased oxidation of bitumen, which makes it less elastic. This in turn leads to the formation of surface cracks and reduces asphalt concrete pavement life. These aspects of the temperature dynamics must be considered in the process of pavement design.

96. Regarding railway infrastructure, extreme heat is known to cause rail buckling. The lines with CWR (continuously welded rails), which however are not yet widely used along the Bulgarian railway network, are more vulnerable to extreme heat and prone to rail buckling. The type of the rail sleepers - timber or concrete – also influences the rail buckling risk. In case of extreme heat and buckling risk, maximum admissible operational speed on the railway lines is reduced to avoid possible train derailment. In addition, rail bucking may reduce the life duration of the rails. At the moment due to the relatively short total length of CWR in Bulgaria, this aspect is not considered to be of major importance.[14] However, the relevance of the issue is expected to gradually increase in the future because all projects for modernization or new construction of railway lines along the core TEN-T network in Bulgaria are being designed and implemented with CWR, because this technology provides for higher speed and comfort. Thus, the adverse effect of extreme heats should be considered during the preparation of design and during the construction works for modernization of railway infrastructure.

97. Regarding extreme heat, the RVA from 2014 notes that the adaptation costs for dealing with thermal stress for both roads and railways will be substantial.

98. *Extreme cold* also has an adverse effect on asphalt concrete pavements, as it makes bitumen less elastic, resulting in the formation of surface cracks. Extreme cold may also cause water in the lower (base) layers of the pavement, or below the pavement, to freeze. As frozen water increases its volume, this causes substantial damage to the asphalt concrete pavement structure.

99. Extreme cold negatively affects the vehicle fleet. Mainly, it reduces the output of car batteries and may result in them becoming unable to start vehicle engines. Generally, vehicle failures due to extreme cold are more frequent among obsolete vehicles, which is the case of big share of Bulgarian vehicle fleet.

100. And even bigger problem is that extreme cold may cause failures to traffic management equipment that is part of the transport infrastructure. This problem applies to all modes of transport, although its exact significance is not clear and is very difficult to estimate due to the lack of data.[15]

101. Railway signaling, and telecommunication equipment is particularly vulnerable to cold – most notably the railway switches, which are prone to freezing. For this reason, heaters are installed to keep the switches at temperatures above freezing. Even in this case, however, freezing is possible at locations where the traffic is high and chunks of ice fall from passing trains on the switches.

> Freezing of the switches may cause substantial safety issues and disruptions of the railway operations. A notable such case occurred in January 2017 when the switches at the central railway station in Sofia froze and train traffic via and in the station, was stopped.[16]

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[16] Dir.bg, 2017. *Frozen railway switches stopped trains*. http://dnes.dir.bg/news/avtobusi-vlakove-snjag-studove-potopat-24946784

102. *Heavy precipitation* is one of the most problematic types of extreme weather events. Continuous heavy rainfall may result in floods and landslides. Floods cause heavy damage to road and railway infrastructure by deteriorating the subbase layers of the road or railway structure. High water content reduces the bearing capacity of the subbase layers and that leads to deterioration of the pavement structure. Water may undermine the subbase leading to catastrophic failure of the pavement structure. High waters may also damage bridge structures by scouring earth material around the foundations of abutments and columns.

Figure 10. Damaged embankment and road due to a river flood (2015)

Source: RIA 2015.[17]

Occurrences of heavy precipitation can cause substantial damage to road and rail infrastructure. In February 2015 two days of heavy rainfall caused huge damage to the road infrastructure. The initial estimates of the Road Infrastructure Agency were for damaged roads and road accessories for more than BGN 10 million.[17]

In September 2014 floods caused damage to railway infrastructure of more than BGN 3 million[18] (see ***Figure 11***).

Figure 11. Damaged railway line due to flooding (2014)

103. The draining of surface and ground water is one of the most important issues in road and railway design and construction. Drainage structures must be designed with an appropriate throughput to accommodate the occurring volumes of water. They must also be constructed of appropriate and durable materials, which prevent water from entering the subbase layers and avoid reduction of the throughput with the time.

104. In the context of heavy precipitation, maintenance of drainage structures is another critical aspect. They must be kept clean of debris which reduce the throughput or even block

[15] See Enei *et al.* (2011) for an extensive discussion on cost estimation methods in the context of CCA and data availability for the different transport subsectors at the EU level.

[16] Dir.bg, 2017. *Frozen railway switches stopped trains*. http://dnes.dir.bg/news/avtobusi-vlakove-snjag-studove-potopat-24946784

[17] RIA 2015. *More than BGN 10 million are the damage to road infrastructure from the floods and rain*. http://www.api.bg/index.php/bg/prescentar/novini/api-nad-10-mln-lv-sa-shetite-vrhu-ptishata-ot-navodneniyata-i-prolivnite-dzhdove/

[18] MTITC 2014. *Minister Angelkova inspected the railway sections damaged by floods*. https://www.mtitc.government.bg/archive/page.php?category=92&id=7659

them.

105. Heavy precipitation adversely affects the use of roads, as it reduces both visibility and traction. This results in a much higher accident rates during rain and on wet pavement than in any other type of conditions. Bulgarian road traffic safety statistics do not register weather-related accidents as a separate category because of the legal obligation drivers have to drive in accordance with the road condition. In other counties, statistical data prove that there is a strong correlation between precipitation/wet pavement and the number of road accidents. In the U.S. for instance, the Federal Highway Administration notes that 73 percent of the weather-related accidents are due to wet pavement.[19] Floods cause significant delays to the railway services and in many cases – operation disruptions. The number of train delays per year due to floods is shown on ***Table 11*** (not including cancelled trains due to operation disruptions). The frequency of such delays in some years is relatively high and they last more than 40 min on average. Assuming average yearly delay of 1,500 min and 65 passengers/train, the estimated time loss because of floods is over 1,600 hours or BGN 11,700.

Table 11. Annual train delays due to floods (2012–2016)

Year	Delays (-)	Total delay (min/train)	Average delay (min/train)
2012	5	140	28.0
2013	1	43	43.0
2014	122	5,054	41.4
2015	21	617	29.4
2016	27	1,660	61.5

106. The issue with the railways is very serious, because the statistics keeps records only for delays of trains that were in the railway section affected by the floods or close to it in the very moment. Repairing the damage caused by the flood require the line to be closed for operation, which in practice mean no supply of transportation services.

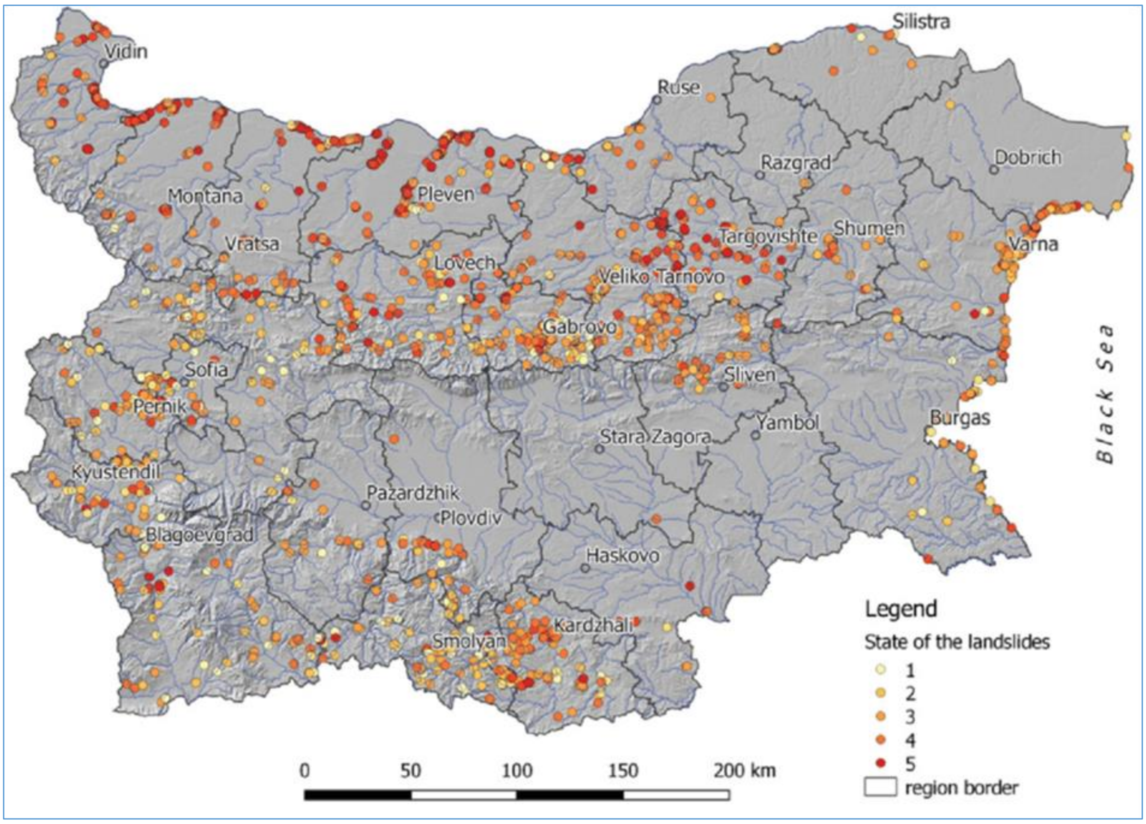
In February 2012, flood-induced water took away over 900 m of Harmanli – Lyubimets railway line. Material damage was estimated at some BGN 3 million, which does not include losses occurred by the National Railway Infrastructure Company (NRIC) and railway operators for lost revenues and due compensations because the line was closed for about a month.[20]

107. As commented in section 1.3, *landslides* are much more likely to occur at times and locations with heavy precipitation. There appears to be a very strong correlation between high precipitation and the appearance of shallow and medium-deep landslides (Bruchev et al. 2007; p. 7). (Precipitation affects deep landslides as well, but the exact casual relations are more difficult to establish.)

[19] Data for 2005-2014 of the Federal Highway Administration, USA (http://ops.fhwa.dot.gov/weather/q1_roadimpact.htm)

[20] Railways Today, 2012 Restoration works in Harmanli – Liubits section are going on http://railwaystoday.eu/news.php?extend.374

Figure 12. Spatial distribution of landslide locations and state



Source: Ivanov et al. 2017.

108. Many areas in the country are under major threat of large landslides. These are as follows:

- Danube River bank between the town of Dunavtsi and Iskar River
- Black sea coast sections of Balchik – Kavarna, Zlatni piasatzi – Kranevo, Sarafovo
- Valley of Cherna River in Rodopi Mountain
- Iskar River gorge
- Areas with intensive coal mining (Maritsa- iztok, Pernik, Oranovo, Brezhani)
- Simitli lowland (BAS 2017; p. 147-149)

109. Areas with medium level of landslides' risk are the following:

- Sofia lowland edges
- Southern parts of Pernik lowland
- Bobovdol
- Valley of Mesta River
- Parts of central and eastern Rodopi Mountain
- Black sea coast between Galata cape and Emine cape
- Valley of Dvoinitsa River in Eastern Balkan
- Volcanogenic complex in Rodopi Mountain
- Area around Veliko Tarnovo, Alexander Stamboliyski Dam and near town of Svishtov (BAS, 2017; p. 149).

110. Stability of river banks is often related to the rivers' water level. In principle, the infiltration of water inside the massifs changes their weight distribution, strength parameters and hydrodynamic pressure (Bruchev et al. 2007; p. 6).

111. *Snowfall* has a similar effect on road users – it causes reduced visibility and traction and hence increases the risk of accidents. In accordance with the Federal Highway Administration's statistics 17 percent of the weather-related accidents are due to snow. As stated earlier, no specific statistical data for road accidents in Bulgaria caused by snowfall are available. It is international experience showing a strong correlation between road accidents and snowfall.

> A recent case of extreme snowfall affecting the whole country occurred in January 2017.[21] Snowfall closed the roads in 6 districts in the Northeast part of Bulgaria – Targovishte, Ruse, Dobrich, Razgrad, Shumen and Silistra. Many other roads in all parts of the country were also closed, most notably sections of Hemus and Trakia Motorway, as well as the road link between Varna and Burgas. The international airport at Varna was also temporarily closed.

112. Snowfall may cause significant disruptions to the railway traffic as well. The annual number of train delays due to snow is shown on ***Table 12*** (again, without cancelled trains). For the period 2012–2016, the total number of delays is almost twice as high as the total number of delays caused by floods. The average delay caused by snow is 88 min, which is more than twice higher than the average train delay caused by floods. Assuming the same average number of passengers per train and average yearly loss of time due to snowfall of some 6,100 min, the total estimated time loss would be 6,600 hours and over BGN 47,500 thousand.

Table 12. Annual train delays due to snow (2012–2016)

Year	Delays (-)	Total Delay (min/train)	Average Delay (min/train)
2012	136	20,889	153.6
2013	10	375	37.5
2014	72	4,114	57.1
2015	88	2,115	24.0
2016	38	2,985	78.6

> In January 2017, intense snowfall caused substantial delays to railway services, as well as damage to the overhead lines (due to fallen or bent tree branches). The railway traffic in some sections was completely stopped, until the fallen snow was removed.[22]

113. In accordance with all RCPs, winters are expected to become milder and the annual quantities of snow precipitation are expected to decrease. This effect, however, is gradual and in the short to mid-term heavy snowfall are expected to occur and to cause problems to the transport operations.

[21]Darik, 2017. *Snow blockade closed the roads*. https://dariknews.bg/novini/bylgariia/snezhna-blokada-i-zatvoreni-pytishta-bydete-vnimatelni-1634656

[22] News.bg, 2017. *Snowfall and drifts stopped trains*. https://news.bg/regions/snegonavyavaniya-i-prespi-spryaha-vlakove.html

114. *Blizzards* may cause long lasting disruptions to the road traffic. In Bulgaria, the Northern and Northeast regions are particularly prone to winter disruptions to traffic due to high speed wind and snowfall. The terrain in these regions is generally flat without natural obstructions to wind and the vegetation is of low height and density. In the past, there have been forested bands of land along roads and railroads, planted with the purpose to prevent snow-drifts. Also, there have been snow protection structures of different kinds at critical locations. Unfortunately, both the natural and technical snow protection measures are no longer being maintained which leads to a perceived increase of the frequency of blizzard-related disruptions to transport services – especially to the road traffic.

Annually, there are numerous of cases for disruptions of traffic and heavy accidents due to blizzards. A recent such example is a blizzard from December 2016 which closed Trakia Motorway for traffic and resulted in the collision of about 25 vehicles (***Figure 13***).

At the same time, several sections of the NRN were closed because of blizzards, as well as the passage of heavy vehicles through some mountain passes was restricted.[23]

Figure 13. A multiple-vehicle collision on Trakia Motorway due to blizzard (2016)

115. An example of the implication of blizzards to railway infrastructure is a project for the establishment of a protecting forest belt along the Chernograd – Aytos railway section. Total costs for implementing this belt are estimated at BGN 280,000 for a total length of 1.725 km.

116. *Hails* appear to be an increasing risk for the vehicle fleet. Normally hails do not cause significant damage to vehicles, but there are recent opposite examples.

A severe hail occurred in July 2014 in Sofia and caused damage to the road vehicle fleet for about BGN 100 million.[24] Subsequently, insurance premiums rose with about 11 percent, presumably to cover insurers' losses from this single extreme weather event.

117. Regardless the lack of specific weather-related national accidents data, over one-fourth of all accidents in Bulgaria are caused by driving with speeds inadequate to the road conditions: 27.3 percent in 2015 and 25.7 percent in 2016. These figures do not include accidents caused by damaged or bad quality road pavement and thus, to a large extent could be attributed to weather-related events. The so estimated rate is like the rates in other countries, in which more sophisticated accident statistics exists. For example, in the U.S. the share of weather-related crashes is estimated at 22 percent of the total number of crashes,[25] which is a substantial share.

[23] Dnes, 2016. *Blizzards and a car accident closed Trakiya Motorway*. http://www.dnes.bg/stranata/2016/12/30/snejna-buria-i-katastrofa-zatvoriha-chast-ot-trakiia.327342

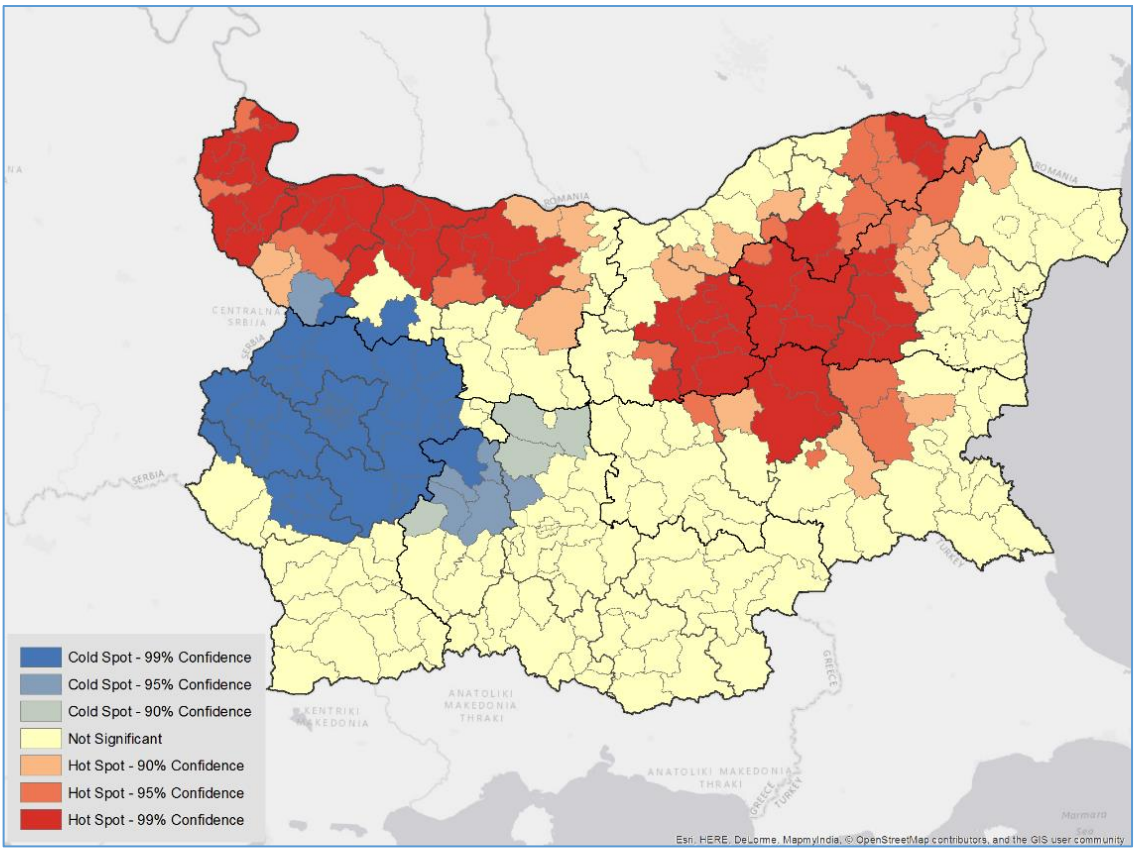
[24] Darik News, 2015. *Insurers have paid more than BGN 100 million after the 2014 hail*. https://dariknews.bg/novini/bylgariia/zastrahovateli-sa-izplatili-100-mln.-leva-sled-gradushkata-ot-2014-g-1426665

[25] Data for 2005-2014 of the Federal Highway Administration, USA (http://ops.fhwa.dot.gov/weather/q1_roadimpact.htm).

1.3.6. Social impacts

118. It is widely accepted that the impacts of climate change will fall disproportionately upon different social groups, and thereby exacerbate inequities. This is especially the case for the population with low income who are expected to experience worsening of their health status and of their access to adequate food, clean water, and other resources. In the context of the transport sector, there are no groups, which are considered not to be vulnerable to weather-related catastrophic events. Nevertheless, lower income groups are generally more vulnerable. In addition, the inhabitants of big cities are relatively more protected from extreme weather-related events and suffer lower impact of such events. Other countries statistics show that the first victims of extreme meteorological events were the most disinherited and most powerless populations: the aged, the poorly housed, handicapped, chronically ill and those with very low incomes or suffering from social isolation, as in principle they have lower adaptive capacity. In the Bulgarian context, most vulnerable seem to be inhabitants of isolated mountain and/or border areas settlements, who usually are aged persons with low incomes. The poorest Bulgarian regions and population are clustered at the intersection of Severen Tsentralen, Severoiztochen and Yugoiztochen, as presented in ***Figure 14***. Another area needing attention is Severozapaden, where many poor regions are situated.

Figure 14. Poverty rate in Bulgaria



Source: World Bank 2017.

1.4 Conclusions

119. Considering the general matrix of factors and impacts, together with the historic data regarding weather-related damage, the following most important risks relevant to the transport sector in Bulgaria may be formulated:

- *Floods* – the second most frequent weather-related type of event and the one with the highest damage on infrastructure. The frequency and impact of floods are expected to increase under all climate change scenarios, as most indices describing rainfall irregularity are projected to change in this direction;
- *Landslides* – the fourth most frequent weather-related type of event and the one with the second highest damage on infrastructure. Precipitation is a major factor in the development of landslides and although the total annual volumes of precipitation are projected to decrease, landslides will continue to be a serious problem;
- *Blizzards* and *snowfall* – a cause of disruptions to transport services during winters. Although the annual volumes of snowfall are projected to decrease, in the short and mid-term blizzards and intense snowfall will continue to be a major source of disruptions to the services of all modes of transport;
- *Extreme heat* – a factor which must be taken into consideration mainly in the design and construction of transport facilities. Thermal stress is a factor that is expected to lead to increased costs for design and construction of road and railway infrastructure.

120. Potential climate change direct risks and opportunities relevant to the transport sector are summarized in the next table.

Table 13. Potential direct risks and opportunities for the transport sector

Event	Risks	Opportunities
Higher temperatures (including heat spells and heat waves)	• Higher damage to asphalt concrete road pavement	• Decreased road, railway and airport winter maintenance costs
	• Higher damage to asphalt concrete airport pavement	
	• Rail buckling	
	• Overheating of railway control equipment	
	• Some increase of costs due to higher energy consumption for cooling (all modes)	
Lower temperatures (including cold spells and cold waves)	• Deterioration of asphalt concrete road pavements	
	• Failure of road vehicles and control infrastructure	
	• Ice on trains, catenary and railway switches	
	• Damage to navigation signs and infrastructure	
	• Disruptions to operations (river transport)	
	• Deterioration of airport pavements	
	• Failure of vehicles and control infrastructure	
	• Icing of aircraft	

Event	Risks	Opportunities
More precipitation and humidity	• Increased frequency and impact of floods and landslides on road and railway infrastructure	• Increased periods with water flows sufficient for normal operation
	• Reduced visibility and traction on roads and streets	
	• High river flows resulting in disruptions to operations	
	• Reduction in airport throughput due to air traffic disruption	
Droughts	• Low river flows resulting in disruptions to operations	• Lower water table resulting in lower chances of damage to cuts, embankments and landslides.
Blizzards	• Snow and obstacles on the roads, streets and railways resulting in major disruptions to operations	
	• Reduced visibility and traction on the roads and streets	
	• Failure of road, railway and airport control systems	
	• Damage to railways signals and catenary	
	• Increased air turbulence	
	• Safety risks for airport ground operations	
	• Damage to aircraft and equipment	
	• Disruptions to operations at ports and airports	
Heavy snowfall	• Snow and obstacles on the roads, streets and railways resulting in major disruptions to operations	
	• Reduced visibility and traction on the roads and streets	
	• Failure of road, railway and airport control systems	
	• Damage to railways signals and catenary	
	• Disruptions to operations at ports and airports	
	• Reduction in airport throughput due to air traffic disruption	
	• Icing of aircraft	
Storms and hails	• Obstacles on the roads, streets and railways resulting in disruptions to operations	
	• Reduced visibility on the roads and streets	
	• Damage to railways signals and catenary	
	• Increased air turbulence	
	• Safety risks for airport ground operations	
	• Damage to aircraft and equipment	
	• Disruptions to operations at ports and airports	
Fog	• Reduced visibility on roads and streets	
	• Reduction in airport throughput due to air traffic disruption	

Chapter 2. Baseline – Policy Context

121. This Chapter presents a review of the legal and institutional framework in the transport sector, as well as the regarding CCA. The most important stakeholders in the sector (both at policy and executive level) are identified and their main duties and authority related to CCA are presented. The adaptive capacity of the stakeholders is also commented upon. Special attention is given to the existing gaps and barriers in the various subsectors.

2.1. State of Awareness and Understanding of Future Consequences of Climate Change and Knowledge Gaps in the Transport Sector

2.1.1. Overview

122. In the recent years, awareness regarding the need of systematic approach regarding CCA has started to build up in the transport sector. The topic has not been popular in general, although the stakeholders in the sector have identified the need of measures to address specific types of issues which are related to climate change.

123. There have been isolated initiatives in the various subsectors, attempting to solve problems related to minimizing the impact of climate change on the transport sector. The increased use of polymer modified bitumen[26] in road pavements is an example of such an initiative.

124. There are other examples of efforts to address the impact of climate change-related issues on the transport sector. In 2013, as part of the *Adriatic-Danube-Black Sea Multimodal Platform* project,[27] a thorough analysis of the external economic costs[28] for the different modes of transport in southeastern European countries was made. The internalization (through charges and by other means) of the external environmental costs is an important measure which has a mitigation effect in the long run and, in some cases, may be considered an adaptation measure. All major national stakeholders in the transport sector were consulted as part of the study.

125. One of the findings of the study (as a result of the surveys and interviews made) was that the stakeholders in the transport sector were generally not very familiar with the concept of external costs and the effects of their internalization. If the specialized entities in the transport sector are not aware of such concepts, that even more so applies to the players on the political scene and the public at large.

126. There certainly is a lack of systematic studies of the longer-term impact of climate change to the transport sector in Bulgaria. Similarly, the definition of specific CCA actions and their effects need more attention and research.

127. A good example for the increasing awareness about the impact of climate change and the need to adapt would be addressing these impacts in the environmental assessments of strategic documents in the transport sector. The environmental assessment of Operational

[26] Polymer modified bitumen has better properties than regular bitumen and helps make pavement resilient to a wider range of temperatures. Further details are presented in section 3.8.2.

[27] For more information, see project's website: www.adbmultiplatform.eu/adb/

[28] External costs are economic costs (for example for climate change or health damage) incurred by parties, which are external to the investment measure being studied. These parties do not use the measure and do not choose whether or not the costs to incur.

Programme Transport and Transport Infrastructure 2014–2020 done in 2014 contains little information about CCA and includes mainly general remarks regarding the long-term climate change effect of the Program. For comparison, the environmental assessment (from 2017) of a strategic document with similar scope – the Integrated Transport Strategy for the Period until 2030 – includes an extensive discussion (based on the RVA) regarding climate change in general and CCA in particular (MTITC 2017b; pp. 95-100).

128. In general, a positive trend could be observed regarding the CCA awareness of the stakeholders. However, much remains to be done in pursuing a more systematic approach and understanding of the issues and their importance by the stakeholders in the various subsectors.

2.1.2 Adaptive capacity of the stakeholders

129. To review the level of awareness and the adaptive capacity of the stakeholders in the Bulgarian transport sector a questionnaire was prepared and distributed among all major public-sector entities that have duties and responsibility related to transport. Included were questions related to the availability of internal documents and guidelines related to CCA, anticipation of climate change events, availability of staff and guidelines for dealing with the effects of climate change. A significant part of the questions was related to the availability of detailed records regarding the effects of climate change in terms of damage to infrastructure (frequency, costs, spatial distribution) and disruptions to services (reason, duration, spatial distribution).

130. About half of the stakeholders[29] declared they have knowledge and understanding of CCA. Their answers regarding extreme weather events, which are most important to the infrastructure or services managed by them, support the statement. The events listed by the stakeholders as critical almost fully coincide with the events identified by this study. It is worth to note that most stakeholders appear to put high emphasis on winter events (snowfall and blizzards) which usually do not significantly affect infrastructure but disrupt the operations.

Another important observation is that almost half of the stakeholders do not demonstrate awareness and understanding of what CCA is.

131. Almost none of the stakeholders use formal internal guidelines or instructions specifically related to CCA. Some noted that CCA is addressed at the project level in accordance with the requirements of OPTTI, OPRG and CEF that stem from the requirements of EC's Common Provisions Regulation.[30] Only one of the stakeholders uses a specialized study of the climate change effects to the transport mode they are responsible for.

132. None of the stakeholders has written procedures regarding the *technical* aspects of project preparation.[31] This means that the scope and sequence of the project preparation stages (pre-feasibility study, feasibility study, application for funding, design, preparation of works and services tender dossiers, EIA, geological surveys, land acquisitions, and so on) are not firmly set. It remains unclear if and how CCA is considered during the project preparation

[29] Five out of the nine that responded to the survey.
[30] For details on how CCA is addressed for EU-funded projects see the discussion in sections 3.4.3 'Common Provisions Regulation', 3.7.2 'Operational Programme Transport and Transport Infrastructure 2014-2020' and 3.7.3 'Operational Programme Regions in Growth 2014-2020'.
[31] Some stakeholders have answered that they use the rules and guidelines for project preparation for OPTTI, OPRG or CEF. These documents, however, are not related to the technical aspects of project preparation (one of which being CCA) but to purely procedural issues.

process.

133. Most stakeholders interviewed declared to use written rules and procedures for emergency response of various levels of detail. Some of these rules and procedures address specifically the response to emergencies caused by extreme weather events.

134. None of the stakeholders consider it necessary to have a dedicated CCA unit. Nearly all stakeholders consider that training on CCA would be of benefit. The estimation about availability of data varies substantially from one stakeholder to another. Some of them keep very detailed records of emergencies (including ones caused by extreme weather), some others appear to collect data with higher level of aggregation, and some do not maintain any records related to emergencies.

135. The stakeholders do not appear to be particularly concerned about future climate change but rather about the effects of the current climate on the transport infrastructure and services (hence their emphasis on winter weather extreme events).

A summary of the answers received from the stakeholders is presented in ***Annex 5***.

2.2. Experience with CCA and Transport in Other (EU) Countries

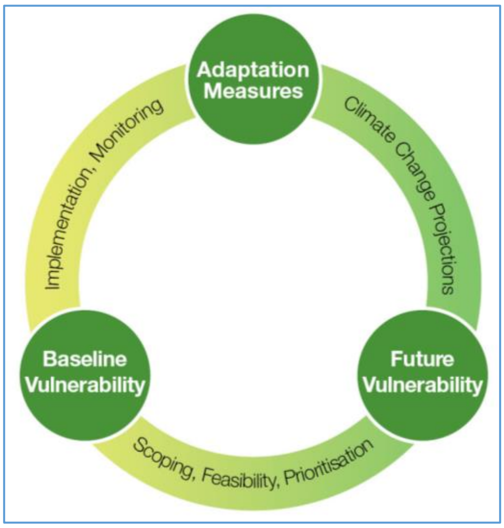
136. The impacts of climate change are typically assessed in two stages:

- assessment of the *baseline vulnerability* – that is influenced by the present weather and adaptation level; and
- assessment of the *future vulnerability* – due to forecasted climate development.

137. Vulnerability is a function of three main factors:

- the *sensitivity* of infrastructure and services to weather and climate;
- the *exposure* to weather-related risks; and
- the *adaptive capacity* – the ability to cope or respond to change.

Figure 15. Overview of adaptation methodology



Source: World Bank 2012a.

138. Vulnerability assessments for the transport sector consider both the *operation* (infrastructure and services) and *design* (infrastructure) aspects. Once vulnerabilities are established, *adaptation options* are scoped. The options then undergo a feasibility assessment and prioritization – which results in *action plans*.

139. Based on the policies, legislation and guidance at the EU-level, many European countries have developed their climate change adaptation strategies and action plans. In most cases this is done through a multi-stage process (as outlined above) where first the general goals and principles are established, then the risks and vulnerability of the different sectors are assessed, and finally appropriate adaptation options are identified and prioritized.

140. CCA may be addressed at various levels of the administration – at a governmental level

(ministries, agencies, and so on) it is appropriate to address system-wide issues, and local-specific issues are best addressed at the local level (municipality, town, and so on). Best results appear to occur when both the central administration and the local authorities play active role in the process of CCA.

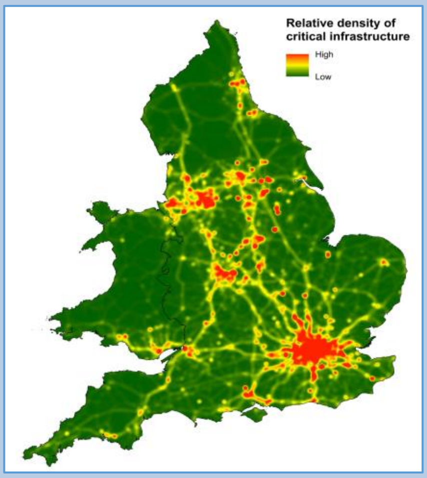
The *UK Climate Change Risk Assessment 2017* is an example of a comprehensive review of the weather-related factors and their impact on the various sectors of the economy (Dawson et al. 2016).

The approach taken is to review the different types of infrastructure – transport, energy, water – as a whole and not only look into the vulnerability of the individual infrastructure networks, but also attempt to identify issues which may result in cascade failures. The interdependencies between the different infrastructure networks are reviewed in detail.

Some of the main extreme weather-related events and factors the study focuses on are floods, droughts, storms, geohazards and extreme heat. The impact of climate change on ICT is also considered.

An interesting example of the joint assessment of the criticality of the different types of infrastructure is shown on ***Figure 16***.

Figure 16. Concentration of critical infrastructure from all sectors



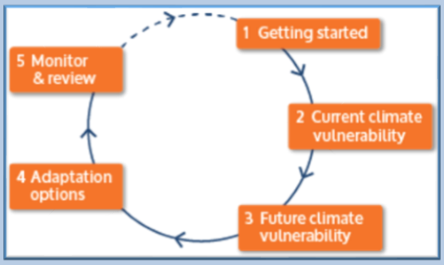
Source: Thacker et al. (n.d.) in Dawson et al. (2016).

141. An approach with increasing significance is the use of information and communication technologies in the adaptation process. There have been several interactive web-based tools developed, which aim to help stakeholders better navigate the vast tree of decisions and options applicable for the different sectors and under different conditions.

142. Some of these tools are focused on the assessment of vulnerability and others on the definition of adaptation options.

A very useful tool to support adaptation efforts has been developed by UKCIP.[32] The so-called *Adaptation Wizard*[33] is a 5-step process (see ***Figure 17***) which allows stakeholders to assess vulnerability to current climate and future climate change, identify options to address key climate risks, as well as help to develop and implement a climate change adaptation strategy.

Figure 17. The five steps of the Adaptation Wizard tool



Source: UKCIP 2010. Adaptation Wizard.

The Adaptation Wizard has been developed as an interactive web-based tool which helps stakeholders to streamline their thinking regarding CCA. Each step is accompanied by detailed guidance and is supported by various tools and resources. All steps of the process are recorded and may be inspected and revised at a later stage.

[32] Formerly known as the UK Climate Impacts Programme, UKCIP is based at the Environmental Change Institute at the University of Oxford

[33] UKCIP, 2010. Adaptation Wizard available at: www.ukcip.org.uk/wizard/

143. Another example of the use of information technologies in the CCA process is the *European Climate Adaptation Platform*.[34] Platform's web-site hosts a large library of policy documents at the EU-level, as well as numerous case studies from member states. Also available are interactive tools to support the adaptation efforts and focus the search of stakeholders for best practices. One such tool is the adaptation options selector[35] which proposes adaptation options and relevant studies based on the input of users regarding the weather events they are interested in, as well as the specific sector of the economy.

2.3. EU CCA Legal Framework and Policies in the Sector

2.3.1. Overview

144. At the EU level, CCA is addressed by a number of legal and policy documents. Some of them are focused on the general aspects of CCA, others address the issue at the level of the specific funding instruments and sectors, and some specifically discuss cross-cutting issues. This section summarizes the most important legal and policy documents with relevance to the transport sector.

2.3.2. EU Strategy on Adaptation to Climate Change

145. The *EU Strategy to Adaptation to Climate Change* (COM (2013) 216) from 2013 lays the main principles of the CCA in the Community. The strategy aims to proactively and coherently address CCA in Member States. It also sets a financing target for CCA measures and sets the framework for monitoring and evaluation of the implementation of CCA.

146. One of the specific actions identified in the strategy – and directly related to the transport sector – is *Action 7: Ensuring more resilient infrastructure*. Within the scope of this action, an EU-wide review and revision of standards and industry codes and regulations to better consider CCA is made, as well as the provision of specific guidance for the development of CCA-related strategies and plans.

147. The strategy is accompanied by a number of working documents, which discuss specific aspects of CCA. *Adapting Infrastructure to Climate Change* (SWD (2013) 137) is an important such working document – it covers the sectors, which have been given priority under the *White Paper on Climate Change Adaptation* from 2009 (COM (2009) 147), and namely *energy and transport infrastructure*, and *buildings*.

148. The working document underlines the importance of proper planning of infrastructure, and detailed feasibility analysis in the light of CCA. It is also recognized that design codes and standards must be regularly adapted and revised to accommodate the present and forecasted climate conditions (SWD (2013) 137, pp. 14-15). The need of focusing on the *local* climate impact is also discussed in detail.

149. Several adaptations instruments are identified, for example technical standards, the EIA and SEA Directives,[36] the flood risk assessment and management framework,[37] and so on of special interest for the planning and development of new transport infrastructure are the

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[34] Available at: climate-adapt.eea.europa.eu/.
[35] Available at: climate-adapt.eea.europa.eu/knowledge/adaptation-information/adaptation-measures/.
[36] Directive 2014/52/EU and Directive 2001/42/EC respectively.
[37] Directive 2007/60/EC.

provisions of the new EIA Directive regarding the assessment of disaster risks.

150. Finally, Annex 1 of the working document *An EU Strategy on adaptation to climate change* provides a general summary of the climate risk and impacts on the various transport infrastructure subsectors at the EU and regional level (SWD (2013) 137, pp. 31-33, pp. 36-37).

2.3.3. Common Provisions Regulation

151. The *Common Provisions Regulation*[38] (CPR) is the document that harmonizes the framework of the cohesion policy funds (European Regional Development Fund, the European Social Fund and the Cohesion Fund), with the fund for rural development (the European Agricultural Fund for Rural Development), and for the maritime and fisheries sector (the European Maritime and Fisheries Fund). In addition to that, the CPR sets out the means to achieve consistency with the economic policies of the EU and its Member States, provides coordination mechanisms with the European Structural and Investment Fund and with other EU policies and instruments, horizontal principles, and cross-cutting policy objectives.[39]

152. The CPR defines eleven thematic objectives.[40] Of relevance to the transport sector are the following three thematic objectives:

4. Supporting the shift towards a low-carbon economy in all sectors.
5. Promoting climate change adaptation, risk prevention and management.
7. Promoting sustainable transport and removing bottlenecks in key network infrastructures.

153. By explicitly including the development of sustainable transport, and climate change adaptation and mitigation in the thematic objectives, the CPR provides very strong incentive to Member States to seriously consider and address these issues.[41] The thematic objectives are translated to the local context by the Partnership Agreement of Bulgaria[42] for programming period 2014–2020 (the Partnership Agreement is presented in detail in section 2.4.4 of this report).

154. In addition to that, the CPR contains the following specific provisions:

- Article 96(7) (a): '[Each operational programme […] shall, […] include a description of] (a) the specific actions to take into account environmental protection requirements, resource efficiency, climate change mitigation and adaptation, disaster resilience and risk prevention and management, in the selection of operations;'
- Article 101 (f): '[Before a major project is approved, the managing authority shall ensure that the following information is available] (f) an analysis of the environmental impact, taking into account climate change adaptation and mitigation needs, and disaster resilience.'

[38] Regulation (EU) No. 1303/2013.
[39] A detailed review of the CPR and how it, and other EU legislation, contribute to the mainstreaming of climate action is provided by DG CLIMA (2015).
[40] See Article 9 'Thematic objectives' of the CPR.
[41] See also Article 8 'Sustainable development' of the CPR.
[42] CoM (2014).

155. These explicit requirements have been complied with by the main investment instruments in the transport sector in Bulgaria – *Operational Programme Transport and Transport Infrastructure* (OPTTI) 2014–2020 and *Operational Programme Regions in Growth* (OPRG) 2014–2020.

2.3.4. The EU Strategy for the Danube Region

156. The strategy recognizes the historic economic disparities and under investment in infrastructure in the Danube Region and aims to 'create a secure, prosperous and fair Region for all its 115 million residents' (European Union 2011; p. 4). The four 'pillars' of the strategy are (European Union 2011; p. 4):

- Connecting the Danube Region;
- Protecting the environment in the Danube Region;
- Building prosperity in the Danube Region; and
- Strengthening the Danube Region.

157. Under the four pillars, 12 priority areas (PA) are defined and namely:

- PA 1A – Waterways Mobility;
- PA 1B – Rail-Road-Air Mobility;
- PA 2 – Sustainable Energy;
- PA 3 – Culture & Tourism;
- PA 4 – Water Quality;
- PA 5 – Environmental Risks;
- PA 6 – Biodiversity & Landscapes;
- PA 7 – Knowledge Society;
- PA 8 – Competitiveness of Enterprises;
- PA 9 – People & Skills;
- PA 10 – Institutional Capacity & Cooperation;
- PA 11 – Security.

158. The priority areas related to transport, environmental risk, knowledge society, institutional capacity and cooperation, and security are of relevance for the adaptation to climate change by the transport sector.

2.4. Bulgarian CCA Legal Framework and Policies in the Sector

2.4.1. Overview

159. Climate change is being considered in the strategic documents and the legislation at the subsector level (road, rail, air, and so on). Regarding the development of the transport system, the most important such documents are the *Strategy for the Development of the Transport System of the Republic of Bulgaria to 2020* (2010) and the *Integrated Transport Strategy for the Period until 2030* (2017). In complying with the ex-ante conditionality of the EC, an Integrated Transport Strategy for the Period until 2030 that meets specific requirements of the ex-ante conditionality[43] has been developed. The Integrated Transport Strategy for the Period

[43] The ex-ante conditionalities are listed in Annex 3 to the Partnership Agreement

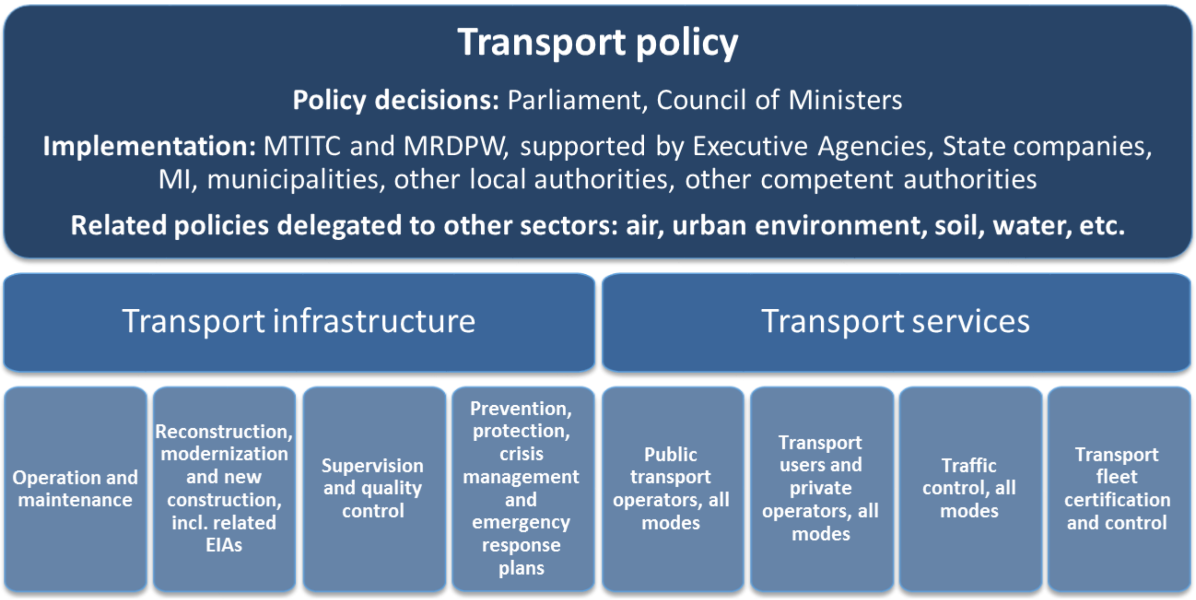
until 2030 was adopted by the Council of Ministers of the Republic of Bulgaria with Decision No 336/23.06.2017. The document is published at the internet site of the MTITC.[44] In general, both strategies are more concerned with climate change mitigation, than with adaptation.

160. Another important document is the *Partnership Agreement of Bulgaria*[45] for the period 2014–2020, which is the framework for the development of all operational programs. As the Agreement is an instrument to translate the principles of the CPR, it is perhaps the document that addresses CCA in the most systematic way. It also puts an emphasis on mitigation, but also prescribes several CCA measures, some of impact to the transport sector.

161. Other documents with relevance to CCA in the transport sector are the *National Programme for Disaster Protection* 2014–2018 and the *National Programme for Prevention and Mitigation of Landslides on the Territory of the Republic of Bulgaria, Erosion and Abrasion on the Danube and Black Sea shores 2015–2020*. These documents prescribe specific CCA actions to be taken by various entities in the transport sector.

162. Besides the legal framework, some transport infrastructure design codes and a summary and comments on their relevance to CCA are included further in this section. As a whole, serious efforts must be made to update the design guidelines in use to take into account climate change.

Figure 18. Structure and main actors in implementing the Bulgarian transport policy



Source: World Bank design.

163. Finally, of major significance to the development of the transport sector are *Operational Programme Transport and Transport Infrastructure* 2014–2020 and *Operational Programme Regions in Growth* 2014–2020, which include specific CCA provisions. These programs, however, are not considered part of the legal and policy framework, but rather instruments for the implementation of the national policies and are briefly presented in section 2.6 ‘Financial and Human Resources’.

[44] https://www.mtitc.government.bg/en/category/42/integrated-transport-strategy-period-until-2030
[45] CoM (2014).

164. A summary of the most important documents with relevance to CCA in the transport sector is presented in ***Table 14***.

Table 14. Legal documents with relevance to CCA in the transport sector

Document	Relevance to CCA in subsector			
	Roads	Railways	Waterborne	Airborne
Strategy for the Development of the Transport System of the Republic of Bulgaria until 2020	High for the subsector but low for CCA	High for the subsector but low for CCA	High for the subsector but low for CCA	High for the subsector but low for CCA
Integrated Transport Strategy for the period until 2030	High for the subsector but low for CCA	High for the subsector but low for CCA	High for the subsector but low for CCA	High for the subsector but low for CCA
Partnership Agreement for the 2014–2020 period	High. Sets policy-level requirements	High. Sets policy-level requirements	High. Sets policy-level requirements	High. Sets policy-level requirements
Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change	Medium. Mostly includes general observations	Medium. Mostly includes general observations	Medium. Mostly includes general observations	Medium. Mostly includes general observations
National Programme for Disaster Protection 2014–2018	High	High	High	High
National Programme for Prevention and Mitigation of Landslides on the Territory of the Republic of Bulgaria, Erosion and Abrasion on the Danube and Black Sea shores 2015–2020	High. Landslides causing most damage to road and railway infrastructure	High. Landslides causing most damage to road and railway infrastructure	Low	Low
Critical Infrastructure Ordinance	High	High	High	High
Climate Change Adaptation Strategy of the Municipality of Sofia	High. Most effects on street infrastructure and services	Medium. Some effects on tram and metro infrastructure and services	N/A	Low. Some effects on Sofia Airport

2.4.2. Strategy for the Development of the Transport System of the Republic of Bulgaria until 2020

165. The *Strategy for the Development of the Transport System of the Republic of Bulgaria until 2020* (MTITC 2010) has been one of the main documents framing the development of the Bulgarian transport system since 2010.

166. The Strategy defines priorities and Priority 5 is devoted to climate change mitigation. It states the importance of promoting shift to sustainable modes of transport, fuel efficiency, support of the use of cleaner fuels, and so on Measures to implement the priorities of the strategy are also formulated. These measures could be the basis for the scope of Operational Programme Transport and Transport Infrastructure 2014–2020.

167. The Strategy includes a comprehensive review of the EU legislation and policies regarding climate change. The focus, however, is mostly on climate change mitigation and adaptation is not a subject of the discussion.

2.4.3. Integrated Transport Strategy for the Period until 2030

168. Availability of an *Integrated Transport Strategy for the Period until 2030* (MTITC 2017) is an obligatory requirement for the transport sector in complying with an *ex-ante* conditionality from the EU-Bulgaria Partnership Agreement the 2014–2020 period. The strategy was adopted by Decision No 336/23.06.2017 of the Council of Ministers. The strategy is in line with the Partnership Agreement as was confirmed by a letter of the EC stating that with the Strategy Bulgaria complies with the earlier mentioned ex-ante conditionality.

169. The Strategy is a comprehensive study of the state of the transport systems of all sub-sectors/modes of transport. As part of the work, a large amount of data about the transport sector is collected and presented to the Ministry of Transport, Information Technology and Communications. A pivotal element of the strategy is the national multimodal transport model, allowing traffic forecasts to be made for a substantial future period.

170. CCA is not explicitly addressed in the Strategy. The document mainly focuses on a standard set of climate change mitigation measures – mostly efforts to promote shift to sustainable modes of transport and reduction of the emissions by optimizing the transport system.

171. CCA is commented upon in the *Environmental assessment of Integrated Transport Strategy for the Period until 2030* (MTITC 2017b) chapter, which includes a discussion based on the RVA from 2014.

2.4.4. Partnership Agreement for the 2014-2020 period

172. Partnership Agreements are provided for in the CPR and are the basis for the development of Operational Programmes for the 2014–2020 programming period[46]. The *Partnership Agreement* of Bulgaria[47] has been prepared by the national authorities in dialogue with the services of the EC. It translates in the local context the provisions of the CPR and gives details on how the thematic objectives of the CPR are to be implemented.

46 Described in Article 14 of the CPR and their content is listed in detail in Article 15 of the CPR.
47 CoM (2014).

173. The Partnership Agreement recognizes the present and expected climate change and provides a summary of their impacts.[48]

174. Regarding the transport sector, the Partnership Agreement focuses mainly on mitigation, rather than adaptation (see for example the description of 'Sub-priority: Shift to low-carbon economy, energy and resource efficiency'[49]). The Agreement includes a section devoted to CCA ('Sub-priority: Climate and climate change, risk prevention and management'[50]), which provides an extensive list of measures to be supported. The CCA issues related of the transport sector are not specifically addressed, although many of the measures listed are relevant to the sector, more important being the following:

- the development of the second Flood Risk Management Plans and flood prevention/protection through the implementation of the measures of the Flood Risk Management Plans – reliable projections of flood risk have major importance in the planning and design of transport infrastructure;
- planning, design and construction of early warning systems for flood risk; improving institutional planning for emergencies; changes in land use and planning; building defenses and retention volumes; planning, design and development of information systems, including such for improving the forecasting of flood risk, and so on – of importance in the planning and design of transport infrastructure;
- improving disaster risk management through the creation of a single database of the main types of disasters and the damage they cause on the territory of Bulgaria and by modernizing the equipment and systems for storage and dissemination of data and maps of disaster risk – the availability of reliable data is required for the preparation of sector-specific analyses related to CCA;
- strengthening the administrative capacity to reduce disaster risk by developing and implementing programs for establishing of expertise for analysis and risk assessment of the main types of disasters and continuous improvement of the knowledge and skills of the responsible staff – adequate response to emergencies is particularly important for the transport sector.

2.4.5. Risk and Vulnerability Analysis and Evaluation of the Transport Sector

175. The national *Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change* (MoEW 2014) is a comprehensive study, which:

- includes a general review of the state of CCA at the EU and Bulgarian level;
- provides information regarding the expected climate change scenarios for Bulgaria; and
- provides risk and vulnerability assessments at the sectoral level of the economy.

176. In identifying the main climatic factors and their impact, the RVA draws heavily from the PESETA II study (Nemry and Demirel 2012), which provides rich aggregate information about various CCA issues in the road and railway sector.

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[48] CoM (2014; pp. 46-48).
[49] CoM (2014; pp. 83-84).
[50] CoM (2014; pp. 84-85).

177. The main conclusions of the RVA are that, as a whole, the transport sector can be classified as *extremely resilient*, but the adaptive capacity of the sector is insufficient.

178. The importance of the RVA lies in formulation of general directions and guidelines as to the main factors to be considered. These form the basis for this study.[51]

2.4.6. National Programme for Disaster Protection 2014-2018

179. The *National Programme for Disaster Protection* 2014–2018[52] sets the objectives, priorities and tasks of disaster protection in the country for a period of five years. This is the main document around prevention, containment and overcoming the consequences of disasters and accidents, and outlining the guidelines for creating an efficient, funded and technologically provided system for national disaster prevention and response. The strategic objective of the National Programme and the state policy for protection against disaster is to secure the prevention, containment and the consequences overcoming, as well as to protect the life and health of the people and to preserve culture heritage.

180. The *main priority* of the program for 2014–2018 is conducting an analysis and assessment of the disaster risks on the territory of the Republic of Bulgaria and their mapping. The main objectives of the program are:

- assessment and mapping of the risks of earthquakes, nuclear and radiation accidents, geological risk;
- completion of the assessment of the risk of floods and preparing maps of the threat and maps of the risk;
- implementation of the disaster risk reduction measures;
- enhancing the resilience of the critical infrastructure to disasters;
- completion of the process of buildings' passportisation;
- readiness instructions for the organs of executive power and the emergency task-forces to respond to disasters;
- completion of the siren system as part of the National Early Warning and Announcement System, informing the people about the dangers registered by the monitoring systems of the meteorological, hydrological, seismic, chemical, biological, radiation, nuclear, ecological and other sites and occurrences.

181. The program defines the duties of all relevant entities (ministries, agencies, and so on) regarding disaster protection and prevention. It also foresees the development of *annual plans* for disaster protection, which include a list of specific actions to be taken by the authorities each year.

182. The *Annual Plan for Disaster Protection for 2016* includes specific measures with relevance to CCA of the transport sector:

- preventive treatment of landslides, development of National Programme for Prevention and Mitigation of Landslides on the Territory of Republic of Bulgaria, Erosion and

[51] The conclusions of the RVA are presented in more detail in section 1.4.4 of this report.
[52] CoM (2013).

Abrasion on the Danube and Black Sea shores 2015–2020 (Ministry of Regional Development and Public Works);

- preventive treatment of problematic areas posing risk to road infrastructure (Road Infrastructure Agency);
- preventive treatment of problematic areas posing risk to railway infrastructure, signaling and catenary (National Railway Infrastructure Company).

2.4.7. National Programme for Prevention and Mitigation of Landslides on the Territory of the Republic of Bulgaria, Erosion and Abrasion on the Danube and Black Sea shores 2015–2020

183. The protection from (and prevention of) landslides in Bulgaria is a duty of the Ministry of Regional Development and Public Works. The ministry has developed a *National Programme for Prevention and Mitigation of Landslides on the Territory of the Republic of Bulgaria, Erosion and Abrasion on the Danube and Black Sea Shores* 2015–2020.[53]

184. The program includes a thorough review of the geological conditions in the country regarding the development of landslides. Also included is a methodology for assessment of the risk (and hence the urgency of remedial measures) of the landslides. The risk of the known landslides is assessed using the methodology. The program sets priority areas for monitoring of landslides and defines an extensive list of priority actions, such as technical studies, information exchange, preventive actions to protect transport infrastructure, and so on.

2.4.8. Critical Infrastructure Ordinance

185. The *Critical Infrastructure Ordinance*[54] has been issued in 2012 and its goal is to determine the critical infrastructure elements and sites in the country and thus help reduce the risks and impact of damage to them. The ordinance covers all types of infrastructure – transport, energy, water, health, information, and so on. The leading role in the process of establishing the criticality of infrastructure has the Ministry of Interior and the various sectoral ministries are responsible for evaluating the infrastructure within their domain of responsibility.

186. The ministers, responsible for distinctive sectors, appoint permanent working groups that establish rules for determining the level of criticality of infrastructure and propose priority lists of critical infrastructures.[55]

187. The criteria to be used by the workgroups are:[56]

- potential number of affected persons – expected casualties and injured;
- potential economic consequences – economic losses, including consequences for the environment;
- potential social consequences – loss of social trust, physical suffering caused, disruptions to normal life, loss of basic services, and so on.

[53] MRDPW (2014).
[54] CoM (2012).
[55] CoM (2012; art. 5, para. 2).
[56] CoM (2012; art. 7, para. 1).

188. The availability of detailed inventories of critical infrastructure is a prerequisite for adequate response in case of emergencies – including emergencies caused by extreme weather events. The ordinance is thus relevant to CCA in the transport sector and must be considered when formulating adaptation actions.

2.4.9. Climate Change Adaptation Strategy of the Municipality of Sofia

189. The *Climate Change Adaptation Strategy of the Municipality of Sofia (Sofia Municipality 2016)* has been prepared in 2016 as part of the *Covenant of Mayors for Climate and Energy* initiative.[57] Regarding the transport system of Sofia, it identifies the following general climate-related risks:

- Floods of underground infrastructure (metro and underpasses);
- Disruptions to the power of traffic management systems, trolleybuses, metro, private cars (due to floods, cold and other extreme climate factors);
- Discomfort to the users of the transport system (due to disruptions of the services).

190. As a result of the analysis, the following specific risks to the transport system are identified:

- Damage to the road pavement because of high temperatures and consequent increased risk of accidents;
- Discomfort to citizens in urban and suburban transport;
- Increased risk of accidents due to extreme rainfall;
- Increased need for cooling of passenger cars with air conditioning, resulting in higher than normal fuel consumption and consequently higher emissions;
- Risk of damage to road infrastructure due to intense rainfall;
- Risk of interruption of access from/to remote areas due to damaged road infrastructure;
- Delays and/or interruptions in the supply chain because of climatic factors.

191. The following climate factors are considered to have positive effect:

- Higher winter temperatures will reduce the risk of icing of transport infrastructure, as well as the periods with snow cover, which will reduce the related costs;
- Higher winter temperatures and less icing and snow on the roads will lead to less road accidents;
- Less icing and snow will result in less delays and/or interruptions in the supply chain.

192. As a conclusion, the Strategy recognizes that data collection must be improved significantly, so to provide for planning adequate CCA measures. A next step is the development of a specific plan for implementation of the strategy, as well as a performance evaluation framework to help monitor the implementation.

[57] For more information, see http://www.covenantofmayors.eu/

2.4.10. Design codes and regulations

193. Several transport infrastructure design codes are part of the Bulgarian legal framework. Some of them are:

- Ordinance No. 1 from 26 May 2000 for Design of Roads;
- Ordinance No. 2 from 29 June 2004 for Planning and Design of Communication and Transport Systems of Urbanized Areas;
- Ordinance No. 55 from 29 January 2004 for Design and Construction of Railway Lines, Rail Stations, Crossings and Other Elements of the Railway Infrastructure.

194. The ordinances for planning and design of transport infrastructure typically do not discuss issues related to the impact of climate change such as determining precipitation volumes, snow protection, accounting for thermal stress, and so on Usually these are focused on the purely technical aspects of construction of infrastructure. The requirements to drainage systems can serve as an illustration to this – none of the ordinances for design of roads, railways and urban transport systems prescribe methods for calculation of maximum precipitation quantities for the drainage systems; they are focused on specifying how the drainage systems must be constructed.

195. Issues, related to CCA, are discussed in separate guides and documents, which most often are not part of the legal framework. Notable such documents are:

- Instructions for Determining Bridge Spans (Patproject ca. 1980) (used in the design of roads since around 1980);
- Instructions for Determining Road Culverts' Spans (GRA 1998) (in use since 1998);
- Manual for Design of Asphalt Pavement (CRBL 2003) (the manual was published in 2003 but the aspects related to climate conditions are from before 1980);
- Standard pavement designs for streets, parking lots, pedestrian zones, sidewalks, alleys, and guidance for their application (MCA 1982) (in use since 1982; the aspects related to climate conditions are from before 1980);
- Technical Specification (RIA 2009) of the Road Infrastructure Agency (prescribes the use of polymer modified bitumen[58] to cope with thermal stress; in use since 2009);
- Technical Requirements for Elements of the Railway Infrastructure (NRIC 2005) (in use since 2005);
- Technical Requirements for Structure, Construction and Repair of CWR (NRIC 2010) (in use since 2010; ambient temperature is a major factor when installing CWR).

196. In summary, CCA issues are generally not addressed in the design codes that are part of the legal framework and are partially addressed in auxiliary guides and internal documents of the administrations managing the infrastructure. Unfortunately, most of these auxiliary documents are severely outdated. This issue is discussed in detail as part of section 3.9 'Gaps and Barriers'.

[58] For details see the discussion in section 2.8.2.

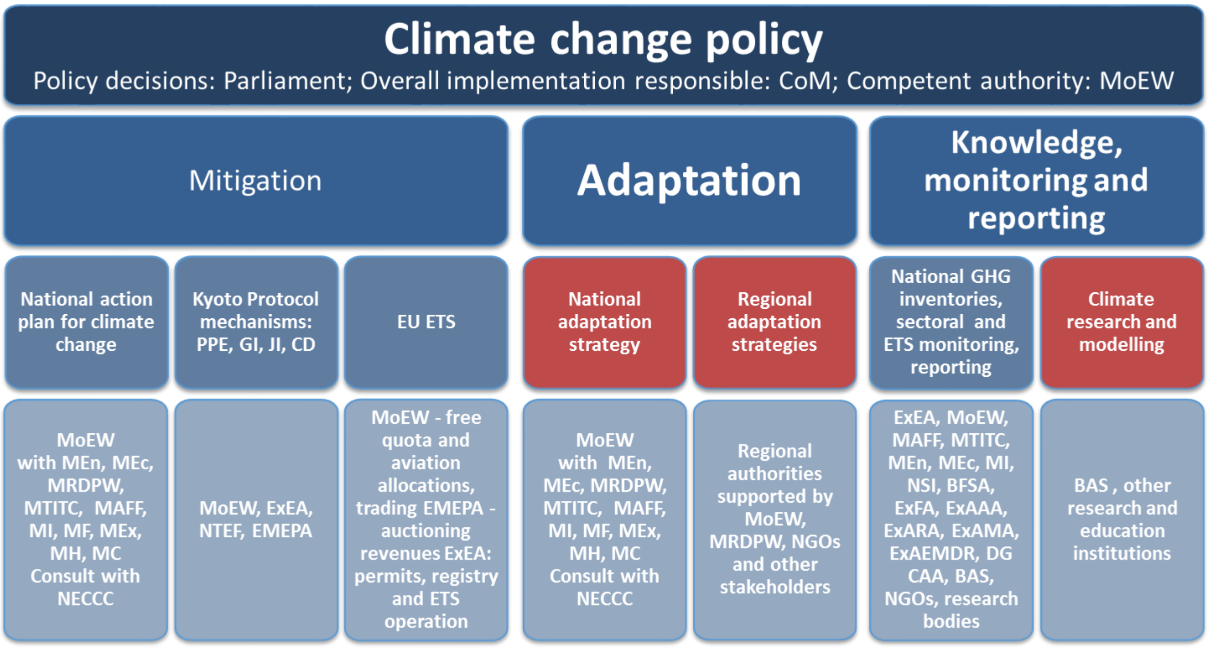
197. There is a need to adapt the design codes and regulations considering that climate change is generally recognized by the infrastructure managers[59] but the current level of adaptation is low.

2.5. Institutional Framework and Stakeholder Community in Bulgaria

2.5.1. Overview

198. The overall climate change policy institutional framework is presented in ***Figure 19***.

Figure 19. Structure and main actors in implementing the Bulgarian climate change policy



Note: All abbreviations used in this figure could be found in the Abbreviations and Acronyms section.

Source: World Bank design.

199. The institutional framework for the *transport sector* in Bulgaria at the policy-making level includes two main entities – the Ministry of Transport, Information Technology and Communications (MTITC) and the Ministry of Regional Development and Public Works (MRDPW).

200. At the *implementation level*, an extremely important role is played by the various agencies, companies and state enterprises under the two ministries. The most important such entities are the Road Infrastructure Agency (RIA), the National Railway Infrastructure Company (NRIC), the Bulgarian Ports Infrastructure Company (BPI), Executive Agency for Exploration and Maintenance of the Danube River (EAEMDR) and Directorate General Civil Aviation Administration (CAA).

201. Regarding the urban transport, the most important entities are the *municipalities* and the *public transport operators*. The municipalities are responsible for the preparation of general and transport masterplans and are in charge of employing and controlling the operators.

202. The duties and authority of the various entities in the transport sector, as well as the subordination between them, are described in this section. A table summarizing the duties and

[59] For an example, see the discussion in section 2.8.4.

responsibility of the transport sector public entities is presented as ***Annex 6***.

2.5.2. Ministry of Transport, Information Technology and Communications

203. MTITC is responsible for the development of the transport policy of the country. More specifically, the *National Transport Policy Directorate* has a leading role in the development of programs and strategies in the transport sector. With the most important funding source supporting the national transport policy being EU's Operational Programme Transport and Transport Infrastructure 2014–2020, the *Coordination of Programmes and Projects Directorate* (the Managing Authority for OPTTI) also plays an important role in the formation of the transport policy in Bulgaria.

204. MTITC does not have a dedicated unit specifically responsible for climate change adaptation and the *Safety, Technical Supervision and Crises Management Directorate* and the *European Coordination and International Cooperation Directorate* are involved in the subject as part of their general duties.

205. The Ministry has inspectors in charge with monitoring the safety of all modes of transport. They also register events like catastrophes, infrastructure failures, obstructions to the services, and so on

206. The following more important public administrations and companies are subordinated to MTITC:

- National Railway Infrastructure Company;
- Bulgarian Ports Infrastructure Company;
- Executive Agency Railway Administration (ExARA);
- Directorate General Civil Aviation Administration (CAA);
- Executive Agency Automobile Administration (ExAAA).
- Executive Agency Maritime Administration (ExAMA)
- Executive Agency for Exploration and Maintenance of the Danube River (ExAEMDR)
- Bulgarian Air Traffic Services Authority (BULATSA).

2.5.3. Ministry of Regional Development and Public Works

207. MRDPW has a wide scope of duties and authority. Of relevance to the transport sector is its governing role regarding the Road Infrastructure Agency.[60] MRDPW is also responsible for delivering guidance to municipalities regarding the development of masterplans, as well as the development and maintenance of the municipal road network.

208. With a limited role in the preparation of rehabilitation and construction programs on the national road network is *Directorate General Urban and Regional Development*. The DG is also Managing Authority for EU's Operational Programme Regions in Growth 2014–2020.

209. A unit with potential role in CCA is the *Technical Rules and Regulations Directorate*. The directorate is responsible for the preparation of the regulations regarding road infrastructure, more specifically road design and urban transport planning and design.

[60] Unlike many countries where the road administration is subordinate to the ministry of transport, in Bulgaria it is under the Ministry of Regional Development and Public Works.

"Geoprotection and public works" Directorate is responsible for registration and monitoring of landslides.[61]

210. MRDPW provides assistance and specialized technical support to municipal and district administrations, specialized and control bodies, and other state institutions in the event of emergencies related to the occurrence of unfavorable geodynamic processes, as well as ensures coordination between the different agencies for limiting landslides on the territory of the country, abrasive processes on the Black Sea, and erosion processes along the Danube coast through three geo-protection companies located in Varna, Pleven, and Pernik.

211. MRDPW does not have a unit responsible for climate change adaptation.

2.5.4. Ministry of Interior

212. MI is one of the largest ministries in Bulgaria (both in terms of budget and number of staff) and has a wide range of duties and responsibility related to the safety of the population. Of relevance to the transport sector is its role in the management of road traffic, reaction to road accidents, as well as response in emergencies of all modes of transport.

213. The Ministry participates in the preparation of policies and legislation related to emergency response and plays an important role in the coordination between the various stakeholders in case of emergencies. The Ministry has no duties and responsibility directly related to climate change and does not have a unit dedicated to climate change adaptation.

2.5.5. Road Infrastructure Agency

214. RIA is an administration under the MRDPW. It is responsible for the planning, development, operation and maintenance of the Bulgarian national road network. RIA is a beneficiary under OPTTI 2014–2020 and OPRG 2014–2020.

215. The *Design and Land Acquisition Directorate* of RIA is responsible for commissioning the designs of all projects of the agency. Two directorates are responsible for the implementation of new projects – the *Implementation of Projects under OP Regions in Growth Directorate* and the *Implementation of Projects under OP Transport and Transport Infrastructure Directorate*. The control over the maintenance of the national road network is responsibility of the *Maintenance of Road Infrastructure Directorate*.

216. A unit dedicated to the response to emergencies and monitoring the conditions of the NRN, is part of the *Maintenance of Road Infrastructure Directorate*. The agency does not have a unit responsible for climate change adaptation but has a unit within the *Design and Land Acquisition Directorate* responsible for EIA and AA procedures.

2.5.6. National Railway Infrastructure Company

217. NRIC is a state-owned enterprise in which the MTITC is the majority owner. It is responsible for the planning, development, operation and maintenance of the Bulgarian railway infrastructure network. NRIC is a beneficiary of OPTTI 2014–2020, too. Regarding the development of the railway network, the most important role is played by *Strategic Development and Investment Projects Directorate*, which is responsible for the preparation and

[61] Article 95, paragraph 1 of the Spatial Planning Act

implementation of railway projects under OPTTI 2014–2020.

218. Operation of the national railway network is the most important part of NRIC's duties and a number of divisions are responsible for different aspects of it. The safety of operations and emergency response is another important aspect of the work of NRIC. The company does not have a unit specialized in climate change adaptation or responsible for environmental issues in general.

2.5.7. Executive Agency Railway Administration

219. ExARA is an executive agency and a secondary manager of budget allocations within the MTITC. It is responsible for controlling the access to railway infrastructure of licensed operators and is the regulatory entity for railway transport. ExARA is also the National Safety Authority (NSA) for railway transport in Bulgaria. Finally, it controls the application of Regulation (EC) No. 1371/2007 of the European Parliament and the Council of 23 October 2007 on rail passengers' rights and obligations.

220. ExARA has the authority to propose to the Minister of Transport, Information Technology and Communication measures for avoiding, as well as mitigating the effects of natural disasters and accidents having impact on the railway infrastructure and services.

2.5.8. Bulgarian Ports Infrastructure Company

221. BPI Co. is a state-owned enterprise in which the MTITC is the majority owner. The state-owned company is responsible for managing the infrastructure of the national public ports. That includes the planning, development and maintenance of public ports of national importance; the development and maintenance of approach canals, port 'aquatories', sea and river depots for the disposal of dredging material, and so on

222. The second very important aspect of the activities of the BPI is that it develops, operates and maintains the system for monitoring of ship movement and the River Information System in the Bulgarian Part of the Danube (BULRIS). It is also responsible for navigation safety, provides services through the Global Maritime Distress and Safety System (GMDSS), as well as various other information services.

223. The *Strategic Planning, Port Services and Ecology Directorate* of BPI has duties related to the environmental protection.

2.5.9. Executive Agency for Exploration and Maintenance of the Danube River

224. ExAEMDR is a secondary manager of budget allocations within the MTITC. It is responsible for the maintenance of the waterway, the 'aquatory' of the ports and the winter camps to ensure safe navigation in the Bulgarian section of the Danube River. The Agency carries out complete hydro-morphological and hydrological surveys of the river and coordinates all activities related to the utilization of the Danube River.

225. ExAEMDR informs other authorities in case of precautionary measures against floods, corrosion of banks, and so on, are needed. The agency also publishes navigational maps, hydrological reference books and other navigational aids, two- and seven-day river level forecasts, as well as daily weather forecasts for the Bulgarian section of the river.

2.5.10. Executive Agency Maritime Administration

226. ExAMA is a secondary manager of budget allocations within the MTITC. It organizes and coordinates activities related to the safety of shipping at sea and inland waterways; ensures the actual liaison between the government and ships carrying the Bulgarian flag; exercises control on the observation of shipping safety requirements by ships; working and living conditions of seafarers; provision of services for traffic management and information on shipping maritime spaces, inland waterways, canals, ports in Bulgaria, and other duly defined regions; compliance with the quality requirements for marine fuels.

227. The Agency is also responsible for the organization and coordination of search and rescue of people, vessels, and aircraft in distress; the supervision and organization of the protection of the marine environment and the Danube River from pollution from ships; organization and conduction of examinations for competencies to seafarers; issuing certificates of competency to seafarers; and for maintenance of registers of ships, seafarers, ports and port operators in the Republic of Bulgaria.

2.5.11. Directorate General Civil Aviation Administration

228. DG CAA is a secondary manager of budget allocations within the Minister of transport, information technologies and communications. It is responsible for the safety of air traffic in Bulgaria. The *Aviation Safety Directorate* has a leading role in the development of safety strategies and analyses. It is also responsible for the control and enforcement of the existing safety requirements.

2.5.12. Bulgarian Air Traffic Services Authority

229. BULATSA is a state-owned enterprise in which the MTITC is the majority owner. The state-owned company is responsible for organizing the air traffic in Bulgaria.

230. BULATSA is mainly responsible for:

- Air traffic management and provision of air navigation services to enable the safe, efficient and expeditious flow of traffic in the controlled civil air space;
- Planning, provision, implementation, maintenance and operation of the relevant systems and equipment to ensure the communications, navigation, surveillance, power-supply, meteorological and aeronautical aspects of air traffic management and its supporting infrastructure;
- Provision of communications, navigation and surveillance services;
- Provision of meteorological services;
- Provision of aeronautical information services;
- Provision of information services for aircraft search and rescue operations;
- Management of the safety system in the framework of its vested competence;
- Fulfilment of the obligations of the Republic of Bulgaria arising from international agreements in the ATM area, to which the Republic of Bulgaria is a party;
- Collection of en-route charges for the provision of air navigation services.

2.5.13. Executive Agency Automobile Administration

231. The ExAAA is a secondary manager of budget allocations within the MTITC. Its main responsibility is control and regulation of the road public transport services, road transport of dangerous goods, vehicle roadworthiness, vehicles' certification and motor vehicles' driver qualification, licensing, improving qualification, psychological selection and others.

2.5.14. Municipalities

232. Municipalities have an important role in the transport sector. They are responsible for developing and maintaining the municipal street and road networks, which serve the highest share of short-distance trips by car. Municipalities are also responsible for developing and managing the public transport networks and services – bus, trolleybus, tram and metro.

233. Several Bulgarian municipalities are members of the *Covenant of Mayors for Climate and Energy* initiative, the largest of them being the municipalities of Sofia, Burgas and Varna. Most of the municipalities participating in the initiative have developed CCA strategies and action plans and have units with duties and responsibility related to CCA.

234. In some municipalities, there are public transport authorities that are intermediate bodies between the municipal administration and public transport operators. These authorities play an important role in the planning, development, operation and maintenance of the public transport networks. One such authority is the Sofia Urban Mobility Centre (SUMC) which has a wide range of responsibilities for the public transport on the territory of Sofia municipality.

2.5.15. Non-governmental organizations in the transport sector

235. Some of the more important NGOs in the transport sector are listed below:

- Bulgarian Construction Chamber (www.ksb.bg);
- Bulgarian Road Safety Branch Chamber (www.bbars.bg);
- National Association of the Municipalities in the Republic of Bulgaria (www.namrb.org);
- National Association of the Bulgarian Road Carriers (www.nabcbg.com);
- Union of International Haulers (www.smp-eu.org/bg/);
- Association of Bulgarian Enterprises for International Road Transport and the Roads (www.aebtri.com);
- Bulgarian Association of Road Transport Organisations (www.basat.eu);
- Association of Bulgarian Railway Carriers (www.abzp.eu).

2.6. Financial and Human Resources in Bulgaria

2.6.1. Overview

236. During the last decades, the *national financing* for the development of the transport infrastructure was mainly oriented to provision of national co-financing for programs funded from external sources. The main sources of funding have been EU co-financed programs and to a lesser extent - loans from IFIs.

237. This section focuses on the parameters of the main financing sources in the transport sector and the extent to which the CCA actions could be considered eligible for funding. *Operational Programme Transport and Transport Infrastructure* (OPTTI) 2014–2020 and *Operational Programme Regions in Growth* (OPRG) 2014–2020 are considered such sources. The Operational Programmes are based on the Partnership Agreement between Bulgaria and the EU for programming period 2014–2020 and further detail its provisions.

238. Regarding *human resources*, the availability (or lack thereof) of units with clear duties for CCA is noted in sub-chapter 2.5 for each particular stakeholder in the transport sector. In principle, only a few of the administrations discussed have units with responsibilities related to the protection of environment and none appear to have units or staff with responsibilities specifically related to CCA. A proposal for actions in this direction is formulated in Chapter 3.

2.6.2. Operational Programme Transport and Transport Infrastructure 2014-2020

239. OPTTI 2014–2020 consists of the following priority axes:

1) Development of *railway infrastructure* along the "core" Trans-European Transport Network (€673 million).
2) Development of *road infrastructure* along the "core" and "comprehensive" Trans-European transport network (€673 million).
3) Improvement of *intermodal transport services* for passengers and freights and development of sustainable *urban transport* (€425 million).
4) *Innovations* in management and services – establishment of modern infrastructure for traffic management and improvement of transport safety and security (€68 million).
5) Technical Assistance (€47 million).

The total amount to be financed under the programme is €1.887 billion.

240. The *railway infrastructure* priority axis supports the "*construction, modernization, rehabilitation, electrification and establishment of signaling and telecommunication systems of railway sections along the 'core' and 'comprehensive' Trans-European Transport Network*". The National Rail Infrastructure Company is the beneficiary under this priority axis.

241. Similarly, the *road infrastructure* priority axis is focused on the development of the national road network along the core and comprehensive Trans-European Transport Network (TEN-T). The Road Infrastructure Agency is the beneficiary under this priority axis.

242. The *intermodal transport* priority axis seeks to improve the intermodal services and, even more importantly, supports the development of the *Sofia metro*. The National Rail Infrastructure Company and the Sofia Metro Company are the beneficiaries under this priority axis.

243. The fourth priority axis is related to the *smart mobility*. It includes a wide variety of potential measures, like improvement of the navigation conditions on the Danube River, improvement of the access to the Bulgarian TEN-T ports, improved management of the air and railway transport, as well as the introduction of intelligent transport systems (ITS) on the road network along TEN-T. The beneficiaries under the priority axis are the Executive Agency for Exploration and Maintenance of the Danube River, the Bulgarian Port Infrastructure Company,

the Road Infrastructure Agency, the Maritime Administration Executive Agency, National Railway Infrastructure Company and Directorate General Civil Aviation Administration.

244. The *technical assistance* priority axis is intended to support the development of the administrative capacity of the beneficiaries and finance the development of strategic documents, plans, analyses, and so on All beneficiaries under the main priority axes are beneficiaries under the technical assistance axis.

245. Regarding *climate change mitigation*, OPTTI is expected to contribute to the overall objective of Bulgaria to reduce emissions from the transport sector. Special attention is given to the principles of sustainable development in the context of environmental protection, which are integrated into the implementation principles of all priority axes. The main way OPTTI is considered to contribute to climate change mitigation goals is the support of the development of 'green' modes of transport like railway transport, support intramodality and the introduction of smart mobility measures.

246. The Program explicitly refers to the guidelines for integrating resilience to climate change in the conventional lifecycle of assets and the defined modules in the process of resistance to climate change developed in the *Non-Paper Guidelines for Project Managers: Making vulnerable investments climate resilient* (DG CLIMA 2013). OPTTI contributes to CCA in a direct way with the support of the development of information systems for early warning and monitoring of emergency events; forecasting of disasters and information provision, coordination and exchange of data between the stakeholders, and so on

247. In principle, consideration of CCA is made in all steps of the project preparation and implementation process. Firstly, CCA is considered at the program level (in the program itself and in its environmental assessment). Secondly, at the project level CCA is to be part of the feasibility studies for the specific project proposals. The issue is also explicitly discussed in the applications for funding of major[62] projects. Consequently, no project could be financed under the program, unless CCA is given all due consideration.[63]

248. The Program contains an estimate of the amounts likely to be spent on climate change adaptation and mitigation,[64] and that amounts to €394,635,288, or 24.6 percent, of the total allocation under the Program.

249. OPTTI is a possible source of funding for CCA measures in the transport sector. The best option for this would be the '*smart mobility'* axis of the program – priority axis 4 'Innovations in management and services' – deployment of modern infrastructure for traffic management and improvement of transport safety and security. Eligible for funding would be activities such as the development of transport plans and strategies related to CCA, as well as the implementation of some CCA measures (for example information systems, navigation and emergency systems, and so on). If such projects would be related to one of the available modes of transport, the initiative must be initiated by one of the beneficiaries of the priority axis. If the issue concerned is related to more than one mode of transport, it could be the Managing

[62] Projects are considered 'major' if their expected total cost amounts to more than € 75 million (for more information see the CPR). All projects under priority axes 1 and 2 of OPTTI are major.
[63] This is an explicit requirement of Article 101 (f) of the CPR.
[64] With reference to Article 27(6) of Regulation (EU) No 1303/2013.

Authority of the program to initiate the process.

2.6.3. Operational Programme 'Regions in Growth 2014–2020'

250. OPRG 2014–2020 consists of the following priority axes:

1. Sustainable and integrated *urban development* (€840 million).
2. Support for *energy efficiency* in support centers in peripheral areas (€105 million).
3. Regional *educational infrastructure* (€114 million).
4. Regional *health infrastructure* (€83 million).
5. Regional *social infrastructure* (€50 million).
6. Regional *tourism* (€100 million).
7. Regional *road infrastructure* (€194 million).
8. Technical assistance (€52 million).

The total amount to be financed under the program is €1.543 billion.

251. The *urban development* priority axis is the largest by funding. The urban development investments are based on Integrated Plans for Urban Regeneration and Development (IPURD), the development of which has started during the 2007–2013 programming period. It is expected that the development of sustainable urban transport is supported under this axis.

252. The *energy efficiency* priority axis is targeted at supporting energy efficiency measures in both public buildings and residential buildings in smaller towns, such as peripheral municipal centers. The priority axes for *educational, health and social infrastructure* are focused on supporting these types of infrastructure in specific aspects like social inclusion and improvement of the base level of social services in the country. The *regional tourism* priority axis supports the conservation, protection, promotion and development of the cultural heritage in the country. Possible beneficiaries under these priority axes are municipalities.

253. Regional *road infrastructure* priority axis is targeted at investments in the 1st, 2nd and 3rd class national roads to improve the connectivity and accessibility of secondary and tertiary territorial nodes with the TEN-T network. The projects financed under the axis are expected to be mostly for rehabilitation and upgrading of existing roads. The beneficiary under this priority axis is the Road Infrastructure Agency.

254. Regarding *climate change mitigation*, OPRG is expected to contribute to the overall objective of Bulgaria to reduce emissions from the transport sector. The main way OPRG is considered to contribute to climate change mitigation goals is the support of the development of public transport and modal shift from private cars, as well as with the introduction of smart mobility measures. This role is especially important as the emissions from urban road transport have a major share in the total emissions from the transport sector.

255. OPRG contributes to CCA in a direct way with the support of the development of public transport information systems. Like OPTTI, consideration of the CCA is made in all steps of the project preparation and implementation process – at the program level (in the program itself and in its environmental assessment) and at the project level, as CCA must be part of the feasibility studies for the specific project proposals. CCA is also explicitly discussed in the

applications for funding of the major projects and no infrastructure project could be financed under the program, unless CCA is given all due consideration.

256. The Program contains an estimate of the amounts likely to be spent on climate change adaptation and mitigation,[65] and that amounts to €429,110,869, or 32.71 percent, of the total allocation under the program. The implementation of CCA measures in the transport sector should be possible under OPRG if the measures are included in the integrated plans for urban reconstruction and development, needed as a precondition to fund urban projects.

2.7. Sector Participation in CC(A) Specific International Cooperation or Information Exchange

257. Information exchange initiatives are key to the development of CCA measures in the sector. An example for international cooperation in CCA in the transport sector is the *Adriatic-Danube-Black Sea Multimodal Platform* project (mentioned in sub-chapter 2.2).

258. Such initiatives should be made more frequent and the involvement of a wider range of stakeholders must be sought. The CCA legislation at the EU level requires public entities to be more active in CCA in the transport sector. Other parties, like NGOs, must also be involved in planning and implementing CCA initiatives. This seems a possible area of improvement and future actions.

2.8. Bulgarian Transport Sector Specific Ongoing and Foreseen CCA Related Actions

2.8.1. Overview

259. So far, the approach to CCA in the Bulgarian transport sector has not been very systematic. Specific climate change-related issues have been identified by the stakeholders who have sometimes also attempted to resolve them on a case by case basis. This section presents some examples of CCA actions taken (or in discussion) in the various transport subsectors.

2.8.2. Use of polymer modified bitumen

260. Polymer Modified Bitumen (PMB) is of the specially designed and engineered bitumen grades that is used in pavement for roads with heavy traffic and for home roofing solutions to withstand extreme weather conditions. Adding polymer to the bitumen results in extra strength, high cohesiveness and resistance to fatigue, stripping and deformations. This makes the material favorable for road infrastructure and it is especially interesting in the context of increasing maximum temperatures (and increasing temperature range in general).

261. In the last decade, there has been a notable shift towards the use of PMB in the Bulgarian road sector. Requirements to PMB are given in the standard Technical Specification (RIA 2009) of the Road Infrastructure Agency. The use of PMB in pavement is explicitly required by the specification, based on a number of criteria (RIA 2009; section 5103.5). These are related to the class of the road (motorway, first class, and so on), the forecasted traffic levels (with specific thresholds) and longitudinal gradient (above or below 4.5 percent). For the higher-class roads and the highest levels of traffic the PMB shall be used for both the wearing

[65] With reference to Article 27(6) of Regulation (EU) No 1303/2013.

course and for binder course layers, whilst for lower classes and traffic levels only the wearing course shall be made with PMB. The traffic criteria are set in such a way that almost all new roads, part of the NRN, shall be built with at least the wearing course made with PMB.

262. The use of PMB in heavy duty roads is considered to reduce rutting and to generally improve the pavement resilience to weather (and hence increased its lifetime). Although the positive effects of the use of PMB are generally recognized, it seems there are no studies aiming to evaluate the experience gained so far in Bulgaria and to quantify its effects on the NRN level.

2.8.3. Stopping of heavy vehicles during hot weather

263. For several years, the Road Infrastructure Agency has regularly been issuing temporary traffic management orders restricting the traffic of heavy vehicles with a total weight exceeding 12 tons on the NRN in periods with ambient temperature of more than 35°C. The goal of this measure has been to reduce damage to the road pavement due to high temperatures.

264. The restrictions have caused a lot of inconvenience and losses to freight operators. Operators' associations have repeatedly threatened the authorities with protests and eventually, in 2016, an agreement to abandon the limitations has been reached between representatives of the freight operators and RIA.[66] Strong argument raised by the operators it that none of the neighboring countries, such as Greece, Turkey, and so on, restrict traffic in relation to the temperatures.

265. The limitations to heavy traffic in warm weather are a good example of a CCA measure. However, the economic profitability of such measure is not clear. Whilst the measure certainly helps reduce the damage to pavement, the reduction of costs for pavement repairs is not trivial to quantify. At the same time the measure results in increased costs to freight operators in terms of time and reliability losses, as well as, in some cases, direct damage to the goods being transported. The economic effects of the measure, as well as of the temperature level above which such traffic restrictions would have positive impact, certainly deserve to be studied in more detail.

2.8.4. Revision of the road design codes

266. The Bulgarian road design codes have not been revised since 2000. In 2012–2013 discussions within the administration and with the private sector regarding the scope of a possible update of the road design codes commenced. A number of issues that needed to be addressed were identified, some of them related to CCA. Most important in this regard were the ideas to revise the existing guidance for calculating dimensions of culverts and bridges, as well as the guidance in use for pavement design.[67] Furthermore, these revised methodologies had to be made part of the new road design codes and not remain as separate documents.

267. The MRDPW commissioned an update of the road design codes in 2014 to the University of Architecture, Civil Engineering and Geodesy (Sofia). A draft version of the codes has eventually been submitted to MRDPW in March 2017 and the codes remain to be formally adopted and issued. Unfortunately, this draft version appears to represent only minor updates of the old road design codes and does not include the additions and revisions related to CCA,

[66] News.bg, 2016. HGVs will no longer be stopped in hot days and peak periods.
[67] The current practice and documents in use are presented in more detail in section 2.9 of this report.

as were the original ideas and intentions.

2.8.5. Improvement of Danube River Navigation Status

268. The responsibility for maintaining the navigation along the common Bulgarian and Romanian section of the Danube River is shared between the two countries. The ExAEMDR is responsible for the maintenance from Bulgarian side. There are several sections which are problematic during periods of low water levels and the ExAEMDR is responsible for preparing plans and projects to remedy the situation. This can be done by deepening selected routes in the river and stabilizing the bottom and the banks.

269. Most notably, during the programming 2007–2013 period, ExAEMDR has been preparing a project for improving the navigation status along sections near Batin (between 530 and 520 river km) and Belene (between 576 and 560 river km), which are the most problematic. Part of the preparation was an EIA report, which was not favorably accepted by some NGOs. The efforts to bring improvement in these sections have continued during programming period 2014–2020.

270. Furthermore, ExAEMDR has been the beneficiary of a project to improve the navigation systems along Danube and increase the safety of the users.

2.8.6. Sofia Airport improvements

271. Fog is not an unusual event for the area of the capital city of Sofia. Dense fog disturbs the entire transport system but is especially problematic to air transport. In the event of fog, departure flights from Sofia international airport are sometimes cancelled and arriving flights are rerouted to other airports (for example to the Plovdiv, Belgrade or Bucharest international airports).

272. As a measure to reduce the influence of fog on the air traffic, in 2013 Sofia Airport installed modern equipment and obtained a license for the class IIIB instrumental landing system (ILS).[68] The system is operational since 14 November 2013 and allows landing of planes at visibility of not less than 75 m of properly equipped planes. The lower IIIA ILS class allows landing at visibility of not less than 200 m and the higher IIIC class allows landing at zero visibility.

2.9. Gaps and Barriers Hindering Adequate Response to CCA Action; Interface with Climate Change Mitigation

2.9.1. Overview

273. There are some gaps identified in the rules and regulations for design of road and railway bridges, culverts and other drainage structures. As floods are considered as one of the most significant threats to transport infrastructure,[69] this is likely to be a serious problem.

274. Similarly, some gaps are observed in the rules and regulations for designing the pavement of roads and streets.

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[68] Mediapool, 2013. *Sofia Airport now accepts planes at only 75 m visibility*. http://www.mediapool.bg/letishte-sofiya-veche-shte-priema-samoleti-i-pri-edva-75-m-vidimost-news213485.html

[69] See section 2.3 'Risks and Vulnerabilities' of this report.

275. This section summarizes the existing rules and regulations for design of some critical elements of the road and railway infrastructure. An attempt is made to identify the main deficiencies in these documents.

2.9.2. Design of road bridges

276. One of the most important and early decisions in the design of bridges is the determination of its span, considering mainly the expected water quantities. For this purpose, Bulgarian road designers use a document named *Instructions for Determining Bridge Spans* (Patproject ca. 1980). Until 1989, Patproject was the main state-owned road design bureau in the country and the document is a temporary internal instruction issued around 1980, which effect was supposed to be evaluated within a year of the start of its application. More than 35 years later the instruction is still used by road designers and there is no other guidance or explicit legal requirement for the use of a specific design standard.

277. The instruction determines expected lifetime for concrete and steel bridges of 50 years and in line with this, the span and height of the structure is set such that safe operation is ensured at water levels not exceeding 50 years' forecast values.

278. The instruction describes three methods for determining the water levels:

- in accordance with the catchment area;
- in accordance with the 'wet' profile of the river;
- in accordance with multiannual measurements from the local hydrological service.

279. The *catchment area method* relies on data for rainfall and coefficients for considering the variance of rain intensity that are included in the instruction (from about 1980). These parameters are known to vary with time and, considering the age of the instruction, are very likely to need an update.

280. The *wet profile method* relies on observations of the level of high waters that can visually be determined *in situ* or by reference from people living in the area. This is known to be very sensitive to the values of some of its input parameters (like water body longitudinal gradient and river bed roughness), it is also uncertain whether the high-water levels, as observed on a single occasion, give sufficient guarantee for the lifetime of the bridge.

281. *Multiannual measurements from the local hydrological service* are the most objective and reliable method, but often such data are not available. If available, this is the best and the preferred method to be used. This is the case with most bridges being designed in Bulgaria nowadays.

2.9.3. Design of road culverts

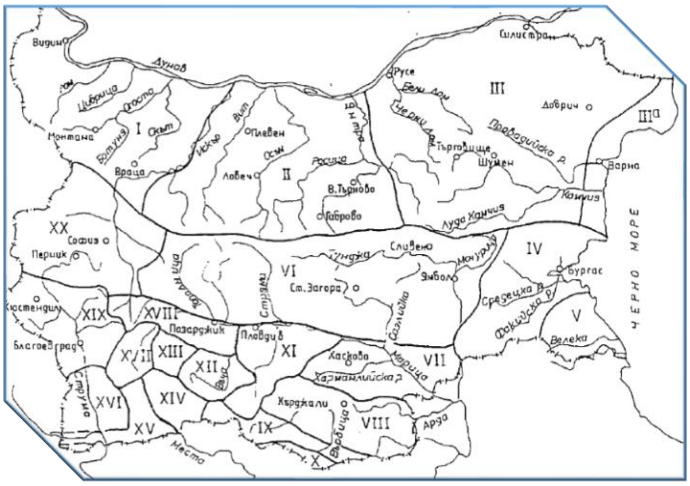
282. Like bridges, a major decision with culverts is the determination of their type and cross-section, which decisions heavily influence culverts' water throughput. A document used for this purpose is the *Instructions for Determining Road Culverts' Spans* (GRA 1998). It has been issued by the General Road Administration in 1998 (nowadays the Road Infrastructure Agency) and has been in use ever since.

283. The approach adopted is like the catchment area method for determining the spans of bridges. Again, an important input in the design process is the maximum quantity of daily

rainfall. This parameter is determined in accordance with the zone the drainage structure is in (determined from ***Figure 20***), as well as the elevation of the catchment area above sea-level.

284. The maximum daily rainfall is known to vary with time and considering the age of the instruction (since 1998) the data included is very likely to need an update.

Figure 20. Zones for determining the maximum daily rainfall



Source: GRA, Instructions for Determining Road Culverts' Spans, 1998.

2.9.4. Design of road pavement

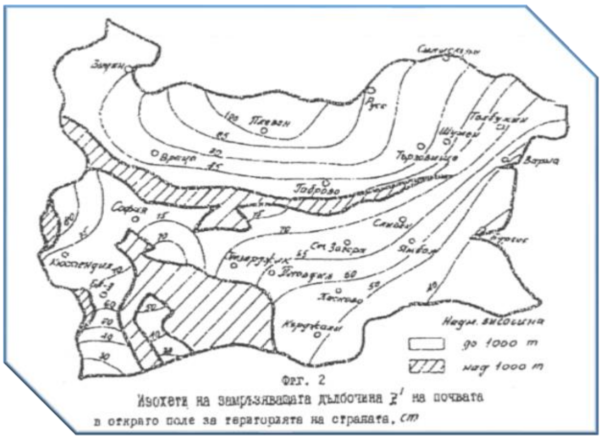
285. The main document in use for the design of asphalt concrete road pavement is the *Manual for Design of Asphalt Pavement* (CRBL 2003). The manual is issued by the Central Roads and Bridges Laboratory, part of the Road Executive Agency (the predecessor of RIA).

286. The manual presents four pavement design methods. The first one was proposed by the Asphalt Institute (USA), the second is an AASHTO standard, the third is a method of the Transport Research Laboratory (UK) and last is a method referred to as Professor Ivanov's method (USSR; Professor Ivanov's method has been by far the best-known in Bulgaria).

287. All pavement design methods are 'adapted' to the Bulgarian conditions: that is, the manual provides a common discussion on issues such as traffic volumes, standard loads, coping with the hydrological conditions and depth of freezing. The latter is one of the main factors that determine the pavement thickness (and to a lesser extent the materials used for its layers).

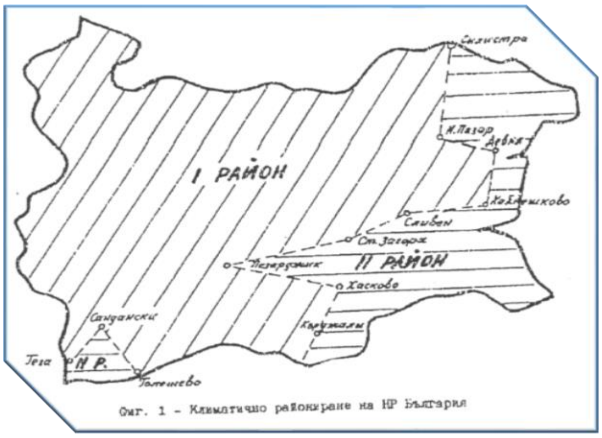
288. The manual uses a graph (shown on ***Figure 21***) to determine the maximum depth of freezing, dependent on the location of the road. No reference is available to the source of this graph (as well as to the climate zoning of Bulgaria shown in ***Figure 22***), but it is likely that both graphs were made no later than the 1980's or perhaps even the 1970's.

Figure 21. Depth of freezing in cm for Bulgaria



Source: CRBL, Manual for Design of Asphalt Pavement, 2003.

Figure 22. Bulgarian climate regions (CRBL, 2003)



Source: CRBL, Manual for Design of Asphalt Pavement, 2003.

289. Since winter temperatures have generally increased since the 1980's and this trend is likely to remain, it could be expected that the depth of freezing will tend to decrease. The use of outdated depth of freezing data could result in a bias of all pavement design methods towards unnecessary big thickness of the pavements designed in the country. Pavement is one of the most expensive components of road construction projects and bigger pavement thickness would directly lead to higher construction costs.

290. Finally, as indicated in sub-chapter 2.8, the use of polymer modified bitumen has become standard for the country in recent years. Its long-term economic effect, however, has not been formally evaluated yet.

2.9.5. Design of street pavement

291. Street pavements in Bulgaria are designed in accordance with the *Standard pavement designs for streets, parking lots, pedestrian zones, sidewalks, alleys, and guidance for their application* (MCA 1982) of the Ministry of Construction and Architecture (now MRDPW) from 1982. The document prescribes the use of certain standard pavement designs to be adapted in accordance with the specific conditions.

292. Regarding the depth of freezing and climate zoning, the document relies on the very same diagrams (shown in ***Figures 21*** and ***22***), as the pavement design manual (CRBL 2003). This means that the pavement thicknesses determined under the street pavement design guidelines are possibly unnecessary big for the present and forecasted climate conditions.

293. The standard pavement designs are in use today, although for particularly heavy-duty streets and boulevards designers often use the road pavement design manual (see section 2.9.4).

2.9.6. Design of railway bridges and culverts

294. The design of railways is regulated by several documents. The most important of them is *Ordinance No. 55 from 29 January 2004 for Design and Construction of Railway Lines, Rail Stations, Crossings and Other Elements of the Railway Infrastructure* (MTITC 2004). The Ordinance discusses various issues related to the design of railway infrastructure but does not provide any specific prescriptions related to the design of bridges and culverts. Specific

requirements on the construction of culverts are included in the *Technical Requirements for Elements of the Railway Infrastructure* (NRIC 2005). Like the methodologies for calculating the dimensions of road bridges and culverts, the methodologies in use in the railway sector need to be reviewed and possibly updated.

2.10 Conclusions

295. CCA awareness among key transport sector stakeholders is not at a high level. Overall, policy documents focus on measures to mitigate the adverse effect of the transport sector on the environment. Reverse climate change effects on the sector are almost not dealt with.

296. In road and inland waterway transport some measures that correlate to climate change were designed and partially applied. However, it seems these are considered in the framework of improving infrastructure performance in general or as attempt to solve issues on a case-by-case basis and not as structured and planned efforts to address the effects of climate change.

297. Direct consequences of a lack of systematic studies on the longer-term impacts of climate change, specifically in the Bulgarian transport sector, are not only the relatively low climate change interest among transport sector stakeholders, but also a stronger focus on short term actions as a response to emergencies rather than developing strategies and long-term action plans to address future problems. This results in a relatively low adaptive capacity of the sector. The lack of availability and quality of statistical data over a longer period, required to support the planning process, is another barrier for setting sound programs that can address the challenges that the transport sector faces and is expected to further and increasingly face.

298. Although a positive trend was observed, much remains to be done in pursuing a more systematic approach and understanding of CC issues and their importance by stakeholders.

Chapter 3. Adaptation Options

Introduction

Types of adaptation

299. Climate change adaptation options can be categorized as contributing to either (UKCIP, no date; p. 12):

- building adaptive capacity; or
- delivering adaptation actions.

300. Adaptive capacity is supported by enhancing the availability of information (data collection, scientific research, awareness rising), building the necessary governance tools (procedures, codes, standards, guidelines and legislation), as well as building and strengthening institutional capacity (organizational development, partnerships between the institutions, partnerships with NGOs).

301. The second category of adaptation options includes specific actions that help to reduce climate change vulnerability. Whilst adaptation actions often occur naturally, they can become more efficient if planned and implemented in a systematic fashion – and this is one of the main goals of building adaptive capacity.

302. The adaptive capacity of the Bulgarian transport sector has been reviewed as part of the 2014 RVA and the conclusion is that *the adaptive capacity is not sufficient* (MoEW 2014; pp. 147-148). The review of the policy context made in this study[70] also suggests that there is a substantial room for improvement of the adaptive capacity.

Adaptation principles

303. Before attempting to identify concrete adaptation options it is important to define key principles and criteria the options must comply with. Some of the most important such principles and criteria are listed below. Adaptation options must be (Defra 2010; p. 15):

- *Sustainable* – sustainability is expected to ensure that threats are minimized but also that opportunities are taken good use of.
- *Proportionate and integrated* – response to climate change must become 'business as usual' and part of the normal workflow of the stakeholders.
- *Collaborative and open* – as climate change has global effect on economy and society, the response to it must be joint and requires collaborative actions involving a wide range of stakeholders and individuals.
- *Effective* – actions must be context specific, implementable, and enforceable.
- *Efficient* – it is critical to attempt to weigh the costs, benefits and risks involved. The results of the actions should be measurable.
- *Equitable* – the consequences of the different options must be distributed within the society in a fair manner and it vulnerable individuals or groups must not bear a disproportionate share of the adaptation costs or residual risks.

[70] For details see section 3.2.2 'Adaptive Capacity of the Stakeholders' and ***Annex 5***.

304. Finally, adaptation options must be *specific*. Adaptation policy making sometimes suffers from lack of concrete actions (SWD (2013) 134, p. 21) and emphasis is often put on the statement of only general intentions and principles.

3.1. Identified Adaptation Options

3.1.1. Overview

305. To achieve efficient CCA action, it is necessary to identify concrete adaptation options. This section first looks at the general areas where adaptation options can be sought and based on the conclusions of the risk and vulnerability assessment (Chapter 1) and the present state of affairs (Chapter 2), formulates a long list of specific adaptation options.

306. The long list of CCA options was presented to the main stakeholders and discussed with them at the Sector Consultation Session. Based on the feedback received, the adaptation options included were assessed for their relevance and priority.

307. There are several areas where adaptation options with relevance to the transport infrastructure can be sought, and namely:

- *Design codes* – the design codes, regulations and guidelines must be (regularly) reviewed and revised to account for climate change and this is widely recognized in the available CCA strategies and literature;
- *Project preparation* – the formal and informal practices, rules and guidelines related to transport infrastructure project preparation need to be review and supplemented to account for climate change; the use of standard forms and documents (specially to aid CCA) is of great benefit to the quality of the project preparation process;
- *Operation and maintenance* – the two main groups of aspects that need to be considered are: (a) the ones related to the level of service to the users of infrastructure; and (b) the ones related to efficient response to extreme weather-related events and their impact on the transport infrastructure;
- *Emergency response* – most extreme weather-related events have the potential to cause emergency situations and adequate response to such events is of critical importance;
- *Data collection* – the availability of detailed and reliable statistical data for the transport systems allows better identification of climate-related issues, formulation of adaptation measures and evaluation of the results;
- *Institutional capacity building* – spreading knowledge regarding climate change mitigation and adaptation is needed to support the formulation and implementation of all policies related to these issues.

308. Each of these adaptation option groups, and their relevance to the Bulgarian transport sector, are detailed below. A complete list of the specific adaptation options proposed in this section is presented as ***Annex 2***.

3.1.2. Review and update design codes

309. As discussed in Chapter 2, at present there appears to be significant gaps in the adoption of CCA provisions in the transport infrastructure design standards. CCA issues are generally not addressed as part of the legal framework and are only partially addressed in the design codes and supplementary guidelines. These documents are often outdated and do not provide designing of transport infrastructure in a sustainable and efficient manner.[71] In addition to that, the design codes and guidelines sometimes use ambiguous and complex language, which can render their application problematic.

310. Design codes and guidelines, especially in the road and railway sectors, do not focus on the appropriate sizing of infrastructure or, in other words, determining the capacity of existing or planned facilities and assessing their potential to meet future demand. It is recommended that the Bulgarian design codes and guidelines start shifting from their present prescription-based model to a more problem oriented model.

311. The need to update and improve the deign codes, also to consider CCA, is often recognized by the Bulgarian infrastructure managers but systematic efforts to address the issue are yet to take place.

312. One of the areas in which the transport sector (and especially the road and railway subsectors) does not appear to be sufficiently adapted is the design of drainage systems. The guidelines in use for dimensioning culverts and determining bridge spans are first, outdated and, secondly, do not constitute legal requirements to the designers.

313. Similarly, the guidelines for design of road and street pavement include outdated data regarding the depths of freezing in the different regions of the country. This is likely to lead to bigger pavement thicknesses than necessary and hence lead to higher construction costs.

314. In principle, the efforts to update the design codes and guidelines should attempt to cover reasonably long future periods. In no case these periods should be shorter than the expected lifecycle of the infrastructure being designed.

315. Some adaptation actions have taken place in the recent years (for example the introduction of requirements for the use of polymer modified bitumen in bituminous asphalt pavement) but their effects do not appear to have been systematically evaluated. It seems useful to bridge this gap.

316. Finally, as parts of the design codes, regulations and guidelines appear to be outdated, the introduction of a formal mechanism to regularly review and revise these is worth considering by the stakeholders. In no case the eventual amendments in the design codes could result in delays in projects' approval and/or implementation and cannot be reason for claims, because the amended codes would become mandatory from the moment of their official adoption and could not have retroactive effect over time.

317. Specific adaptation options proposed are summarized in ***Table 15***.

[71] For details, see section 2.4.9 'Design Codes and Regulations'.

Table 15. Climate change adaptation options – review and update of design codes

CLIMATE CHANGE ADAPTATION OPTIONS		
I. Review and update design codes		
1. Update of guidelines for design of roads' culverts **2.** Update the guidelines for design of railways' culverts **3.** Update the guidelines for determining roads' bridge spans **4.** Update the guidelines for determining railways' bridge spans **5.** Update of the guidelines for bituminous asphalt pavement design of roads **6.** Update of the guidelines for bituminous asphalt pavement design of streets **7.** Review and evaluate the effect of the use of polymer modified bitumen in road pavements **8.** Regular update of design codes		
Subsector	**Description**	**Potential participants**
Roads	Update the guidelines for *design of culverts* to reflect the projected changes in the maximum water quantities in the different regions of the country. Consider including the guidelines, or at least some general requirements, in Ordinance No. 1 from 26 May 2000 for Design of Roads, so that they become a part of the legal framework.	MRDPW, RIA
Railways	Update the guidelines for *design of culverts* to reflect the projected changes in the maximum water quantities in the different regions of the country. Consider including the guidelines, or at least some general requirements, in Ordinance No. 55 from 29 January 2004 for Design and Construction of Railway Lines, Rail Stations, Crossings and Other Elements of the Railway Infrastructure, so that they become a part of the legal framework.	MTITC, NRIC
Roads	Update the guidelines for *determining bridge spans* to reflect the projected climate conditions. Consider including the guidelines, or at least some general requirements, in Ordinance No. 1 from 26 May 2000 for Design of Roads, so that they become a part of the legal framework.	MRDPW, RIA
Railways	Update the guidelines for *determining bridge spans* to reflect the projected climate conditions. Consider including the guidelines, or at least some general requirements, in Ordinance No. 55 from 29 January 2004 for Design and Construction of Railway Lines, Rail Stations, Crossings and Other Elements of the Railway Infrastructure, so that they become a part of the legal framework.	MTITC, NRIC
Roads	Update of the guidelines for *bituminous asphalt pavement design of roads* with new depth of freezing data. Consider including the guidelines, or at least some general requirements, in Ordinance No. 1 from 26 May 2000 for Design of Roads, so that they become a part of the legal framework.	MRDPW, RIA

Subsector	Description	Potential participants
Roads	Update of the guidelines *for bituminous asphalt pavement design of streets* with new depth of freezing data. Consider including the guidelines, or at least some general requirements, in Ordinance No. 2 from 29 June 2004 for Planning and Design of Communication and Transport Systems of Urbanised Areas, so that they become a part of the legal framework.	MRDPW, municipalities
Roads	Review the requirements of RIA's Technical Specification for use of *polymer modified bitumen* in pavement and evaluate the results of their application. Consider including such requirements in Ordinance No. 1 from 26 May 2000 for Design of Roads, so that they become a part of the legal framework.	MRDPW, RIA
Roads Railways	Introduce a formal requirement to RIA and NRIC to review the design codes on a regular fixed term – for example 2-5 years.	MTITC, MRDPW

3.1.3. Review and enhancement of project preparation procedures

318. The preparation of transport infrastructure projects is a complex and sensitive process. It requires coordinated management of many concurrent activities and it is critical to the final success of projects. From the CCA perspective, project preparation is an especially important stage of the project cycle where the risks of climate change should be addressed. Certainly, transport infrastructure projects can be adapted to climate change after they have been implemented but taking climate change considerations into account from the preparation stage is much easier and has the potential to decrease the associated costs.

319. From the purely technical perspective, infrastructure project preparation has a number of distinguishable phases:

- *Project identification* – formulation of the goals of the project (the problems to be solved) and the general means to achieve the goals (how to solve the problems identified);
- *Feasibility study* – formulation of several project alternatives to be compared, that is, development of alignment options in line with identified risks (floods, landslides, and so on); comparison of these alternatives; selection of a preferred alternative;
- *Design* – collection of data (including climate-related) necessary for the design; design of the preferred alternative in one or more stages; check whether the design is in line with the relevant climate change risks; when the design is ready, consultations with various stakeholders.

320. The need to consider climate change in the project preparation process is recognized in the legislation at the EU level and perhaps most notably in the CPR.[72] These requirements are directly translated to the local context by the Partnership Agreement for the 2014–2020 programming period and to the relevant Operational Programmes.[73]

[72] For details see section 2.3 'EU Legal Framework and Policies'.
[73] For details see section 2.4 'National Legal Framework and Policies'.

321. Although CCA is in principle considered in the legal framework related to the preparation of transport infrastructure projects, at the level of the stakeholders there are rarely written guidelines on project preparation and CCA. Usually projects are developed using informal 'rules of thumb' – an approach which has some merit but is certainly inferior to the application of formalized project development frameworks.

322. The development of more rigorous project preparation guidelines with clear references to address CCA issues would greatly benefit most of the stakeholders in the transport sector, which are responsible for the development of the transport infrastructure. This would generally increase the quality of project preparation and will allow CCA to be better considered. As some issues are common to many stakeholders, it may be feasible that the Managing Authorities of OPTTI and OPRG develop general guidelines, recommendations and standard forms for integrating CCA in the project preparation process to all beneficiaries of the programs.

323. Specific adaptation options proposed are summarized in ***Table 16***.

Table 16. Climate change adaptation options – review and enhancement of project preparation procedures

CLIMATE CHANGE ADAPTATION OPTIONS		
II. Review and enhance project preparation procedures		
9. Development of common guidelines **10.** Review of current practices and development of road projects' preparation manual **11.** Review of current practices and development of railway projects' preparation **12.** Review of current practices and development of waterborne projects' preparation **13.** Review of current practices and development of airborne projects' preparation		
Subsector	**Description**	**Potential participants**
All subsectors	Development of *common guidelines* to all beneficiaries for taking CCA into consideration in the project preparation process.	The Managing Authorities of OPTTI and OPRG
Roads	Review the current project preparation practices and rules and based on them develop a comprehensive *project preparation manual*, considering CCA issues.	RIA
Railways	Review the current project preparation practices and rules and based on them develop a comprehensive *project preparation manual*, considering CCA issues.	NRIC
Water	Review the current project preparation practices and rules and based on them develop a comprehensive *project preparation manual*, considering CCA issues.	BPI, ExAEMDR
Air	Review the current project preparation practices and rules and based on them develop a comprehensive *project preparation manual*, considering CCA issues.	DG CAA

3.1.4. Review and improvement of operation and maintenance standards

324. Regarding CCA, operation and maintenance standards have two main goals:

- Keeping an acceptable level of service[74] – reduction of the periods with transport operation disruptions due to extreme weather-related events; and
- Reduction of the damage to infrastructure – manage operation and maintenance in a manner that reduces the damage to transport infrastructure caused by extreme weather-related events.

325. First precondition in this respect is availability of weather monitoring and forecast data to enable both transport infrastructure managers and operators to react in the best way to meeting extreme events and in the long run to better adapt to climate change. These types of data allow to better understand the specific vulnerabilities that local infrastructure faces from extreme weather and long-term climate change. The NIMH-BAS provides meteorological and hydrological forecasts and monitors the amount of precipitation, surface and groundwater. While short-term forecast data at regional level are disseminated free of charge, more detailed data at local level would be very beneficial.

326. To achieve improvement in operation and maintenance standards, it is extremely important to know which the critical sections of the transport networks are. Infrastructure managers should develop and track, at local level, detailed performance metrics related to extreme weather events, for example number and duration of weather related operation disruptions and associated financial and economic costs (material damage, accidents, fatalities, casualties, delays, and so on). This information could afterwards be used for assessing the level of criticality of a section of the transport network. This can be best evaluated by assessing the increase of the total *generalized costs*[75] to all users of the infrastructure in case the section is not operational for a certain period. Studying the criticality of the sections of the transport network allows infrastructure managers to better prioritize CCA actions, and most important – to plan the general response to emergencies and maintenance activities. This issue is especially important for the road network, which is of great length and complexity and where the criticality of the different parts of the network cannot be reasonably assessed without specialized studies. Knowing the most critical sections of the railway infrastructure is of great importance, too, especially considering the high number of people to be put at risk in case of emergency situations with passenger trains.

327. Blizzards and heavy snowfall are of the extreme weather events that cause some of the more dramatic disruptions to the operations on both road and railway networks. Such disruptions are especially frequent in the Northeast and mountainous parts of the country. It is therefore proposed that formal studies are carried out to identify the sections that are most problematic in this aspect. Based on this and the criticality assessment, the infrastructure managers will be able to focus and prioritize their interventions.

[74] The Level of Service (LOS) concept is widely used in transport engineering for measuring the quality of the transport service provided by a facility. It consists in the formal definition of sets of operational conditions to be associated with different service 'levels'. The LOS concept is also used in the definition of maintenance standards.

[75] The generalised costs of travel are composed of a monetary component (the costs of fuel, vehicle amortization, vehicle maintenance, the costs of tickets, etc.) and a non-monetary component (most importantly the value of time spent travelling, the value of access/egress times, etc.). For more details see Antov (2017; pp. 60-63).

328. It seems beneficial to review (and potentially revise) the practices and guidelines related to the general operation and maintenance of the various transport subsectors. Issues that may need to be considered are for example:

- the scope and frequency of planned pavement repairs (due to thermal stress to road and airport pavement);
- the scope and frequency of maintenance of drainage structures (to account for irregular heavy precipitation and its effects to roads, railways and airports);
- the identification of landslides, embankment and cut slope failures (for roads and railways);
- the scope and frequency of railway switches maintenance (to account for cold and snowfall);
- the scope and frequency of inspections and maintenance of catenary and control and signaling equipment in winter (to account for the effects of cold, snowfall and blizzards on railway infrastructure);
- the scope and frequency of dredging of Danube (to account for the effects of low water levels);
- the scope of inspection and maintenance activities of port equipment (to account for the effects cold, snowfall, blizzards); and so on.

329. The review of the practices and guidelines related to the general operation and maintenance must be viewed in the light of the possibility to introduce performance-based maintenance systems (PBMS). PBMS are a tool ensuring more reliable and cost-effective maintenance and in a natural way improve the adaptive capacity of the stakeholders.

330. Finally, with regard specifically to the road subsector, it may be worth to analyze the effects of the stopping of heavy traffic on sections where the ambient temperature is above 35°C. This is an adaptation measure that has been in use for many years and has caused much losses and inconvenience to transport operators and their clients. It is recommended the effects of this and other similar measures (in terms of reduction of pavement damage and increase of the travel times to users) to be evaluated using economic impact analysis tools. This will allow RIA to select the most economically efficient strategy and properly communicate it with the public. In any case, measures restricting the services and use of the transport infrastructure should be avoided as much as possible and introduced in well justified cases following a process of consultation identifying alternative solutions for the stakeholders.

331. Specific adaptation options proposed are summarized in ***Table 17***.

Table 17. Climate change adaptation options – review and improvement of operation and maintenance standards

CLIMATE CHANGE ADAPTATION OPTIONS		
III. Review and improvement of operation and maintenance standards		
14. Assess the criticality of the sections of the national road network **15.** Identify highly vulnerable road sections to extreme winter weather events. **16.** Develop and implement a Program for strengthening the road network resilience to extreme winter weather events **17.** Assess the criticality of the sections of the railway network **18.** Identify highly vulnerable railway sections to blizzards and heavy snowfall. **19.** Develop and implement a Program for strengthening the railway network resilience to extreme winter weather events **20.** Evaluate the effects of restricting HGV traffic during high air temperature periods **21.** Review and improve roads' operation maintenance standards **22.** Review and improve railways' operation maintenance standards **23.** Review and improve waterways' operation maintenance standards **24.** Review and improve airports' operation maintenance standards		
Subsector	**Description**	**Potential participants**
Roads	Assess the criticality of the sections of the national road network using the traffic model operated by the Roads Institute (part of RIA) using an appropriate methodology[76].	RIA
Roads	Carry out a formal study of the sections with high risk of traffic disruptions due to *blizzards and heavy snowfall*.	RIA
Roads	Based on the study of blizzards and snowfall risk, and considering the road sections' criticality study, prepare and implement a *program for improving* the most vulnerable sections (for example plant snow protection vegetation, install snow protection barriers, and so on).	RIA
Rail	Assess the criticality of the sections of the national railway network	NRIC
Railways	Carry out a formal study of the sections with high risk of disruptions due to *blizzards and heavy snowfall*.	NRIC
Rail	Based on the study of blizzards and snowfall risk, and considering the railway sections' criticality study, prepare and implement a program for improving the most vulnerable sections (for example plant snow protection vegetation, install snow protection barriers, and so on).	NRIC
Roads	Carry out formal studies to evaluate the effects of the stopping of heavy traffic on sections where the ambient temperature is above 35°C in terms of reduction of pavement damage and increase of the travel times to users. Propose alternative strategies and evaluate them using CBA.	RIA

[76] For example, the methodology described by Enei *et al.* (2011; pp. 40-46) could be used.

Roads	Review *operation and maintenance standards* in the light of CCA, for example the scope and frequency of planned pavement repairs (thermal stress), the scope and frequency of maintenance of drainage structures (precipitation), the identification of landslides, embankment and cut slope failures, and so on[77]	RIA
Railways	Review *operation and maintenance standards* in the light of CCA, for example the scope and frequency of switch maintenance (cold), the scope and frequency of inspections and maintenance of catenary and control and signaling equipment in winter (cold, snowfall, blizzards), the identification of landslides, embankment and cut slope failures, and so on	NRIC
Water	Review *operation and maintenance standards* in the light of CCA, for example the scope and frequency of dredging of Danube (precipitation), the scope of inspection and maintenance activities of port equipment (cold, snowfall, blizzards), and so on	ExAEMDR, BPI, port operators
Air	Review *operation and maintenance standards* in the light of CCA, for example the scope and frequency of planned pavement repairs (thermal stress), the scope and frequency of maintenance of drainage structures (precipitation), the scope of winter maintenance (snowfall, blizzards), and so on	Airport operators

3.1.5. Review and improvement of emergency response procedures

332. In principle, the rules and procedures for emergency response are a component of the rules and procedures for operation of infrastructure. They are, however, of such importance that it is considered appropriate to review them separately.

333. Emergencies are often directly or indirectly related to extreme weather. Some of the most frequent extreme weather-related events, like for example floods, are also the ones that cause the most severe direct damage to transport infrastructure and long-lasting disruptions to transport services. Other catastrophic events, like for example landslides, are often triggered by extreme weather events – heavy precipitation, changes of the water table, and so on Road traffic accidents are frequently a result of extreme weather events – for example multiple vehicle collisions due to low visibility during blizzards, road icing, or periods with heavy snowfall or fog.

334. All stakeholders, responsible for the operation and management of transport infrastructure, have units and staff devoted to the response to emergencies. It would appear appropriate to review these in the context of CCA. Furthermore, the process of reviewing their level of adaptation to climate change may be a good opportunity to review, assess (and revise if needed) their emergency response strategies, plans, procedures and staffing. In case of road and railway infrastructure, these should obligatorily include traffic management plans to restore mobility and accessibility, including detour routes, communication channels, and so on).

[77] See for example Meyer *et al.* (2010) for a thorough discussion on how to incorporate CCA consideration into asset management.

335. It is highly recommended that the emergency response and return to level of services plans are reviewed and revised/developed in close cooperation with transport operators, so as to take into account the needs of transport users and service clients. Otherwise, there is significant risk that the plans focus to the needs of infrastructure managers only.

336. In this context, the role of ITS in emergency response must be explicitly underlined. ITS is an extremely useful tool in the efficient identification and response to emergencies affecting all subsectors of the transport sector. The importance of ITS must be recognized by the stakeholders and they must make good use of it – especially considering the availability of substantial funding devoted to the development of ITS under Priority Axis 4 of OPTTI 2014–2020.

337. Considering the above, specific adaptation options proposed are summarized in ***Table 18***.

Table 18. Climate change adaptation options – review and improvement of emergency response procedures

CLIMATE CHANGE ADAPTATION OPTIONS		
IV. Review and improvement of emergency response procedures		
25. Develop and track mode specific performance metrices related to extreme weather events. **26.** Review and improve all subsectors' emergency response plans, rules and procedures. **27.** Develop and implement plans for deployment of road ITS as emergency response mitigation and management tool.		
Subsector	**Description**	**Potential participants**
All subsectors	Develop and track performance metrics related to extreme weather events	RIA, NRIC, ExAEMDR, BPI, port and airport operators
All subsectors	Review of the emergency response plans, rules and procedures of the stakeholders in the context of climate change adaptation. If needed, revise the emergency response plans, rules and procedures of the stakeholders, as well as provide training (to be focused mainly on joint action of the various actors)	All public sectors stakeholders operating transport infrastructure
Road	Develop plans for deployment of ITS as emergency response tool	RIA, municipalities

3.1.6. Review and improvement of data collection procedures and building knowledge base

338. The lack of sufficient and specific data for the transport infrastructure and services to be correlated with the climate conditions is a factor that restricts the development of specific measures for CCA. Even more importantly, it greatly limits the overall ability of the managers of infrastructure to efficiently plan the operation and maintenance activities and ensure adequate level of service.

339. During the process of development of this study a large volume of publicly available data was reviewed, and a substantial volume of transport mode-specific data was requested from the stakeholders. The main conclusion of this process was that data is generally available but with high level of aggregation. In terms of spatial aggregation, the publicly available data is usually presented at the NUTS3 (district) and country level (NUTS0). In terms of economy sectors and subsectors covered, the data is most often presented at the sectoral level and rarely allows analysis at the subsector (mode of transport) level. Even specialized studies for the effects of climate change on the transport sector typically rely on highly aggregate (and sometimes old) data (Karagyozov 2012).

340. It is strongly recommended that all stakeholders, but more specifically infrastructure managers, elaborate their statistical data by developing systems that track and record in a systematic way weather related trends and costs over time (for example number of potholes repaired, number and snow removal costs, labor costs associated, and so on). With the time, this will provide improvement of the overall assets management and increases budgeting efficiency.

341. The Bulgarian studies related to the effects of climate change on the transport sector are most often based on global and EU-level studies (like the PESETA, WEATHER, EWENT projects, and so on) to derive their conclusions from. This approach allows the identification of general effects and trends for the country but poses significant limitations on how specific and detailed the analyses could be. Reliable justification and robust economic evaluation of specific CCA actions in the transport sector could be achieved only if detailed statistical data is available. Such data must be collected, maintained and regularly made publicly available by the entities managing the transport infrastructure.

342. Risks and vulnerabilities of the transport sector on national level that are analyzed, assessed and presented in this document give a basis and direction for further studies. In short-term perspective, the elaboration of detailed mode specific studies to better reveal the particularities of each mode and the territorial aspects of the climate change is a must. In medium-term perspective (5–7 years), these mode studies should be further specified and elaborated using the data collected on purpose. Results of these studies might serve as basis for further elaboration and update of CCA options per transport mode.

343. Considering the above, the following specific adaptation options are proposed in ***Table 19***.

Table 19. Climate change adaptation options – review and improvement of data collection procedures and building knowledge base

CLIMATE CHANGE ADAPTATION OPTIONS
V. Review and improvement of data collection procedures and building knowledge base
28. Review and identify deficiencies in current scope, rules and practice in data collection with focus on CCA
29. Introduce and/or improve CCA relevant data collection practice
30. Carry out dedicated studies to assess mode specific climate change risk and vulnerability

Subsector	Description	Potential participants
All subsectors	Review the existing internal rules and practices for the collection of data related to the transport infrastructure and services operated and maintained by the various stakeholders. Identify gaps and deficiencies (general and in the context of climate change adaptation).	MTITC, MRDPW and all other public-sector stakeholders
All subsectors	Develop and introduce formal internal rules for data collection (for the stakeholders that do not have any). Revise the existing internal rules for data collection (when deemed necessary).	MTITC, MRDPW and all other public-sector stakeholders
All subsector	Develop new climate change risk and vulnerability studies per transport mode using data collected. Elaboration and update of CCA options per mode	MTITC, MRDPW and all other public-sector stakeholders

3.1.7. Building institutional capacity

344. As demonstrated by the review of the institutional framework in the transport sector,[78] very few administrations have units or staff with duties related to CCA. This does not come as a surprise and does not in itself present a problem considering that the potential workload of dealing with CCA at the level of most stakeholders would not be significant. And whilst complete units, or even full-time staff, would rarely be justified, it is considered important that within stakeholders' organizations it is made clear who is responsible for CCA related issues. This would allow continuity and much more efficient addressing of the problems related to CCA.

345. It is also considered that general awareness regarding CCA must be widespread in stakeholders' organizations. This is supported by the self-assessment of the need of training of most stakeholders, who noted that further training would be beneficial for their organizations.

346. Specific adaptation options proposed are summarized in ***Table 20***.

Table 20. Climate change adaptation options – building institutional capacity

CLIMATE CHANGE ADAPTATION OPTIONS		
VI. Building institutional capacity		
31. Review, gap assessment and adaptation of institutional setup per transport subsectors to address CCA issues **32.** Assign CCA responsibilities in the statute and internal procedures of the relevant stakeholders **33.** Training needs assessment and implement training programs **34.** Raising public awareness towards transport relevant climate change and CCA issues		
Subsector	**Description**	**Potential Participants**
All subsectors	A formal review of the institutional setup of all transport sector stakeholders and proposal for changes to their structures to introduce human resources with duties in CCA. The study should also include a review of the internal	MTITC, MRDPW and all other public-sector stakeholders identified

[78] See section 3.6 'Institutional Framework and Stakeholders'.

Subsector	Description	Potential Participants
	procedures and if needed propose amendments to integrate CCA in the workflow.	
All subsectors	Introduction of the CCA responsibilities in the statute and internal procedures of the stakeholders.	MTITC, MRDPW and all other public-sector stakeholders identified
All subsectors	Detailed assessment of the need for training, preparation of a training program for the stakeholders. Training of enough staff to build up awareness of CCA issues.	All stakeholders
All subsectors	Design and implementation of public awareness raising campaigns aiming to inform the society about the CCA need and actions taken in this respect in the transport sector	All stakeholders

3.2. Experience with Selecting Adaptation Options in the Sector in Other (EU) Countries

347. The Romanian *Transport Sector Rapid Assessment* (Ministry of Environment and Climate Change 2014) from 2014 recommends that detailed assessments in all subsectors of the transport sector are made. For roads, the detailed assessment should include the following main areas (Ministry of Environment and Climate Change 2014; p. 57):

(a) reassess parameters used for design storm for drainage systems and structures;

(b) investigate the need for river training and increased channel maintenance and bridge scour protection;

(c) review culvert designs that cause limited damage to roads during flooding;

(d) reassess methods for slope stabilization and protection; and

(e) pavement specifications.

348. Asset management has received substantial attention in the report and adaptation actions at various levels of the asset management system are identified.

349. Another excellent example is the study *Support to the Government of Macedonia: Transport Sector Green Growth & Climate Change Analytical Work* (World Bank 2012, 2012a) from 2012, which focuses on road and railway transport. The study includes a very detailed analysis of the existing vulnerabilities (‘baseline vulnerability’), which systematically assesses the vulnerabilities based on limited data.

350. As a result, a comprehensive long list of specific adaptation options is defined. Following the best practices,[79] the long list is jointly discussed with the stakeholders and based on these discussions a multi-criteria evaluation framework for prioritizing the options is defined.

351. The adaptation options identified in the study are very similar to the ones identified here and include revision of design codes and regulations, revision of operation and

[79] More specifically, the recommendations of SWD (2013) 134 for the sequence of developing adaptation strategies.

maintenance practices, improvement of data collection and many others.

3.3. Adaptation Options Assessed

3.3.1. Overview

352. Based on the findings from the previous Chapters a long list of adaptation options has been identified and presented in sub-chapter 3.1. The current section details the approach for determining the properties of the adaptation options in terms of:

- implementation time;
- costs and benefits;
- implementation efforts/difficulty;
- indicators for measurement;
- needed institutional arrangements; and
- consequences of no action.

353. The purpose of this approach is to inform the decision-making process regarding the characteristics of the adaptation options, so that they can be properly prioritized.

354. The complete list of adaptation options and an initial assessment of their properties is presented as ***Annex 2***.

3.3.2. Time

355. The time needed for implementation of the adaptation options must be identified with sufficient accuracy to allow proper planning. Some options are 'self-sufficient' and do not depend on other options; and some depend on the results of the implementation of one or more of the other options.

356. The implementation time is not considered a critical aspect in the process of prioritizing the adaptation options and information about it is provided for information and to ease planning. The time estimations presented include not only the expected net implementation time for the options (for example development of a study) but also realistic estimates of the time to prepare it (for example drafting of the study scope, preparation and carrying out of tender, and so on). It does not include, however, time for deploying the results of the option, if the case, for example to reconstruct all the bridges and/or culverts.

357. Regardless the above, it is recommended that options aiming at building adaptive capacity are given highest priority because: (1) these will provide a suitable basis for development and implementation of delivering adaptation options and (2) these could be brought in practice relatively fast and costs thereof are minimal or nil.

3.3.3. Budget

358. The costs of adaptation options are of the most critical inputs to the priority setting process. The budgets needed for preparation of each of the adaptation options have been estimated based on the costs of services of similar scope and duration. These budgets are adequate for the Bulgarian market at the time of preparation of this study and are expected to remain largely applicable for a period of not less than 2 years. Of course, it is up to the stakeholders who will prepare, tender and manage the implementation of the adaptation options

to use their own budget estimates. These estimates may reflect different assumptions and will not necessarily be the same as the ones provided herein as a starting point.

359. It is important to emphasize that in most cases the budgets cover only the direct cost of services necessary for planning and preparation of the implementation of the adaptation options. For example, in the case of the proposed revision of road drainage design guidelines only the cost of the review itself is indicated. The exact costs for construction of road drainage in accordance with the resulting new design guidelines for a given period depend on a large number of external factors and are therefore extremely difficult to determine. This is the case with most of the adaptation options, the costs of which incur over long periods of time and are subject to a lot of uncertainty. For this reason, the costs for implementation of the adaptation options are included in a separate column, as qualitative assessments.

3.3.4. Cost-benefit analysis

360. Apart from costs, the other major input in the decision-making process is the expected benefits. Like the long-term costs for the implementation of adaptation options, the associated benefits may be even more difficult to evaluate with reasonable accuracy. This is particularly true when the benefits are expected to occur over a longer period and depend on many external factors.

361. The CBA for the sector (see ***Annex 3***) focuses on the assessment of soft adaptation measures. The benefits gained as a result of their implementation are best exemplified through the quantification of saved costs in main performance indicators (saved travel costs; expenditures for infrastructure maintenance; and others). Considering the complex impact of the adaptation options on the transport sector, these were not separately quantified in the current CBA. The net present value (NPV) in ***Table 21*** illustrates the monetary value of avoided losses as a result of implemented adaptation measures, while the cost effectiveness quantifies the benefits achieved in relation to the required investments/costs.[80]

Table 21. Benefits of adaptation measures in the Transport sector under different climate scenarios until 2050 (in €, million)

Climate scenarios	NPV (€ million)	Cost-effectiveness (Benefit/Cost ratio)
Realistic scenario +2°C	682.5	2.04
Optimistic scenario +2°C	734.9	2.12
Pessimistic scenario +2°C	632.9	1.96
Realistic scenario +4°C	1,420.4	3.15
Optimistic scenario +4°C	1,501.6	3.27
Pessimistic scenario +4°C	1,343.8	3.04

[80] The NPV of an adaptation option is given by the present value of the estimated benefits and costs. If NPV is more than zero, this indicates that the investment is efficient and incremental benefits of adaptation exceed the incremental resource costs. If NPV is <0 or B/C is <1, then the adaptation measures add no net benefit to the Transport sector. If NPV is >0 or B/C is >1, then it adds positive benefits. The positive value of NPV confirms that investments for adaptation are efficient.
The benefit-cost ratio (B/C) is the ratio of the present value of benefits to the present value of costs. When the B/C ratio is more than one, the present value of the option's benefits is larger than the present value of its costs.

362. The projection shows that on average, under the +2°C realistic scenario, the total cash flow in NPV is €682.5 million, and €1.4 billion under the realistic scenario at +4°C. Under the optimistic scenario, the projected cash flow in NPV is €734.9 million under the +2°C scenario and €1.5 billion – under the +4°C scenario. Even under the pessimistic scenario, the future cash flow in NPV is projected at €632.9 million at +2°C and €1.3 billion at +4°C.

363. The effect of adaptation measures in the transport sector will be travel cost savings as a result of decreased rail and road damage. The estimated financial efficiency related to applied adaptation measures is positive. The NPV calculation until 2050 shows that investment in adaptation measures is positive in all scenarios, thus economically efficient.

3.3.5. Implementation efforts

364. The purpose of this parameter of adaptation options is to indicate the likely complexity and sensitivity of the implementation of the options. Based on that preliminary expectations regarding the efforts related to the implementation of the options are presented. Known and possible implementation risks are also listed.

3.3.6. Indicators

365. As many of the adaptation options identified relate mostly to the development of adaptive capacity, the definition of indicators for their implementation is straightforward. In these cases, the indicators directly relate to the outputs or deliverables of the specific adaptive capacity building action. Such indicators are relevant for measuring *the process* of building adaptive capacity.

366. The development of indicators for successful adaptation (that is, measuring adaptation *outcome* [SWD (2013) 134; p. 31]) is a much more complicated task. It would involve sector wide monitoring of several parameters for a long period of time. Such parameters are, for example, the damage (in monetary terms) from the various types of extreme weather events.

367. Finally, it must also be noted that, to properly monitor adaptation, a clear *baseline* must be established to compare progress and results against.

3.3.7. Institutional arrangements

368. Many adaptation options fall within the duties and authority of a single stakeholder and do not require any coordination with external parties. There are others, however, that need the joint action of two or more stakeholders. It is important to identify and plan the necessary institutional arrangements in advance and ensure that all parties have the knowledge and willingness to act.

The expected institutional interactions and arrangements are indicated accordingly.

3.3.8. Consequences of no action/maladaptation

369. Total economic costs resulting from climate change can potentially reach very high levels, even for modest levels of climate change. These costs even rise significantly under scenarios of greater levels of warming. Projected damage from climate change is higher in southern Europe, where Bulgaria is located, as compared to northern Europe.

370. Estimates of the projected economic impacts of climate change in Europe consider only some sectors and show considerable uncertainty. The EEA (2016) has provided an estimate of the overall annual economic losses from climate extremes by country in 2015 (2015 € value). The total value for Bulgaria is estimated at some €2,361 million, of which only 5 percent were insured. This corresponds to €288 per capita, or €21,393 per square kilometer. Among the 33 countries monitored by the EEA, Bulgaria holds the 24th place in losses across all sectors of the economy, 26th place per square kilometer and 32nd place in losses per capita.

371. Bulgarian transport infrastructure covers the whole country and is vital for the functioning of the national economy and for the daily life of the population. Failure of transport networks and/or services can have knock-on impacts on other sectors and systems. Vulnerability of transport networks and services would inevitably affect the competitiveness of the other economic sectors.

372. Most transport infrastructure assets have a long-life cycle of 20 to 50 years and in some cases even longer. If damaged, the costs for their repair and/or reconstruction are high and always higher than the initial investment costs. An exact estimation of direct costs to repair damaged infrastructure is related to many assumptions and thus, estimates are rather uncertain; but in any case, the costs are significant and will continue to grow. Indirect economic costs related to re-routed, delayed, and or missed trips of both persons and goods due to damaged or destroyed infrastructure, would be much higher and would spread out far beyond the transport sector.

3.4. Cross-cutting Issues, Trade-offs and Synergies of Adaptation Options

373. It must be acknowledged that adaptation to climate change requires two forms of response: dealing with the long-term effects on the infrastructure and developing resilience to extreme weather events. An important issue in the adaptation process is the interdependencies between the different types of infrastructure, as well as the different sectors of the economy, which may lead to ‘cascade failure’ in case of extreme weather events. The interdependencies must be recognized and properly managed (Royal Academy of Engineering 2011; pp. 5-6).

374. Regarding the interdependencies with other infrastructure, the transport sector is dependent on the energy infrastructure for fuel and electricity. It also depends on ICT networks for the management of services and transport infrastructure. There are also internal dependencies within and across the modes of transport where one mode transports users to the infrastructure of another mode. Finally, all sectors depend on the transport systems to carry workforce to sites; food distribution is also highly dependent on transport (Royal Academy of Engineering 2011; pp. 5-6).

375. A summary of the interdependencies between the various sectors of the economy is presented in ***Table 22***.

Table 22. Sectoral interdependencies

Affecting →	TRANSPORT	
CC effect in… ↑ *(see below)*	**Positively**	**Negatively**
Agriculture	• Demand for freight transport services	• Poorly maintained agricultural irrigation and drainage infrastructures could damage region's transport infrastructure and hamper the transport services • CC impact on plants used for bio-fuel production will hamper more intensive use of those fuels
Biodiversity & Ecosystems	• Green infrastructure along road transport routes can increase wind, landslide and erosion protection • Improved water provision and reduced eutrophication in more resilient ecosystems can be of benefit for waterway transport	• Requirements related to the biodiversity protection may increase transport projects' costs • CC may increase the risk in invasive species spread that could cause damage of structures relevant to the transport infrastructures – slopes, culverts, fences, ditches, and so on
Energy	• Energy resources to be transported – higher freight transport demand	• Disruption of power supply may cease or put on risk transport services: ○ Railway transport – delays, disruption, etc.; ○ Road transport – risk in using tunnels, traffic management systems, etc. • Poorly maintained/destroyed energy infrastructure can cause physical damage to transport infrastructure
Forestry	• Protection of transport infrastructure due to the improved growth of tree species	• Increased erosion on steep slopes and forest roads and severe forest damage may disrupt road and rail operation
Human Health	• Incentives for technological development to achieve cleaner and sustainable transport	• Increased transport costs due to the need of cleaner and sustainable transportation
Tourism	• Demand for transport services • Driver to deploy alternative means of transportation	• Increased use of transport infrastructure may increase the maintenance costs
Urban Environment	• Incentives for development of environment friendly urban transport modes – cycling, walking, electrical, and so on.	• Disruption of public transport operation due to destruction of streets and/or accidents • Higher costs for construction and maintenance of the urban transport infrastructure
Water		• Severe damage to transport infrastructure and disruption of transport due to failures in hydro-melioration and hydropower sub-sectors • Failures in water supply and sewerage systems may damage road and rail infrastructure and/or disrupt or decrease the level of transport services

Note: The table reflects how climate change effects in one sector affect the Transport sector

3.5. Priority Setting Approach

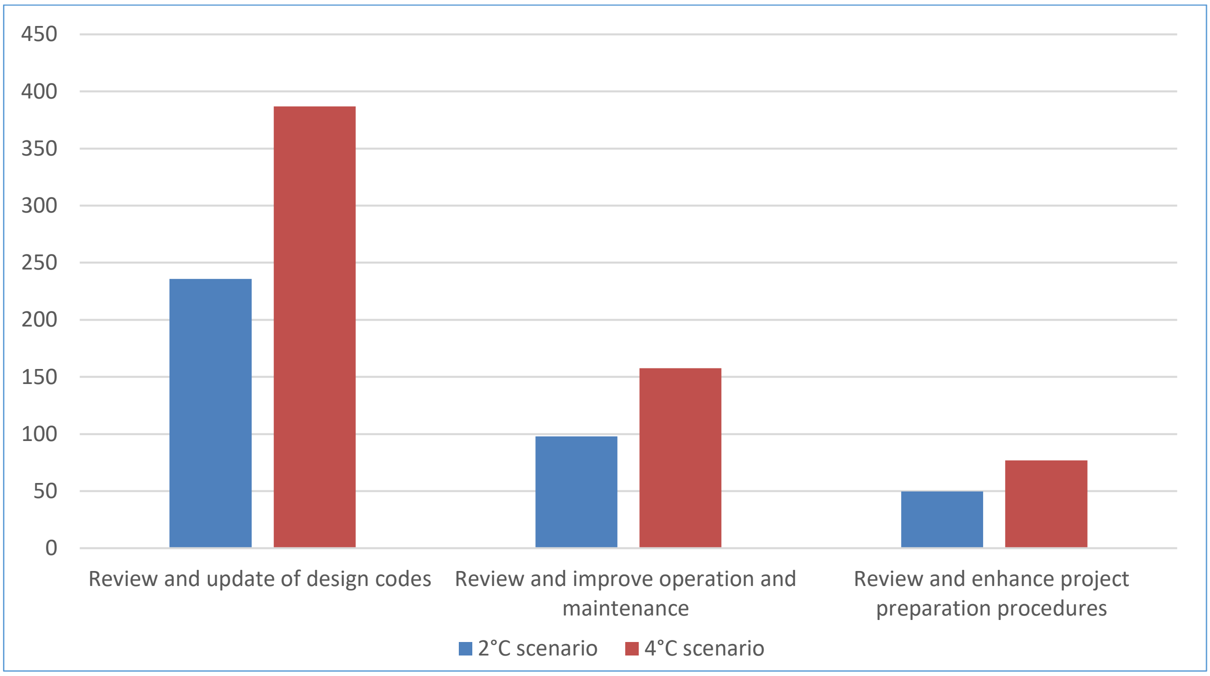
376. Identification of climate change adaptation options is an important step in the process of establishing resilience to climate change. However, it is not realistic to expect that all identified adaptation options can be implemented simultaneously. Therefore, adaptation options are normally scored to establish a priority order for their implementation. In the framework of this report, following EU guidance, the adaptation options specifically identified for the Transport sector have been prioritized.

377. In support of the priority setting a prioritization meeting was organized in Sofia in October 2017, inviting a variety of stakeholders from the sector. The meeting used a basic version of the multi-criteria analysis (MCA) approach. MCA is an approach as well as a set of techniques, that aims at providing an overall ordering of options, ranging from the most preferred to the least preferred. It represents a way of looking at complex problems that are characterized by a mix of monetary and non-monetary objectives. MCA breaks down options into more manageable pieces by using a set of criteria. The two groups of criteria used for the analysis were those of 'Net Benefits', further broken down into economic, social, and environmental benefits, and 'Implementation Risks', further broken down into financial, social, institutional, technical, and technological risks. This approach allows data and judgements to focus on the separate pieces that are then reassembled to present a coherent overall picture.

378. In carrying out the MCA (that is, 'scoring the different adaptation options'), the meeting benefited from the presence of stakeholders with professional knowledge and experience in the sector. Nevertheless, this priority setting effort must be considered as indicative and tentative, for three main reasons. First, the effort was carried out at an early stage in the process of developing a strategic view and planning of sector specific climate change adaptation options. Second, not all those who were invited to the prioritization meeting used this invitation to attend. And third, a broader understanding of underlying information and notions at the side of the stakeholders would be beneficial to allow them to make more founded scores. Therefore, the current priority list only serves as a 'first feel' about the main direction of the actions to be taken first.

379. The results of the CBA identify the most economically efficient adaptation actions and allow for their ranking. The adaptation measures for which the benefit exceeds the cost can be ranked as follows: Review and update of design codes; Review and improve operation and maintenance; and Review and enhance project preparation procedures. The figure below shows the estimated contribution of selected adaptation measures in reaching the overall positive effects of climate change adaptation.

Figure 23. Prioritization of the adaptation measures in the Transport sector (total NPV effect in € million)



380. At a later stage further attention should be paid to the priority setting process, both for this sector as across all economic sectors that play a role in the planning of Bulgaria's climate change adaptation actions.

381. The five main priority adaptation options that were tentatively and indicatively identified for the Transport sector are:

1) ***Review of the institutional settings (# 31) and assign CCA responsibilities in the statute and internal procedures of the relevant stakeholders and train the staff (#32)***: the review of the current institutional framework showed that CCA is not formally included in duties of none of the transport sector stakeholders. However, managing the process of adaptation to climate changes requires long-term systematic actions, which need to be planned, financed and implemented in a coordinated way. This could not be done without responsibilities and resources allocated to institutional bodies. Extending the responsibilities of existing bodies/units to encompass CCA or of establishing new units, if needed, will provide consideration of CCA in all sub-sectors and phases starting from planning of new infrastructure or service through the implementation and operation phase.

2) ***Introduce and/or improve CCA relevant data collection practice***: the review of existing data demonstrated a clear gap in registering, processing and analyzing the reasons and consequences of weather related incidents, especially in the road sector. Starting from the management adagio *'If you can't measure it, you can't manage it'*, it is considered of extreme importance to improve the current data collection process at relevant stakeholders, such that over time a database is built that can correlate weather events, their direct impact on transportation services and infrastructure, and respective financial and economic implications. In the medium term this will provide a solid base for ***carrying out dedicated***

studies to assess mode-specific climate change risk and vulnerability and to identify respective appropriated adaptation measures to be taken.

3) ***Update of design codes*** (with specific focus on ***road and railway bridges and culverts***) and continuous updating of these codes. In the short to medium term it is expected that the frequency of climate change related extreme events will increase. For the land transport modes, extreme precipitation, resulting in floods and landslides, are identified as the most important climate change risks. Therefore, the capability of road and rail bridges and culverts, to let in high water waves, is of utmost importance to prevent floods and landslides. Reconstructing all the thousand bridges and hundred thousand culverts in the existing networks is a highly challenging and long-lasting exercise. The efforts should therefore focus on better design of new and to be reconstructed, taking into consideration the expected change of the climate.

4) ***Develop a common guideline to all beneficiaries for taking CCA into consideration*** and embed it in the project preparation process. Climate change is a gradual process, measures are to be planned today to avoid events expected to happen in future. Transport infrastructure projects, especially the large ones, require a long preparation and implementation time. To prepare new transport infrastructure that meets future challenges, climate change adaptation needs to be embedded in the process of project preparation.

3.6. Conclusions

382. The list of adaptation options identified is long, and could nevertheless be further extended, especially after collecting historical data and carrying out mode-specific studies. However, in the short term, most important seems to be to focus the efforts on adaptation options that aim at building adaptive capacity. The reason is that on the one hand these are relatively easy to implement, and on the other hand provide a suitable basis for development and implementation any other adaptation options.

References

Alexandrov, V., Simeonov, P., Kazandziev, V., Korchev, G., Iotova, A., 2010. *Climate Change*. National Institute of Hydrology and Meteorology, Bulgarian Academy of Science, Sofia

Antov, A., 2017. *Transport Modelling 101, A Practical Guide*. Sofia

BAS, 2017 Mapping the geological risk, Phase II of Performing analysis, assessment and mapping of geological risk, January 2017

Bruchev, I., Dobrev, N., Frangov, G., Ivanov, P., Varbanov, R., Berov, B., Nankin, R., Krastanov, M., 2007. The landslides in Bulgaria – factors and distribution. Geologica Balcanica, 36. 3-4, pp. 3-12. Sofia, December 2007

CCC, 2016. *UK Climate Change Risk Assessment 2017, Synthesis report: priorities for the next five years*. Committee on Climate Change, London

CM, 2012. *Ordinance for the sequence and competent authorities for determining critical infrastructure and infrastructure sites, and assessment of the risk related to them*. Council of Ministers, Sofia

CM, 2013. *National Programme for Disaster Protection 2014-2018*. Council of Ministers, Sofia

CM, 2014. *Partnership Agreement of the Republic of Bulgaria Outlining the Support from the European Structural and Investment Funds for the 2014-2020 Period*. Council of Ministers, Sofia

COM (2009) 147 – *White paper Adapting to climate change: towards a European framework for action*. European Commission, Brussels

COM (2013) 216 – *An EU Strategy on adaptation to climate change*. European Commission, Brussels

CRBL, 2003. *Manual for Design of Asphalt Pavement*. Central Road and Bridges Laboratory, Road Executive Agency, Sofia

Dawson, R.J., Thompson, D., Johns, D., Gosling, S., Chapman, L., Darch, G., Watson, G., Powrie, W., Bell, S., Paulson, K., Hughes, P., and Wood, R., 2016. *UK Climate Change Risk Assessment Evidence Report: Chapter 4, Infrastructure*. Report prepared for the Adaptation Sub-Committee of the Committee on Climate Change, London

DCLG, 2009. *Multi-criteria analysis: a manual*. Department for Communities and Local Government, London

DG Civil Aviation Administration, 2018. Statistic information about International Airports in Republic of Bulgaria www.caa.bg/en/category/602/statistics (visited on 15 February 2018)

Defra, 2010. *Measuring adaptation to climate change – a proposed approach*. Department for Environment, Food and Rural Affairs, London

DG CLIMA (2013). *Non-Paper Guidelines for Project Managers: Making vulnerable investments climate resilient*. DG Climate Action, European Commission

DG CLIMA (2015). *Assessment of climate action. How to assess the mainstreaming of climate action in Cooperation Programmes*. DG Climate Action, European Commission

Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on assessment of the effects of certain plans and programmes on the environment. (The SEA Directive.)

Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks. (The Floods Directive.)

Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment. (The EIA Directive.)

Dobrev, N., Benderev, A., Zhelezov, G., Kocev, C., Berov, B., Ivanov, P., Krastanov, M., Nikolova, M., Nedkov, S., Cherkezova, E., 2014. *Geological and Environmental Risks at River Terraces in the Western Part of the Bulgarian Section of Danube River*. Proceedings of the Great Rivers 2014 International Congress, vol. 1, pp. 408-422, Nizhny Novgorod

EEA (2016) Economic losses from climate extremes, http://www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-3/assessment, last accessed on May 3, 2017

EEA, 2017. *Climate change impacts and vulnerability in Europe 2016: An indicator-based report*. EEA Report No 1/2017. Copenhagen

Enei, R., C. Doll, S. Klug, I. Partzsch, N. Sedlacek, J. Kiel, N. Nesterova, L. Rudzikaite, A. Papanikolaou,V. Mitsakis, 2011. *WEATHER: Vulnerability of transport systems*. Karlsruhe

European Union, 2011. *The EU Strategy for the Danube Region. A united response to common challenges*. Panorama, Inforegio, issue 37/2011

German Strategy for Adaptation to Climate Change, 2008. Federal Government of Germany

GRA, 1998. *Instructions for Determining Road Culvert Spans.* General Road Administration, Sofia

Ivanov, P., Dobrev, N., Berov. B., Krastanov, K., 2017. *Analysis, Mapping the Landslide Hazard in Bulgaria*. Conference Paper, June 2017; https://www.researchgate.net/publication/318151369_Analysis_and_Mapping_the_Landslide_Hazard_in_Bulgaria

Ishev, Y., 2016. *The Roads of Bulgaria, Information collection for the country's road network*. Bulgarian Construction Chamber, Vestnik Stroitel EAD, July 2016

Karagyozov, K., 2012. *Impact of Natural Disasters on Transport Systems – Case Studies from Bulgaria*. Report from the International Panel of the WEATHER project funded by the European Commission's 7th Framework Programme. Sofia, April 2012

MCA, 1982. *Standard pavement designs for streets, parking lots, pedestrian zones, sidewalks, alleys, and guidance for their application*. Ministry of Construction and Architecture, Sofia

McGuinn, J., Stokenberga, L., Medarova-Bergstrom, K., Banfi, P., Volkery, A. and Hjerp, P., 2012. *Climate Proofing Cohesion Policy, Technical Guidance*. A report for DG Climate Action, August 2012

Meyer, M., Amekudzi, A., O'Har, J., 2010. Transportation Asset Management Systems and Climate Change: An Adaptive Systems Management Approach. Report for the Transportation Research Board 2010 Annual Meeting

Ministry of Environment and Climate Change, 2014. *Transport Sector Rapid Assessment*. Romania, Climate Change and Low Carbon Green Growth Programme, Component B Sector Report, January 2014

MoEW [no date]. *Summary of implementation programme*. Ministry of Environment and Water, Sofia

MoEW, 2012. *Third National Action Plan on Climate Change (2013 – 2020)*. Ministry of Environment and Water, Sofia, 2012

MoEW, 2014. *Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change*. Ministry of Environment and Water, Sofia

MRDPW, 2000. *Ordinance No. 1 from 26 May 2000 for Design of Roads*. Ministry of Regional Development and Public Works, Sofia

MRDPW, 2004. *Ordinance No. 2 from 29 June 2004 for Planning and Design of Communication and Transport Systems of Urbanised Areas*. Ministry of Regional Development and Public Works, Sofia

MRDPW, 2015. *National Programme for Prevention and Mitigation of Landslides on the Territory of the Republic of Bulgaria, Erosion and Abrasion on the Danube and Black Sea Shores 2015-2020*. Ministry of Regional Development and Public Works, Sofia

MTITC, 2004. *Ordinance No. 55 from 29 January 2004 for Design and Construction of Railway Lines, Rail Stations, Crossings and Other Elements of the Railway Infrastructure*. Ministry of Transport, Information Technology and Communication, Sofia

MTITC, 2010. *Strategy for the Development of the Transport System of the Republic of Bulgaria until 2020*. Ministry of Transport, Information Technology and Communications, Sofia

MTITC, 2014. *Environmental assessment of Operational Programme "Transport and Transport Infrastructure" 2014-2020*. Ministry of Transport, Information Technology and Communications, Sofia

MTITC, 2017. *Integrated Transport Strategy for the Period until 2030)*. Ministry of Transport, Information Technology and Communications, Sofia

MTITC, 2017a. *MTITC Project "Development of an Integrated Transport Strategy for the Period until 2030" funded by OPTTI 2014 – 2020*

MTITC, 2017b. *Environmental assessment of Integrated Transport Strategy for the Period until 2030*. Ministry of Transport, Information Technology and Communications, Sofia

National Statistical Institute, 2009. *Crisis events for the period 2004-2008*. http://www.nsi.bg/sites/default/files/files/data/timeseries/krizi_3.infra.xls (visited on 19 March 2017)

National Statistical Institute, 2016. *Statistical Reference Book 2016. National Statistical Institute, Sofia*

National Statistical Institute, 2016a. *Crisis events for the period 2010-2015*. http://www.nsi.bg/sites/default/files/files/data/timeseries/Crisis1.1.xls (visited on 19 March 2017)

National Statistical Institute, 2016b.

http://www.nsi.bg/sites/default/files/files/data/timeseries/Transport_2.1.3.1.xls (visited on 19 March 2017)

Nemry, F., Demirel, H., 2012. *Impacts of Climate Change on Transport: A focus on road and rail transport infrastructures*. JRC Scientific and Policy Reports 25553 EN; Joint Research Centre, European Commission, Luxembourg

NRIC, 2005. *Technical Requirements for Elements of the Railway Infrastructure*. National Railway Infrastructure Company, Sofia

NRIC, 2010. *Technical Requirements for Structure, Construction and Repair of CWR*. National Railway Infrastructure Company, Sofia

OPRG 2014-2020. *Operational Programme Regions in Growth 2014-2020*, Bulgaria

OPTTI 2014-2020. *Operational Programme Transport and Transport Infrastructure 2014-2020*, Bulgaria

Patproject, *ca*. 1980. *Instructions for Determining Bridge Spans*. Patproject, Sofia

Prutsch, A., Grothmann, T., Schauser, I., Otto, S., McCallum, S., 2010. *Guiding principles for adaptation to climate change in Europe*. ETC/ACC Technical Paper 2010/6, November 2010, Bilthoven

Regulation (EU) No. 1303/2013 of the European Parliament and of the Council of 17 December 2013 laying down common provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund, the European Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund and laying down general provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund and the European Maritime and Fisheries Fund and repealing Council Regulation (EC) No 1083/2006. (The Common Provisions Regulation.)

RIA, 2009. *Technical Specification*. Road Infrastructure Agency, Sofia

Royal Academy of Engineering, 2011. *Infrastructure, Engineering and* Climate Change Adaptation – ensuring services in an uncertain future. February 2011, the Royal Academy of Engineering, London

Sofia Municipality, 2016. *Climate Change Adaptation Strategy of the Municipality of Sofia*

Sofia Urban Mobility Centre, 2018. Public transport routes. https://www.sofiatraffic.bg/bg/transport/schedules (visited on 15 February 2018)

SWD (2013) 134 – *Guidelines on developing adaptation strategies*. European Commission, Brussels

SWD (2013) 137 – *Adapting infrastructure to climate change*. European Commission, Brussels

UKCIP, no date. *Identifying Adaptation Options*. UK Climate Impacts Programme, Oxford

Vitanov, A. (2017) *Comprehensive Transport Study for Solving Transport Problems in the Southwest Part of the Big Sofia Downtown Area*. Transpro OOD, December 2017

World Bank, 2012. *Support to the Government of Macedonia*: Transport Sector Green Growth & Climate Change Analytical Work, Transport Adaptation Report

World Bank, 2012a. *Support to the Government of Macedonia*: Transport Sector Green Growth & Climate Change Analytical Work, Transport Adaptation Guidelines

World Bank, 2017. *Small area estimates of income poverty in Bulgaria (brief) [to be published]*

Annex 1. Potential Climate Change Impacts on the Transport Sector in Bulgaria

Table 23. Potential climate change impacts on the transport sector in Bulgaria

Affected Transport Sector Aspects	High tempera-tures		Low tempera-tures		Prolonged rainfall		Drought		Water table rise		Sea level rise		Specific effects of CC relevant for the transport sector						Extreme Weather Events													
													Blizzards		Snowfall		Hail storms		Electric storms		Fog		Floods		Avalanches		Landslides		Storms	
	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P
TRANSPORT INFRASTRUCTURE																														
National road network	M	M	M	L	M	M	L	L	M	M			L	H	L	H	L	H	L	H			H	H	L	L	H	H	L	H
Urban street networks	M	M	M	L	M	M	L	L	M	M			L	H	L	H	L	H	L	H			H	H	L	L	H	H	L	H
Railway network	L	M	L	L	M	M	L	L	M	M			M	H	M	H	M	H	M	H			H	H	L	L	H	H	M	H
Underground railway network					M	L			M	L													M	L						
Cycling network																							H	H	L	L	H	H		
Pedestrian facilities																							H	H						
Coastal infrastructure													L	H	L	H	L	H	L	H			H	L			L	H	L	H
Seaports											M	L	L	H	L	H	L	H	L	H			H	L			L	H	L	H
Inland waterways									M	M																				
Airports	M	M	M	L					M	M			L	H	L	H	L	H	L	H			H	M					L	H
Terminals													L	H	L	H	L	H	L	H			M	M					L	H
Pipelines																							H	M			H	H		
TRANSPORT SERVICES USING:																														
National road network	L	L	L	L	L	M							H	H	H	H	H	M	H	H	M	L	H	H	H	L	H	H	H	H
Urban street networks	L	L	L	L	L	M							H	H	H	H	H	M	H	H	M	L	H	H	H	L	H	H	H	H
Railway network	L	L	L	L	L	M							H	M	H	M			H	M			H	H	H	L	H	H	H	M
Underground railway network																							L	L						
Cycling network	L	L	L	L	M	M							H	H	H	H	H	M	H	H	L	L	H	H	H	L	H	H	H	H
Pedestrian facilities	L	L	L	L	M	M							H	H	H	H	H	M	H	H			H	H					H	H
Coastal infrastructure													M	M	M	M			M	M			M	L			L	H	M	M
Seaports											M	L	M	M	M	M			M	M	H	L	M	L			L	H	M	M
Inland waterways			L	L			H	M					H	H	H	H			H	H	H	L	L	L					H	H
Airports					L	M							H	H	H	H	H	M	H	H	H	L	H	M					H	H
Terminals													M	M	M	M			M	M			M	L					M	M
Pipelines																							M	L			H	H		

Legend: D = damage; P = probability of occurrence by 2050 at latest; U = unknown; H = high; M = medium; L = low
red = negative impact; green = positive impact; blank = neutral impact

Annex 2. Climate Change Adaptation Options in Detail

Table 24. Adaptation options presented in detail

CLIMATE CHANGE ADAPTATION OPTIONS						
I. Review and update of design codes						
1. Update of guidelines for design of roads' culverts						
Relevant to:			Road	Rail	Waterborne	Airborne
			X			
Description			Update the guidelines for design of culverts to reflect the projected changes in the maximum water quantities in the different regions of the country. Consider including the guidelines, or at least some general requirements, in Ordinance No. 1 from 26 May 2000 for Design of Roads, so that they become a part of the legal framework. Potential participants: MRDPW, RIA.			
Option's relevance						
Economic	Ecologic	Social				
-	+	++				
Opportunities that arise			Design codes amended in line with expected changes will provide for designing and building/reconstructing infrastructure that is resilient to the future climate.			
Cross-cutting relevance			NO			
Risks addressed			Heavy precipitations, storms and hails, snowfall.			
2. Update the guidelines for design of railways' culverts						
Relevant to:			Road	Rail	Waterborne	Airborne
				X		
Description			Update the guidelines for design of culverts to reflect the projected changes in the maximum water quantities in the different regions of the country. Consider including the guidelines, or at least some general requirements, in Ordinance No. 55 from 29 January 2004 for Design and Construction of Railway Lines, Rail Stations, Crossings and Other Elements of the Railway Infrastructure, so that they become a part of the legal framework. Potential participants: MTITC, NRIC.			
Option's relevance						
Economic	Ecologic	Social				
-	+	++				
Opportunities that arise			Design codes amended in line with expected changes will provide for designing and building/reconstructing infrastructure that is resilient to the future climate.			
Cross-cutting relevance			NO			
Risks addressed			Heavy precipitations, storms and hails, snowfall.			
3. Update the guidelines for determining roads' bridge spans						
Relevant to:			Road	Rail	Waterborne	Airborne
			X			
Description			Update the guidelines for determining bridge spans to reflect the projected climate conditions. Consider including the guidelines, or at least some general requirements, in Ordinance No. 1 from 26 May 2000 for Design of Roads, so that they become a part of the legal framework. Potential participants: MRDPW, RIA,			
Option's relevance						
Economic	Ecologic	Social				
-	+	++				
Opportunities that arise			Design codes amended in line with expected changes will provide for designing and building/reconstructing infrastructure that is resilient to the future climate.			
Cross-cutting relevance			YES	Bigger spans will result in larger right-of-way and thus, will impact larger adjacent areas.		
Risks addressed			Heavy precipitations, storms and hails, snowfall.			

4. UPDATE THE GUIDELINES FOR DETERMINING RAILWAYS' BRIDGE SPANS				
Relevant to:	Road	Rail	Waterborne	Airborne
		X		
Description	Update the guidelines for determining bridge spans to reflect the projected climate conditions. Consider including the guidelines, or at least some general requirements, in Ordinance No. 55 from 29 January 2004 for Design and Construction of Railway Lines, Rail Stations, Crossings and Other Elements of the Railway Infrastructure, so that they become a part of the legal framework. Potential participants: MTITC, NRIC.			
Option's relevance: Economic: - ; Ecologic: + ; Social: ++				
Opportunities that arise	Design codes amended in line with expected changes will provide for designing and building/reconstructing infrastructure that is resilient to the future climate.			
Cross-cutting relevance	YES	Bigger spans will result in larger right-of-way and thus, will impact larger adjacent areas.		
Risks addressed	Heavy precipitations, storms and hails, snowfall.			

5. UPDATE OF THE GUIDELINES FOR BITUMINOUS ASPHALT PAVEMENT DESIGN OF ROADS				
Relevant to:	Road	Rail	Waterborne	Airborne
	X			
Description	Update of the guidelines for bituminous asphalt pavement design of roads with new depth of freezing data. Consider including the guidelines, or at least some general requirements, in Ordinance No. 1 from 26 May 2000 for Design of Roads, so that they become a part of the legal framework. Review the requirements of RIA's Technical Specification for use of polymer modified bitumen in pavement and evaluate the results of their application. Consider including such requirements in Ordinance No. 1 from 26 May 2000 for Design of Roads, so that they become a part of the legal framework. Potential participants: MRDPW, RIA.			
Option's relevance: Economic: ; Ecologic: ; Social: +				
Opportunities that arise	Financial savings could arise due to potentially thinner road pavements.			
Cross-cutting relevance	YES	Thinner road pavements would less affect the soil ecosystems.		
Risks addressed	Extreme cold.			

6. UPDATE OF THE GUIDELINES FOR BITUMINOUS ASPHALT PAVEMENT DESIGN OF STREETS				
Relevant to:	Road	Rail	Waterborne	Airborne
	X			
Description	Update of the guidelines for bituminous asphalt pavement design of streets with new depth of freezing data. Consider including the guidelines, or at least some general requirements, in Ordinance No. 2 from 29 June 2004 for Planning and Design of Communication and Transport Systems of Urbanised Areas, so that they become a part of the legal framework. Potential participants: MRDPW, municipalities.			
Option's relevance: Economic: ; Ecologic: ; Social: +				
Opportunities that arise	Financial savings could arise due to potentially thinner road pavements.			
Cross-cutting relevance	YES	Urban environment.		
Risks addressed	Extreme cold.			

7. Review and evaluate the effect of the use of polymer modified bitumen in road pavements					
Relevant to:			Road	Rail	Waterborne	Airborne
			X			
Description			Review the requirements of RIA's Technical Specification for use of polymer modified bitumen in pavement and evaluate the results of their application. Consider including such requirements in Ordinance No. 1 from 26 May 2000 for Design of Roads, so that they become a part of the legal framework. Potential participants: MRDPW, RIA, municipalities.			
Option's relevance						
Economic	Ecologic	Social				
-		+				
Opportunities that arise			Potential broader use of PMB would improve the resilience of the road pavements and would decrease the maintenance costs.			
Cross-cutting relevance			NO			
Risks addressed			Extreme heat, extreme cold, snowfall.			

8. Regular update of design codes						
Relevant to:			Road	Rail	Waterborne	Airborne
			X	X		
Description			Introduce a formal requirement to RIA and NRIC to review the design codes on a regular fixed term – for example 2–5 years. Potential participants: MTITC, MRDPW.			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			Regular review and update, if necessary, of the design code would provide for designing and building transport infrastructure that is resilient to the climate changes.			
Cross-cutting relevance			NO			
Risks addressed			All.			

II. Review and enhance project preparation procedures

9. Development of common guidelines						
Relevant to:			Road	Rail	Waterborne	Airborne
			X	X	X	X
Description			Development of common guidelines to all beneficiaries for taking CCA into consideration in the project preparation process. Potential participants: the Managing authorities of OPTTI and OPRG.			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			If CCA issue is formally embedded in the project preparation process, this would provide for implementing resilient projects.			
Cross-cutting relevance			NO			
Risks addressed			All.			

10. Review of current practices and development of road projects' preparation manual						
Relevant to:			Road	Rail	Waterborne	Airborne
			X			
Description			Review the current project preparation practices and rules and based on them develop a comprehensive project preparation manual, considering CCA issues. Potential participants: RIA.			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			If CCA issue is formally embedded in the road projects' preparation process, this would provide for implementing resilient road infrastructure and services.			
Cross-cutting relevance			NO			
Risks addressed			All.			

11. *Review of current practices and development of railway projects' preparation*					
Relevant to:		Road	Rail	Waterborne	Airborne
			X		
Description Option's relevance Economic / Ecologic / Social / / ++		Review the current project preparation practices and rules and based on them develop a comprehensive project preparation manual, considering CCA issues. Potential participants: NRIC.			
Opportunities that arise		If CCA issue is formally embedded in the rail projects' preparation process, this would provide for implementing resilient rail infrastructure and services.			
Cross-cutting relevance		NO			
Risks addressed		All.			

12. *Review of current practices and development of waterborne projects' preparation*					
Relevant to:		Road	Rail	Waterborne	Airborne
				X	
Description Option's relevance Economic / Ecologic / Social / / ++		Review the current project preparation practices and rules and based on them develop a comprehensive project preparation manual, considering CCA issues. Potential participants: BPI, ExAEMDR.			
Opportunities that arise		If CCA issue is formally embedded in the waterborne transport projects' preparation process, this would provide for implementing resilient waterborne transport infrastructure and services.			
Cross-cutting relevance		YES	Water.		
Risks addressed		All.			

13. *Review of current practices and development of airborne projects' preparation*					
Relevant to:		Road	Rail	Waterborne	Airborne
					X
Description Option's relevance Economic / Ecologic / Social / / ++		Review the current project preparation practices and rules and based on them develop a comprehensive project preparation manual, considering CCA issues. Potential participants: DG CAA			
Opportunities that arise		If CCA issue is formally embedded in the airborne transport projects' preparation process, this would provide for implementing resilient airborne transport infrastructure and services.			
Cross-cutting relevance		NO			
Risks addressed		All.			

III. Review and improve operation and maintenance standards

14. *Assess the criticality of the sections of the national road network*					
Relevant to:		Road	Rail	Waterborne	Airborne
		X			
Description Option's relevance Economic / Ecologic / Social / / ++		Assess the criticality of the sections of the national road network using the traffic model operated by the Roads Institute (part of RIA) using an appropriate methodology. Potential participants: RIA.			
Opportunities that arise		Estimated criticality of the road sections would allow RIA to better plan the general response to emergencies and maintenance activities, decreasing this way material damages, accidents, fatalities, casualties, and delays.			
Cross-cutting relevance		NO			
Risks addressed		All.			

15. IDENTIFY HIGHLY VULNERABLE ROAD SECTIONS TO EXTREME WINTER WEATHER EVENTS						
Relevant to:			Road	Rail	Waterborne	Airborne
			X			
Description			Carry out a formal study of the sections with high risk of traffic disruptions due to blizzards and heavy snowfall. Potential participants: RIA			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			Results of the study would serve as a basis for regional RIA offices to improve preventive maintenance and to focus and prioritize the interventions in case of extreme events.			
Cross-cutting relevance			YES	Human health, tourism.		
Risks addressed			Snowfall, blizzards.			

16. DEVELOP AND IMPLEMENT A PROGRAM FOR STRENGTHENING THE ROAD NETWORK RESILIENCE TO EXTREME WINTER WEATHER EVENTS						
Relevant to:			Road	Rail	Waterborne	Airborne
			X			
Description			Based on the studied risks, and considering the road sections' criticality study, prepare and implement a program for improving the most vulnerable sections (for example plant snow protection vegetation, install snow protection barriers, and so on). Potential participants: RIA.			
Option's relevance						
Economic	Ecologic	Social				
-		+++				
Opportunities that arise			Preparation and implementation of the Program would mitigate the risk of emergency situations due to extreme weather events.			
Cross-cutting relevance			YES	Human health, tourism.		
Risks addressed			Snowfall, blizzards, storm and hails, fog.			

17. ASSESS THE CRITICALITY OF THE SECTIONS OF THE RAILWAY NETWORK						
Relevant to:			Road	Rail	Waterborne	Airborne
				X		
Description			Assess the criticality of the sections of the national railway network. Potential participants: RIA.			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			Estimated criticality of the railway sections would allow NRIC to better plan the general response to emergencies and maintenance activities, decreasing this way material damages, accidents, fatalities, casualties, and delays.			
Cross-cutting relevance			NO			
Risks addressed			All.			

18. IDENTIFY HIGHLY VULNERABLE RAILWAY SECTIONS TO BLIZZARDS AND HEAVY SNOWFALL						
Relevant to:			Road	Rail	Waterborne	Airborne
				X		
Description			Carry out a formal study of the sections with high risk of disruptions due to blizzards and heavy snowfall. Potential participants: NRIC.			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			Results of the study would serve as a basis for the Infrastructure manager to improve preventive maintenance and to focus and prioritize the interventions in case of extreme events.			
Cross-cutting relevance			YES	Human health, tourism.		
Risks addressed			Snowfall, blizzards.			

19. DEVELOP AND IMPLEMENT A PROGRAM FOR STRENGTHENING THE RAILWAY NETWORK RESILIENCE TO EXTREME WINTER WEATHER EVENTS						
Relevant to:			Road	Rail	Waterborne	Airborne
				X		
Description			Based on the studied risks, and considering the railway sections' criticality study, prepare and implement a program for improving the most vulnerable sections (for example plant snow protection vegetation, install snow protection barriers, and so on). Potential participants: NRIC			
Option's relevance						
Economic	Ecologic	Social				
-		+++				
Opportunities that arise			Preparation and implementation of the Program would mitigate the risk of emergency situations due to extreme weather events.			
Cross-cutting relevance			YES	Human health, tourism.		
Risks addressed			Snowfall, blizzards, storm and hails, fog.			

20. EVALUATE THE EFFECTS OF RESTRICTING HGV TRAFFIC DURING HIGH AIR TEMPERATURE PERIODS						
Relevant to:			Road	Rail	Waterborne	Airborne
			X			
Description			Carry out formal studies to evaluate the effects of the stopping of heavy traffic on sections where the ambient temperature is above 35°C in terms of reduction of pavement damage and increase of the travel times to users. Propose alternative strategies and evaluate them using CBA. Potential participants: RIA.			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			Results of the study will provide inside data for the costs and benefits associated with this practice and its impact on the roads and road transport industry.			
Cross-cutting relevance			NO			
Risks addressed			Extreme heat.			

21. REVIEW AND IMPROVE ROADS' OPERATION MAINTENANCE STANDARDS						
Relevant to:			Road	Rail	Waterborne	Airborne
			X			
Description			Review operation and maintenance standards in the light of CCA, for example the scope and frequency of planned pavement repairs (thermal stress), the scope and frequency of maintenance of drainage structures (precipitation), the identification of landslides, embankment and cut slope failures, and so on. Potential participants: RIA.			
Option's relevance						
Economic	Ecologic	Social				
-		++				
Opportunities that arise			The review could provide for introducing a performance-based maintenance system, which is a tool ensuring more reliable and cost-effective maintenance of the road infrastructure.			
Cross-cutting relevance			NO			
Risks addressed			Extreme heat, heavy precipitation.			

22. REVIEW AND IMPROVE RAILWAYS' OPERATION MAINTENANCE STANDARDS						
Relevant to:			Road	Rail	Waterborne	Airborne
				X		
Description			Review operation and maintenance standards in the light of CCA, for example the scope and frequency of switch maintenance (cold), the scope and frequency of inspections and maintenance of catenary and control and signaling equipment in winter (cold, snowfall, blizzards), the identification of landslides, embankment and cut slope failures, and so on. Potential participants: NRIC.			
Option's relevance						
Economic	Ecologic	Social				
-		++				
Opportunities that arise			The review could provide for introducing a performance-based maintenance system, which is a tool ensuring more reliable and cost-effective maintenance of the railway infrastructure.			
Cross-cutting relevance			NO			
Risks addressed			Extreme cold, snowfall, blizzards, heavy precipitation.			

23. Review and improve waterways' operation maintenance standards				
Relevant to:	Road	Rail	Waterborne	Airborne
			X	
Description Option's relevance Economic: - / Ecologic: -- / Social:	Review operation and maintenance standards in the light of CCA, for example the scope and frequency of dredging of Danube (precipitation), the scope of inspection and maintenance activities of port equipment (cold, snowfall, blizzards), and so on. Potential participants: ExAEMDR, BPI, port operators.			
Opportunities that arise	The review could provide for introducing a performance-based maintenance system, which is a tool ensuring more reliable and cost-effective maintenance of the waterborne transport infrastructure.			
Cross-cutting relevance	YES	Water.		
Risks addressed	Extreme heat, extreme cold, snowfall, blizzards.			

24. Review and improve airports' operation maintenance standards				
Relevant to:	Road	Rail	Waterborne	Airborne
				X
Description Option's relevance Economic: - / Ecologic: / Social: +	Review operation and maintenance standards in the light of CCA, for example the scope and frequency of planned pavement repairs (thermal stress), the scope and frequency of maintenance of drainage structures (precipitation), the scope of winter maintenance (snowfall, blizzards), and so on. Potential participants: Airport operators.			
Opportunities that arise	The review could provide for introducing a performance-based maintenance system, which is a tool ensuring more reliable and cost-effective maintenance of the airborne transport infrastructure.			
Cross-cutting relevance	NO			
Risks addressed	Extreme heat, heavy precipitations, snowfall, blizzards.			

IV. Review and improve emergency response procedures

25. Develop and track mode specific performance metrices related to extreme weather events				
Relevant to:	Road	Rail	Waterborne	Airborne
	X	X	X	X
Description Option's relevance Economic: / Ecologic: / Social: ++	Develop and track performance metrics related to extreme weather events. Potential participants: all infrastructure managers.			
Opportunities that arise	Availability of the performance metrics is a precondition for establishing sound emergency response plans, rules, and procedures.			
Cross-cutting relevance	NO			
Risks addressed	All.			

26. Review and improve all subsectors' emergency response plans, rules and procedures						
Relevant to:			Road	Rail	Waterborne	Airborne
			X	X	X	X
Description			Review of the emergency response plans, rules, and procedures of the stakeholders in the context of climate change adaptation. If needed, revise the emergency response plans, rules, and procedures of the stakeholders, as well as provide training (to be focused mainly on joint action of the various actors). Potential participants: all public-sector stakeholders operating transport infrastructure.			
Option's relevance						
Economic	Ecologic	Social				
		+++				
Opportunities that arise			Emergency response plans, rules and procedures that are brought in line with the climate change challenges will provide for more adequate reaction and will reduce economic and financial costs (material damage, accidents, fatalities, casualties, and delays).			
Cross-cutting relevance			YES	Need for coordination with other relevant institutions and/or bodies.		
Risks addressed			All.			

27. Develop and implement plans for deployment of road ITS as emergency response mitigation and management tool						
Relevant to:			Road	Rail	Waterborne	Airborne
			X			
Description			Develop plans for deployment of ITS as emergency response tool. Potential participants: RIA, municipalities.			
Option's relevance						
Economic	Ecologic	Social				
--		+++				
Opportunities that arise			ITS is effective and efficient tool to manage traffic flows so to avoid or mitigate the financial and economic costs in case of emergency events.			
Cross-cutting relevance			NO			
Risks addressed			All.			

V. Review and improve data collection procedures and building knowledge base

28. Review and identify deficiencies in current scope, rules and practice in data collection with focus on CCA						
Relevant to:			Road	Rail	Waterborne	Airborne
			X	X	X	X
Description			Review the existing internal rules and practices for the collection of data related to the transport infrastructure and services operated and maintained by the various stakeholders. Identify gaps and deficiencies (general and in the light of climate change adaptation). Potential participants: MTITC, MRDPW, and all other public-sector stakeholders.			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			Availability of specific climate change-oriented data will provide for carrying out specific studies to analyze and justify the relevance of specific CCA options.			
Cross-cutting relevance			YES	Need for coordination with other relevant institutions and/or bodies. Potential participants:		
Risks addressed			All.			

29. Introduce and/or improve CCA relevant data collection practice						
Relevant to:			Road	Rail	Waterborne	Airborne
			X	X	X	X
Description			Develop and introduce formal internal rules for data collection (for the stakeholders that do not have any). Revise the existing internal rules for data collection (when deemed necessary). Potential participants: MTITC, MRDPW, and all other public-sector stakeholders.			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			Availability of specific climate change-oriented data will provide for carrying out specific studies to analyze and justify the relevance of specific CCA options.			
Cross-cutting relevance			YES	Need for coordination with other relevant institutions and/or bodies.		
Risks addressed			All.			

30. Carry out dedicated studies to assess mode specific climate change risk and vulnerability						
Relevant to:			Road	Rail	Waterborne	Airborne
			X	X	X	X
Description			Develop new climate change risk and vulnerability studies per transport mode using data collected. Elaboration and update of CCA options per mode. Potential participants: MTITC, MRDPW, and all other public-sector stakeholders.			
Option's relevance						
Economic	Ecologic	Social				
		+++				
Opportunities that arise			Availability of mode specific climate change-oriented studies will provide for identifying the most effective and efficient CCA options.			
Cross-cutting relevance			YES	Coordination with other CCA studies at national level might be needed.		
Risks addressed			All.			

VI. Building institutional capacity

31. Review, gap assessment and adaptation of institutional setup per transport subsectors to address CCA issues						
Relevant to:			Road	Rail	Waterborne	Airborne
			X	X	X	X
Description			A formal review of the institutional setup of all transport sector stakeholders and a proposal for changes to their structures to introduce human resources with duties in CCA. The study should also include a review of the internal procedures and if needed propose amendments to integrate CCA in the workflow. Potential participants: MTITC, MRDPW, and all other public-sector stakeholders.			
Option's relevance						
Economic	Ecologic	Social				
		++				
Opportunities that arise			The review will serve as a basis for developing CCA institutional capacity in the transport sector.			
Cross-cutting relevance			NO			
Risks addressed			All.			

32. Assign CCA responsibilities in the statute and internal procedures of the relevant stakeholders					
Relevant to:		Road	Rail	Waterborne	Airborne
		X	X	X	X
Description Option's relevance Economic: - / Ecologic: / Social: ++		Introduction of the CCA responsibilities in the statute and internal procedures of the stakeholders. Potential participants: MTITC, MRDPW, and all other public-sector stakeholders.			
Opportunities that arise		Availability of specific bodies formally in charge with the CCA is a precondition for planning and implementing adaptation options in a structured and coordinated way.			
Cross-cutting relevance		YES	Need for coordination with other relevant institutions and/or bodies.		
Risks addressed		All.			

33. Training needs assessment and implement training programs					
Relevant to:		Road	Rail	Waterborne	Airborne
		X	X	X	X
Description Option's relevance Economic: - / Ecologic: / Social: ++		Detailed assessment of the need for training, preparation of a training program for the stakeholders. Training of enough staff to build up awareness of CCA issues. Potential participants: all stakeholders.			
Opportunities that arise		Well trained stakeholders will identify, prepare, and implement the right CCA options and will monitor the results so to further improve these.			
Cross-cutting relevance		YES	Need for coordination with other relevant institutions and/or bodies.		
Risks addressed		All.			

34. Raising public awareness towards transport relevant CC and CCA issues					
Relevant to:		Road	Rail	Waterborne	Airborne
		X	X	X	X
Description Option's relevance Economic: - / Ecologic: / Social: +++		Design and implementation of public awareness raising campaigns aiming to inform the society about the CCA need and actions taken in this respect in the transport sector. Potential participants: all stakeholders.			
Opportunities that arise		Implementation of CCA options needs support from society and thus, society should be well informed about the risks, vulnerabilities, and the options to address these correctly to the benefit of the entire society.			
Cross-cutting relevance		YES	Need for coordination with other relevant institutions and/or bodies.		
Risks addressed		All.			

Annex 3. Cost-benefit Analysis

1. General Description

The transport sector is one of the important sectors where climate change can have large impacts, affecting transport systems and, consequently, the functioning of other economic sectors. The conceptual framework of the cost-benefit-analysis (CBA) was developed on the basis of climate change affecting the transport sector.

The purpose of this section is to:

- Estimate the parameters of a relationship between key performance indicators and climate change indicators for the transport sector (temperature +2°C and +4°C, and precipitation changes). It is considered that climatic drivers associated with the impact assessment are average temperature and average precipitation.
- Develop a CBA model – appraising the costs and benefit of adaptation actions, thus measuring the efficiency of investments. It quantifies the anticipated costs and benefits of adaptation options with the aim of comparing them and determining whether the benefits outweigh the costs. Benefits are the advantages or positive effects of adaptation measures. Costs are the resources required to deliver adaptation measures. The effects are expressed as a decrease in costs because of measures taken.
- Evaluate and rank the adaptation options in terms of their economic efficiency.

1.1. Description of the methodology

Climate effects were evaluated in an integrated assessment model, which combines a regression (or sensitivity) analysis with CBA, that is, assesses the value of the costs and benefits of each adaptation action - giving a net present value (NPV) - and compares the costs (investment expenditure) and benefits (costs avoided). Costs and benefits are expressed in monetary terms and a discount rate is used to determine the NPV[81] of the adaptation measures.

The regression analysis - as a technique to assess adaptation measures under uncertainty - identifies those factors that have most influence on main sectoral indicators.[82] The effect can be positive or negative. Positive impact, for example, results in smooth functioning of the transport system and seamless traffic flows while disruption of the system and flows is a negative impact.

Regression analysis was used to determine the effect of climatic variables on the performance of the transport indicators. This function is normally used when both the dependent and the explanatory variables are linear. The dependent variables are the main sectoral indicators where the independent variables are climatic (temperature and precipitation). Linear extrapolation of the key indicators was accounted aiming at identifying how the sector would develop under each scenario. Extrapolation quantified each individual indicator.

[81] The NPV of an adaptation option is given by the present value of the estimated benefits net of costs. If NPV is more than zero', this indicates that the investment is efficient and incremental benefits of adaptation exceed the incremental resource costs. If NPV is <0 or B/C is <1, then the adaptation measures add no net benefit to the Transport sector. If NPV is >0 or B/C is >1, then it adds positive benefits and. The positive value of NPV confirms that investments for adaptation are efficient.
The benefit-cost ratio (B/C) is the ratio of the present value of benefits to the present value of costs. When the B/C ratio is more than one, the present value of the option's benefits is larger than the present value of its costs.

[82] The regression is linear; the dependent and the explanatory variables are linear.

The estimation of the negative and positive effects of climatic change was developed according to distinct scenarios at +2°C and +4°C temperature rise by 2050. These main scenarios are divided into sub–scenarios: optimistic, realistic, and pessimistic. The sub-scenarios are considered in the context of efficient and effective implementation of the proposed climate change adaptation measures.

The projected effects of adaptation measures are expressed as a logarithmic function, which is a tool to measure the effects of investments that would be gradually made until 2050.

An assessment was carried out of the NPV and the benefits until 2050, holding all other aspects constant. The monetary value of the effects was discounted by 4.5 percent for public funding and by 8 percent for private funding.

The benefits are defined as the positive effect of the implementation of climate change adaptation measures in the transport sector.

1.2. Data collection procedure

The primary data used for the CBA was obtained from the Action Plan that is part of the draft proposal for a National Climate Change Adaptation Strategy and Action Plan for Bulgaria, and from official statistical data.

The correlation determined whether there is a relationship between the performance indicators and climate factors. The relationship indicates which indicators are significantly dependent on climate change. Estimation of the correlation coefficient (dependence between each sectoral indicator and climate change factors [temperature and precipitation]) is used to stand out and select the critical variables (variables, which are highly sensitive to climate factors).

1.3. Model specifications - assumptions and limitations

- It is assumed that the transport performance indicators depend on climate factors (temperature and precipitation).
- The projected trend value of each sector indicator is based on historical data (2005–2016).
- The main performance indicators are: damage costs for road infrastructure, damage costs for rail infrastructure, maintenance costs for road infrastructure, and maintenance costs for rail infrastructure. An additional key parameter included in the CBA is saved travel costs.
- Climate projection (temperature and precipitation) was applied to historical variances experienced in Bulgaria (1991–2015). The input data for climate factors consist of annual temperatures (maximum, minimum, and average) and precipitation (maximum, minimum, and average).
- A baseline scenario was used to evaluate the development trend of the performance indicators under the +2°C and +4°C temperature rise scenarios. The baseline scenario reflects a continuation of current policies and plans, that is, a future in which no new measures are taken to address climate change.

2. Results of the Regression Analysis

A differential assessment was carried out by comparing the climate change effects on key A differential assessment was carried out by comparing the climate change effects on key performance indicators in all climate scenarios against the baseline scenario. The results display negative or positive effects on the indicators per scenario.

The statistical dependency between the performance indicators and climate change factors is not significant, which means that there is no explicit relationship. The reason is that there are a range of other factors (economic, social, human, management, financial, and others) that affect the performance indicators.

The social and economic costs of the negative impact of climate change without adaptation options are quantified in the baseline scenario.

According to the baseline scenario the expected total damage costs until 2050 for road and rail infrastructure is €1.2 billion at a temperature rise of +2°C and €2.6 billion at +4°C temperature rise. The expected damage on roads of the projected temperature increase is €1.2 billion at +2°C and €2.4 billion at +4°C. The costs for covering the losses from increased temperatures are higher for roads than for railways.

The expected costs for maintenance of the road infrastructure will reach a value of €7,0 billion at an average temperature increase of +2°C and €14.1 billion at +4°C. Less costs are expected for maintenance of the rail infrastructure: €1.8 billion at +2°C and €3.7 billion at +4°C.

The estimated social effect takes into account infrastructure operation and damage costs without applied adaptation options until 2050. The value of the total social effect will be €263.6 million at an average temperature rise of +2°C and €459.3 million at an average rise of +4°C.

The overall cumulative effect in monetary value (damage and maintenance costs) projected until 2050 will be €10.2 billion at an average temperature rise of +2°C and €20.4 billion at an average rise of +4°C.

The cumulative sector effects presented in ***Table 25*** illustrate the difference between the baseline scenario (that is, without implementing selected adaptation options), and the +2°C and +4°C temperature rise scenarios until 2050.

Table 25. Expected total sector effects from climate change without adaptation measures in millions of euros until 2050 (baseline scenario)

Performance Indicators	2°C scenario (in millions of €)	4°C scenario (in millions of €)
1. Damage costs for road infrastructure	1,243.8	2,487.6
2. Damage costs for rail infrastructure	42.9	85.8
3. Maintenance costs for road infrastructure	7,059.0	14,118.1
4. Maintenance costs for rail infrastructure	1,875.2	3,750.4
Total sector effect until 2050	10,221.0	20,442.1

3. Results of the Cost-benefit Analysis

The CBA for the sector focuses on the assessment of soft adaptation measures. The benefits gained as a result of their implementation are best exemplified through the quantification of saved costs in main performance indicators (saved travel costs; expenditures for infrastructure maintenance; and others). Considering the complex impact of the adaptation options on the Transport sector, these were not separately quantified in the current CBA. The net present value (NPV) in ***Table 26*** illustrates the monetary value of avoided losses as a result of implemented adaptation measures, while the cost effectiveness quantifies the benefits achieved in relation to the required investments/costs.[83]

Table 26. Benefits of adaptation measures in the Transport sector under different climate scenarios until 2050 (in €, million)

Climate scenarios	NPV (€ million)	Cost-effectiveness (Benefit/Cost ratio)
Realistic scenario +2°C	682.5	2.04
Optimistic scenario +2°C	734.9	2.12
Pessimistic scenario +2°C	632.9	1.96
Realistic scenario +4°C	1,420.4	3.15
Optimistic scenario +4°C	1,501.6	3.27
Pessimistic scenario +4°C	1,343.8	3.04

The projection shows that on average, under the +2°C realistic scenario, the total cash flow in NPV is €682.5 million, and €1.4 billion under the realistic scenario at +4°C. Under the optimistic scenario, the projected cash flow in NPV is €734.9 million under the +2°C scenario and €1.5 billion – under the +4°C scenario. Even under the pessimistic scenario, the future cash flow in NPV is projected at €632.9 million at +2°C and €1.3 billion at +4°C.

Within the current analysis, the cost-effectiveness of the adaptation measures is used to quantify the effect of investments under each scenario.[84] Under the +2°C realistic scenario the benefit/cost ratio is €2.04 (that is, the benefits achieved per Euro spent) and €3.15 under the +4°C realistic scenario. The benefit is higher at +4°C temperature rise. In that case, the benefit is €3.27 per one Euro of investment under the optimistic scenario and €3.04 per one Euro of investment under the pessimistic scenario.

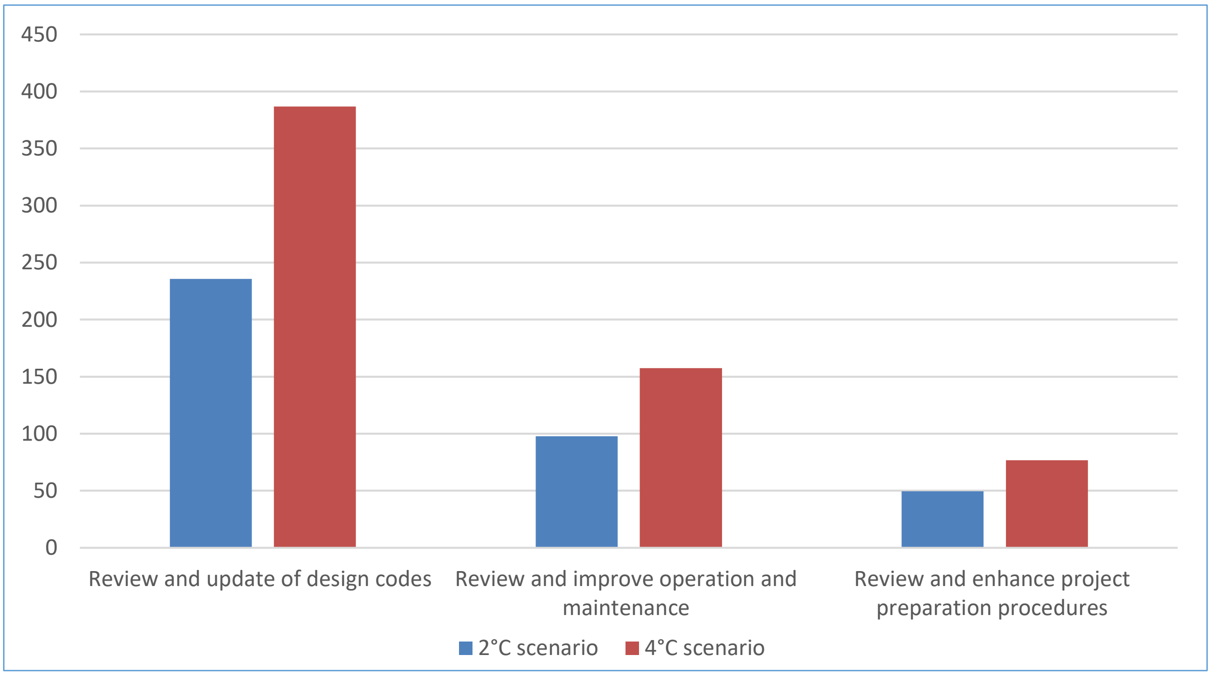
3.1. Prioritization of Adaptation Measures according to CBA

CBA can be used for decision making as a tool to identify measures that efficiently use financial resources. The results of the CBA identify the most economically efficient adaptation actions and allow for their ranking. The adaptation measures for which the benefit exceeds the cost can be ranked as follows: Review and enhance project preparation procedures, Review and improve

[83] The NPV of an adaptation option is given by the present value of the estimated benefits and costs. If NPV is more than zero, this indicates that the investment is efficient and incremental benefits of adaptation exceed the incremental resource costs. If NPV is <0 or B/C is <1, then the adaptation measures add no net benefit to the Urban Environment sector. If NPV is >0 or B/C is >1, then it adds positive benefits. The positive value of NPV confirms that investments for adaptation are efficient.
The benefit-cost ratio (B/C) is the ratio of the present value of benefits to the present value of costs. When the B/C ratio is more than one, the present value of the option's benefits is larger than the present value of its costs.
[84] The cost-effectiveness refers to all measures.

operation and maintenance, and Review and update of design codes. ***Figure 24*** shows the estimated contribution of selected adaptation measures in reaching the overall positive effects of climate change adaptation.

Figure 24. Prioritization of the adaptation measures in the Transport sector (total NPV effect in € million)



4. Conclusions

The effect of adaptation measures in the transport sector will be travel cost savings as a result of decreased rail and road damage. The estimated financial efficiency related to applied adaptation measures is positive. The NPV calculation until 2050 shows that investment in adaptation measures is positive in all scenarios, thus economically efficient.

Annex 4. Future Vulnerabilities of Road and Railway Infrastructure and Services

Table 27. Future vulnerability of road infrastructure and services

Asset / service category	Climate variable	Sensitivity	Exposure	Change in exposure	Future vulnerability (change in category)	Marginal cost*
Road pavement	Snow/ice/cold	Direct damage for example potholes	Particularly in mountains	Warming will make winters shorter and less severe, but ice and freeze-thaw issues will still occur	High (*decreased*)	-€
	Hot/dry	Direct damage for example bitumen melting; indirect damage for example rutting	Particularly on south-facing slopes; exacerbated by overloading	Hotter, drier summers will increase exposure	Very high (*no change*)	€€
	Rain	Flood damage	Thunder-storm areas* and close to rivers	Greater severity of rainfall and floods will increase exposure	Very high (*increased*)	€€€
Embankment and cuttings	Snow/ice/cold	Subsidence / rockfalls	Particularly in mountains	Warming will make winters shorter and less severe, but ice and freeze-thaw issues will still occur	High (*decreased*)	-€
	Hot dry	Subsidence; vegetation loss (fire)	Particularly in embanked sections	Increased likelihood of subsidence and fire	High (*increased*)	€
	Rain	Subsidence; erosion by rivers Landslides and rockfalls	Particularly in embanked sections	Greater severity of rainfall and floods will increase exposure	Very high (*no change*)	€€
Drainage	Snow/ice cold	Freezing, blockage, damage	Ubiquitous	Warming will make winters shorter and less severe, but ice and freeze-thaw issues will still occur	Medium (*no change*)	-€
	Hot/dry	Build-up of pollutants	Ubiquitous	Dry spell length likely to increase which could increase build up	Medium (*no change*)	-/+

Asset / service category	Climate variable	Sensitivity	Exposure	Change in exposure	Future vulnerability (change in category)	Marginal cost*
	Rain	Capacity exceedance, erosion	Ubiquitous – but higher in thunder-storm areas* and near rivers draining mountains	Greater severity of rainfall will increase exposure	Very high (*no change*)	€€
Street Furniture (for example guard rails, planters)	Snow/ice/cold	Guard rails subject to damage from snow ploughs	Ubiquitous	Warming will make winters shorter and less severe, but significant snow ploughing will still be required	Medium (*decreased*)	-€
Vehicles	Snow/ice/cold	Delays, closures, risk of accident	Particularly in mountains	Warming will make winters shorter and less severe, but snow and ice will still occur	Medium (*no change*)	-€
	Hot/dry	Delays, reduced skid resistance; reduced passenger comfort; freight heating	Particularly in central and SE areas	Hotter drier conditions will increase exposure	High (*increased*)	€
	Rain	Flooding leading to closure, delay or risk of accident	Thunder-storm areas* and close to rivers	Greater severity of rainfall will increase exposure	High (*increased*)	€

**Marginal economic cost beyond present day costs that is, cost due to climate change. Qualitative estimate of costs: -/+ no or slight decrease or increase in cost; -/€ decrease/increase in cost; -/€€ large decrease/increase in cost; -/€€€ very large decrease/increase in cost.*

Source: World Bank 2012.

Table 28. Future vulnerability of railway infrastructure and services

Asset/service category	Climate variable	Sensitivity	Exposure	Change in exposure	Future vulnerability (change in category)	Marginal cost^
Bridges and viaducts	Wet weather	Sensitive to floods exceeding the design standard (and erosion)	Especially rivers emerging from mountains	More intense rainfall could lead to flash floods; spring snow melt may be faster	High (*increased*)	€€
Tunnels	Low temperatures	Low temperatures can cause problems with ice Impact to underground waters Destructions	Mountains	Low temperatures less likely but sub-zero temperatures will still occur	Medium (*no change*)	-/+
Track and points	Temperature extremes	Rail deformation at extremes; points freeze	Widespread	Higher temperatures lead to greater deformation problems; points freeze less often	Very high (*increased*)	€
	Hot and dry	High sensitivity to fire	Especially in forests	Hotter, drier conditions will increase exposure	Very high (*no change*)	€€
	Wet weather	Sensitive to flooding, erosion and deposition via landslides and rockfalls	Close to rivers; near steep, unstable slopes	More intense rainfall could lead to flash floods; spring snow melt may be faster	Very high (*increased*)	€€
Substructure	Wet weather	Sensitive to, erosion and damage via landslides and rockfalls	Close to rivers; near steep, unstable slopes	More intense rainfall could lead to flash floods; spring snow melt may be faster	Very high (*increased*)	€€
Vegetation	All	Species and growth sensitive to weather and climate	Ubiquitous	Increase in temperature and change in precipitation patterns will alter favourability of species	High (*increased*)	€
	Hot and dry	High sensitivity to fire	Especially in forests	Hotter, drier conditions will increase exposure	Very high (*no change*)	€€

Asset/service category	Climate variable	Sensitivity	Exposure	Change in exposure	Future vulnerability (change in category)	Marginal cost^
Passenger	Temperature extremes	Passenger comfort in hot/cold weather; risk of accident and delays	Ubiquitous; accentuated in areas and times of extremes	Increase in hot weather problems; reduction in cold weather problems	Medium (*no change*)	-/+
	Wet weather	Risk of accident and delays	Close to rivers; near steep, unstable slopes	Increase in heavy rainfall could increase exposure	Medium (*no change*)	-/+
Freight	Temperature extremes	Freight integrity in hot/cold weather; risk of accident and delays	Ubiquitous; accentuated in areas and times of extremes	Increase in hot weather problems; reduction in cold weather problems	Medium (*no change*)	-/+
	Wet weather	Risk of accident and delays	Close to rivers; near steep, unstable slopes	Increase in heavy rainfall could increase exposure	Medium (*no change*)	-/+

^Marginal economic cost beyond present day costs that is, cost due to climate change. Qualitative estimate of costs: -/+ no or slight decrease or increase in cost; -/€ decrease/increase in cost; -/€€ large decrease/increase in cost; -/€€€ very large decrease/increase in cost.

Source: World Bank 2012.

Annex 5. Summary of Stakeholder Adaptive Capacity Survey

Table 29. Stakeholder adaptive capacity (1)

Topic	MTITC	RIA	NRIC	ExAEMDR	ExARA
Climate change adaptation awareness self-assessment	High	Low	High	High	Low
Availability of internal documents and guidelines related to climate change adaptation	No	No	No	No	No
Expected climate change events and effects	Yes	Snowfall and flooding of short sections of the secondary road network	No. CCA dealt with on project by project basis	Snowfall, blizzards, storms, low water levels	None
Most important climate-related risks relevant to the stakeholder	N/A	Extreme snowfall and precipitation (result in disruptions to traffic and landslides)	Extreme heat, forest fires, more frequent extreme weather events – floods, landslides, and so on	Ice blocks and water freezing, low water levels	Freezing and icing of equipment, disruptions to railway traffic because of floods, landslides and snow
Identified need for a dedicated climate change adaptation unit or staff	No	No. There is a unit for response to emergencies	No. The Safety Inspectorate is responsible for CCA	No	No
Identified need for additional training on climate change adaptation	Yes	Yes	Yes	No	No
Availability and use of formal project preparation guidelines and procedures	N/A	No	No	No	N/A
Availability and use of formal instructions and guidelines for emergency response	N/A	No	Yes	Yes	N/A
Availability of detailed statistical data for *floods*	N/A	No	Yes	N/A	No
Availability of detailed statistical data for *landslides*	N/A	No	Yes	N/A	No
Availability of detailed statistical data for *intense heat*	N/A	No	Yes	N/A	No
Availability of detailed statistical data for *snowfall and blizzards*	N/A	No	Yes	Yes	No

Note: shaded cells indicate areas where further action may be necessary.

Table 30. Stakeholder adaptive capacity (2)

Topic	BPI	ExAMA	BULATSA	SUMC
Climate change adaptation awareness self-assessment	Low	Low	High	Yes
Availability of internal documents and guidelines related to climate change adaptation	No	No	Yes	No. Uses the municipal strategy
Expected climate change events and effects	No	No	Winter weather extremes, air turbulence, extreme heat	No
Most important climate-related risks relevant to the stakeholder	Extreme cold and water freezing, precipitation, storms, fog, increase of the sea level	No	Storms, heavy snow, blizzards, fog, heavy precipitation, freezing rain	No
Identified need for a dedicated climate change adaptation unit or staff	No	No	No	No. Has an environmental unit that deals with CCA
Identified need for additional training on climate change adaptation	Yes	No	Yes	Yes
Availability and use of formal project preparation guidelines and procedures	No	N/A	Yes, but not clear if related to technical aspects	No
Availability and use of formal instructions and guidelines for emergency response	Yes. Order by the director of the company	No	Yes	
Availability of detailed statistical data for *floods*	No	N/A	No	No
Availability of detailed statistical data for *landslides*	No	N/A	No	N/A
Availability of detailed statistical data for *intense heat*	No	N/A	No	No
Availability of detailed statistical data for *snowfall and blizzards*	No	No	No	No

Note: shaded cells indicate areas where further action may be necessary.

Annex 6. Responsibilities of the Transport Sector Stakeholders

Table 31. Transport sector stakeholders' responsibilities

Entity	Subsector	Duties and responsibility in the area of				
		Sector Policy	Planning	Implementation of Infrastructure Projects	Emergency Response	Data Collection
MTITC	All	Yes. Leading role in the definition of the national transport policy	Yes. Leading role in the planning of programs for development of transport and the transport infrastructure	No. Monitoring of projects implemented under OPTTI	Yes. Leading role in the definition of emergency response policies and legislation; coordination role	Yes. Collection of data regarding emergencies and accidents for railway, waterborne and airborne transport
MRDPW	Roads	Yes. Leading role in the definition of municipal and urban transport policy	Yes. Leading role in the planning of programs for development of National Road Network and for regional and urban development	No. Monitoring of projects implemented under OPRG	No. Role in the development of policies and legislation (roads)	Yes. Entities under MRDPW are responsible for collecting and maintaining landslides data
MI	All	Yes. Leading role in the definition of emergency response policies across all sectors of the economy	No	No	Yes. Both reaction to accidents and role in the definition of emergency response policies and legislation	Yes. Collection of data regarding road traffic accidents and other emergencies
RIA	Roads	Yes. Major role in the definition of the national road transport policy	Yes. Leading role in the planning of programs for development and maintenance of the national road network	Yes	Yes	Yes. Responsible for the collection of data regarding the national road infrastructure
NRIC	Railways	Yes. Major role in the application of the national railway transport policy	Yes. Leading role in the planning of programs for development and maintenance of the national railway network	Yes	Yes	Yes. Responsible for the collection of data regarding the national railway infrastructure
ExARA	Railways	Yes. Major role in the transposition of European rail transport legislation into national legislation	No	No	No. Role in the development of policies and legislation regarding railway transport	No (of relevance to CCA)

Entity	Subsector	Duties and responsibility in the area of				
		Sector Policy	Planning	Implementation of Infrastructure Projects	Emergency Response	Data Collection
BPI	Waterborne	Yes. Major role in the application of the national waterborne transport policy	Yes	Yes, but most projects are related to the development of information systems, pollution management and similar	Yes	No (of relevance to CCA)
ExAEMDR	Waterborne	Yes. Major role in the application of the national waterborne transport policy	Yes. Leading role in the planning of programs for improvement and maintenance of the navigation conditions along Danube river	Yes	Yes	Yes
ExAMA	Waterborne	Yes. Organize and coordinate safety navigation activities in maritime and inland waterways of the Republic of Bulgaria	No	No	Yes	
DG CAA	Airborne	Yes. Aviation safety programmes, rules and procedures	No	No	Yes	No (of relevance to CCA)
ExAAA	Road transport	No (of relevance to CCA)	No	No	No	No (of relevance to CCA)
Municipalities	Road and urban railway transport	Yes. Consultative role in the preparation of national policy documents	Yes. Preparation of programs for the development and maintenance of the municipal road and street networks, planning and management of public transport	Yes	Yes	Yes. Responsible for collecting data regarding the assets being managed, as well as the public transport system

Annex 7. Adaptation Options Details

Table 32. Costs, benefits, efforts, and institutional arrangements

Ref.	Adaptation Option	Time	Preparation Costs (BGN)	Costs	Benefits	Implementation Efforts	Institutional Arrangements
1	Adaptation of road culvert design standards	18 months	100,000	Low. Minor increase in culvert construction costs could be expected	Medium. Decreased damage to road and other infrastructure	Low. No complicated coordination involved	Joint action between RIA and MRDPW to amend Ordinance No. 1
2	Adaptation of rail culvert design standards	18 months	100,000	Low. Minor increase in culvert construction costs could be expected	Medium. Decreased damage to rail and other infrastructure	Low. No complicated coordination involved	Joint action between NRIC and MTITC to amend Ordinance No. 55
3	Adaptation of road bridges design standards (bridge spans)	18 months	90,000	Low. Minor increase in bridge construction costs could be expected	Medium. Decreased damage to bridges	Low. No complicated coordination involved	Joint action between RIA and MRDPW to amend Ordinance No. 1
4	Adaptation of railway bridges design standards (bridge spans)	18 months	90,000	Low. Minor increase in bridge construction costs could be expected	Medium. Decreased damage to bridges	Low. No complicated coordination involved	Joint action between NRIC and MTITC to amend current regulation
5	Adaptation of road pavement design code	18 months	80,000	None or low. Expected reduction of pavement thickness	Medium. Cost savings due to decreased pavement thickness	Low. No complicated coordination involved	Joint action between RIA and MRDPW to amend Ordinance No. 1
6	Adaptation of road pavement design of streets	18 months	60,000	None or low. Expected reduction of pavement thickness to be possibly offset depending on whether PMB should be used	Medium. Cost savings due to decreased pavement thickness and longer life of the road pavement	Low. No complicated coordination involved	MRDPW to amend Ordinance No. 2
7	Review and evaluation of the effect of the use of polymer modified bitumen in road pavements	18 months	80,000	None or low. Depending on whether the use of PMB should increase	Low to medium. Depending on how close to optimal are the existing requirements.	Low. No complicated coordination involved.	Joint action between RIA and MRDPW to amend Ordinance No. 1
8	Regularly design codes review & update obligation	6 months	0	No direct costs	Medium to high benefits of keeping the codes up to date	Low. No complicated coordination involved	Supervisory role of MRDPW over RIA and of MTITC over NRIC

Ref.	Adaptation Option	Time	Preparation Costs (BGN)	Costs	Benefits	Implementation Efforts	Institutional Arrangements
9	Development & adopt common CCA guidelines for project promoters	6 months	40,000	No direct costs	Medium. Improved quality of project preparation will reduce costs over time	Low to medium. The managing authorities of OPTTI and OPRG to coordinate with beneficiaries	None
10	Develop road project preparation manual	6 months	30,000	None	Medium. Improved quality of project preparation will reduce costs over time	Low. No complicated coordination involved	None
11	Develop railway project preparation manual	6 months	30,000	None	Medium. Improved quality of project preparation will reduce costs over time	Low. No complicated coordination involved	None
12	Develop waterborne project preparation manual	6 months	30,000	None	Medium. Improved quality of project preparation will reduce costs over time	Low. No complicated coordination involved	None
13	Develop air project preparation manual	6 months	30,000	None	Medium. Improved quality of project preparation will reduce costs over time	Low. No complicated coordination involved	None
14	Road network criticality assessment	18 months	60,000	None	Medium. Improved prioritization of interventions	Low. No complicated coordination involved	None
15	Railway network criticality assessment	12 months	40,000	None	Medium. Improved prioritization of interventions	Low. No complicated coordination involved	None
16	Identification of road sections prone to winter disruptions	12 months	50,000	None	Medium. Improved prioritization of interventions	Low. No complicated coordination involved	None
17	Identification of railway sections prone to winter disruptions	6 months	20,000	None	Medium. Improved prioritization of interventions	Low. No complicated coordination involved	None
18	Investment program for improving the road sections prone to winter disruptions	3 months	15,000	Low. Expected to consist of installation of snow protection barriers and planting of vegetation	High. Less winter disruptions to traffic due to blizzards and intense snowfall	Low. No complicated coordination involved	None

Ref.	Adaptation Option	Time	Preparation Costs (BGN)	Costs	Benefits	Implementation Efforts	Institutional Arrangements
19	Investment program for improving railway sections prone to winter disruption	3 months	40,000	Low. Expected to consist of installation of snow protection barriers and planting of vegetation	High. Less winter disruptions to traffic due to blizzards and intense snowfall	Low. No complicated coordination involved	None
20	Evaluation the practice of stopping of HGVs during hot weather	6 months	30,000	Low to none. Costs to operators and for damage to infrastructure	Medium to low. Depending on how close to optimal are the existing arrangements	Low. Consultations with operators highly recommendable	None
21	Adaptation of road operation and maintenance standards in the light of CCA	12 months	50,000	None to low. May require some additional activities	Medium. Will result in increased maintenance quality and less damage to infrastructure	Low. No complicated coordination involved	None
22	Adaptation of railway operation and maintenance standards in the context of CCA	12 months	50,000	None to low. May require some additional activities	Medium. Will result in increased maintenance quality and less damage to infrastructure	Low. No complicated coordination involved	None
23	Adaptation of waterborne operation and maintenance standards in the context of CCA	12 months	50,000	None to low. May require some additional activities	Medium. Will result in increased maintenance quality and less damage to infrastructure	Low. No complicated coordination involved	None
24	Adaptation of airborne operation and maintenance standards in the context of CCA	12 months	50,000	None to low. May require some additional activities	Medium. Will result in increased maintenance quality and less damage to infrastructure	Low. No complicated coordination involved	None
25	Develop performance metrics for extreme weather events	6	40,000	None to low. May require some additional activities	Medium. Will gradually increase the adaptation capacity	Low. No complicated coordination involved	Most likely none
26	Review and improve all subsectors' emergency response plans, rules and procedures, as well as provide training	18 months	100,000	None	High. Possible improvement of emergency response	Low to medium. Coordination with other stakeholders will be required	All public-sector stakeholders operating transport infrastructure
27	ITS deployment	18 months	200,000	Low to medium	High. Expected significant improvement in reaction to extreme events and emergency response thereto	Low to medium. Coordination with other stakeholders will be required	Most likely none

Ref.	Adaptation Option	Time	Preparation Costs (BGN)	Costs	Benefits	Implementation Efforts	Institutional Arrangements
28	Review the existing data collection procedures in the context of CCA	3 months	10,000	None	Medium to high. Possible improvement of data collection procedures	Low. No complicated coordination involved	None
29	Develop and establish formal data collection rules	9 months	30,000	None	Medium to high. Will allow better planning not only of CCA response but to OM	Low. No complicated coordination involved	None
30	Conduct detailed vulnerability assessment studies per sub-sectors	12 months	200,000	None	Medium to high. Will provide for better addressing mode specific CCA issues	Low. No complicated coordination involved	None
31	Review of the context institutional setup in the of CCA	3 months	15,000	None	Medium. Possible improvement of CCA capacity within the stakeholders	Low. No complicated coordination involved	None
32	Assign CCA responsibilities	3 months	10,000	None to low. Most likely will not require additional staff	Medium. Will improve CCA capacity within the stakeholders	Low. No complicated coordination involved	May require changes to the statute and structure of some stakeholders
33	Needs assessment and training	24 months	100,000	None	Medium to high. The improved awareness and capacity of the stakeholders' staff will facilitate CCA	Low. No complicated coordination involved	None
34	Awareness raising regarding CCA	24 months	100,000	None	Medium to high. The improved awareness of the society will provide for better acceptance and reaction in case of whether related extreme events	Low. No complicated coordination involved	None
TOTAL			**2,020,000**				

Annex 8. Costs of Damage to Transport Infrastructure

Information compiled in this Annex is collected through a survey carried out in the first half of 2017. Stakeholders were kindly requested to answer in writing 12 questions. Questions related to data presented below were formulated as follows:

Q. 9 Are detailed statistical data available about damage caused by ***floods*** (date, event description, precise location/area/length of affected infrastructure, repair costs)? If yes, could you provide such data (e.g. for the previous 5 years)?

Q. 10 Are detailed statistical data available about damage caused by ***landslides*** (date, event description, precise location/area/length of affected infrastructure, repair costs)? If yes, could you provide such data (e.g. for the previous 5 years)?

Q. 11 Are detailed statistical data available about damage caused by ***intense heat*** (date, event description, precise location/area/length of affected infrastructure, repair costs)? If yes, could you provide such data (e.g. for the previous 5 years)?

Q 12 Are detailed statistical data available about damage caused by ***snowfalls and snow storms*** (date, event description, precise location/area/length of affected infrastructure, repair costs)? If yes, could you provide such data (e.g. for the previous 5 years)?

Road infrastructure

RIA does not maintain statistics on damage incurred to road infrastructure caused by floods, landslides, snowfalls, and snow storms. In relation to intense heat waves, RIA also does not report damages as a result of restrictions imposed on the movement of heavy vehicles during the times of day when peak temperatures are usually registered.

In relation to abundant rainfalls in the period of 16 to 20 June 2014, RIA applied and was awarded with a grant from the EU Solidarity Fund amounting BGN 3.4 mln. for emergency works on republican roads III-609 (Tryavna - Dryanovo) and II-55 (Debelets – Gurkovo).

In relation to torrential rains in the entire country from 30 January to 1 February 2015, RIA applied and was awarded with a grant from the EU Solidarity Fund amounting BGN 6 mln. for emergency works on republican roads on the territories of District Road Administrations of Blagoevgrad, Burgas, Gabrovo, Haskovo, Kardzhali, Kyustendil, Montana, Pernik, Razgrad, Ruse, Shumen, Smolyan, Sofia, Stara Zagora, Targovishte, Varna and Yambol.

Railway infrastructure

NRIC maintains a very detailed registry of emergency events along the national railway network. This allows costs to be analyzed by both event type and spatial distribution. A summary of the events over the last five years (2012–2017) is shown in ***Table 33***.

Table 33. Damage to railway infrastructure from catastrophic events (2012–2017)

Event	Events (number)	Events with damage (number)	Damage (BGN)	Damage (percentage)
Floods	84	14	7,007,558	37.8
Landslides	69	6	10,724,672	57.9
Rockfalls	139	14	723,709	3.9
Snow	34	8	78,494	0.4
Total	**326**	**42**	**18,534,433**	**100**

The most frequent event is *rockfalls*, which in most cases do not result in damage to the infrastructure but only to disruptions to the services. *Landslides* (mostly shallow) are also frequent. In most cases, they do not result in material damage. However, if damage from landslides occurs it is the event class that is costliest to rectify. Together, landslides and rockfalls make up for 61.8 percent of the total damage.

Floods are the second most common event and the second costliest to rectify. The damage from floods amounts to 37.8 percent of total damage.

Snow results mostly in disruptions to services but not so much in damage to infrastructure. The damage from snow is negligible compared to the damage from landslides, rockfalls and floods and amounts to only 0.4 percent of the total damage.

No damage is registered because of *extreme heat*.

Table 33 and ***Figure 25*** show the monthly distribution of the different classes of extreme weather-related events affecting railway infrastructure.

Figure 25. Monthly distribution of catastrophic events affecting railway infrastructure (2012–2017)

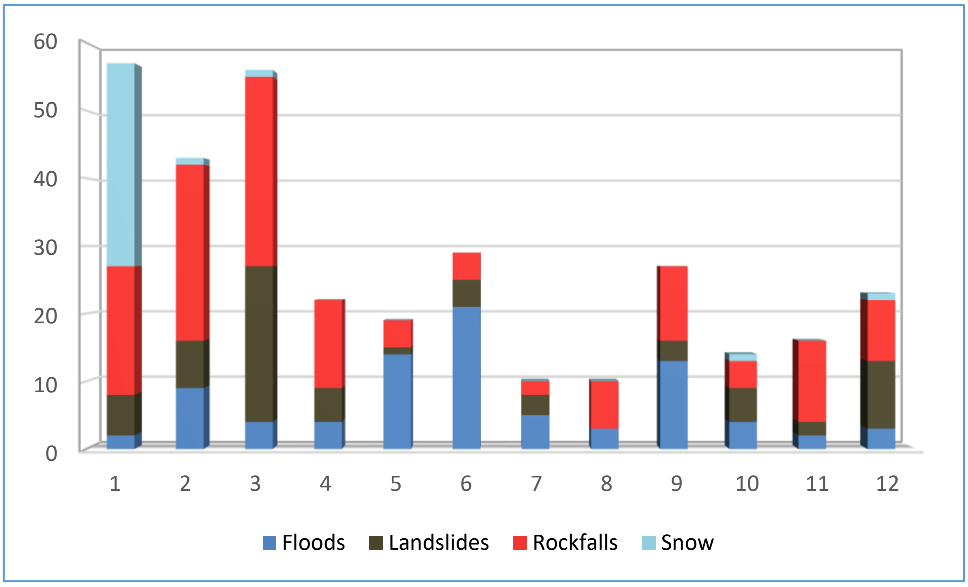


Table 34. Monthly distribution of catastrophic events affecting railway infrastructure (2012–2017)

Event	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Floods	2	9	4	4	14	21	5	3	13	4	2	3
Landslides	6	7	23	5	1	4	3	0	3	5	2	10
Rockfalls	19	26	28	13	4	4	2	7	11	4	12	9
Snow	30	1	1	0	0	0	0	0	0	1	0	1

Port infrastructure

No data. BPI does not maintain records of damage to port infrastructure.

Inland waterway infrastructure (Danube River)

The navigation infrastructure along Danube suffers damage mostly from ice blocks and freezing of the river. ExAEMDR maintains a detailed record of such damage. Typically, affected are items like buoys, steel ropes, concrete anchors, D-shackles, and so on. Over the last five years (2012–2017) the following damage to navigation equipment have been registered:

- BGN 27,077 for the period 02.02.2012 – 08.02.2012;
- BGN 65,951 for the period 08.01.2017 – 28.02.2017.

The total costs for damage due to heavy winter conditions for the period 2012–2017 are *BGN 93,028*. These costs do not include losses for inland waterway operators occurred due to closed navigation due to low drought and or icing.

Airport infrastructure

BULATSA survey showed that no flood, landslide, intensive heat, or snowfall and snow storm events were registered, and no statistical data exists. BULATSA is not responsible for keeping records of statistical data for the damage to the airport infrastructure.